

INTRODUCTION

The Paradise Creek Watershed was the focus of a comprehensive environmental study sponsored by the Brodhead Watershed Association and funded through a Growing Greener Grant from the Pennsylvania Department of Environmental Protection (DEP). The goal of the project was to develop a management plan to protect natural resources within the watershed boundaries. A large technical team was organized to define existing conditions and to identify and prioritize areas of concern. An action plan was then developed (refer to Chapter Two) to address those areas of concern, and to identify actions that need to be taken to safeguard the watershed in the future.

The Paradise Creek Watershed is located in the north central area of Monroe County. Most of the 44.5 square mile (28,480 acre) watershed is located in Paradise Township. Headwaters for the creek are in Barrett and Coolbaugh Townships to the north, Tobyhanna Township and Mt. Pocono Borough to the west, and Pocono Township to the south. Extremely small areas of Price and Stroud Townships exist in the watershed to the east. The Paradise Creek drainage area is a sub-watershed to the Brodhead Creek Watershed (approximately 285 square miles), which encompasses almost half of Monroe County. The Brodhead joins the Delaware River in the southern end of the Delaware Water Gap National Recreation Area.

Tributary streams to the Paradise Creek include Butz Run, Cranberry Creek, Devils Hole Creek, Forest Hills Run, Indian Run, Swiftwater Creek, Tank Creek, and Yankee Run. The Commonwealth has designated all of these streams as either high quality or exceptional value water.

Creeks and their watersheds are naturally occurring features of the landscape. A municipal boundary is a manmade feature that is imposed on the landscape without regard for watersheds in the area. This inconsistency between watershed and municipal boundaries is particularly apparent in the Paradise Creek Watershed. Each of the municipalities in the watershed has its own set of land use plans and ordinances that are not coordinated to ensure uniform standards and regulations.

If the quality of the water in the streams flowing through the watershed is to be maintained, and improved where possible, it is essential that the management of land use be integrated and coordinated with the management of the water resources. Managing the land and water resources in a watershed is a community-wide endeavor. The community includes the residents, landowners, developers, businesses, volunteer associations, civic groups and the local, county, state and federal regulatory agencies.

Sources of pollution that can degrade water quality can be described generally in two ways: point sources and nonpoint sources. Point sources originate from discrete locations, such as the flow of treated wastewater or stormwater from pipes. Nonpoint sources are more ubiquitous, and are not discharged through pipes. The focus for this project is not to investigate point sources that are regulated and controlled by the Pennsylvania Department of Environmental Protection (DEP) and/or the Monroe County Conservation District (MCCD). This management plan is intended to focus on actions that can be taken by the community to limit pollution from nonpoint sources. The following table explains the two through the use of examples.

POINT SOURCES	POTENTIAL POLLUTANTS
Sewage treatment plants & industrial discharges	Toxic chemicals, temperature, nutrients, organic pollutants
Piped stormwater discharges	Metals, bacteria, garbage, nutrients, sediments
NONPOINT SOURCES	POTENTIAL POLLUTANTS
Septic systems	Nitrates, bacteria, viruses, household chemicals
Roads & parking lots	Temperature, hydrocarbons & metals
Lawns, farm fields, recreational fields	Pesticides & herbicides, nutrients, sediment
Pets & other animals	Bacteria, viruses, nutrients

The primary objective of this management plan is to present the findings of a three-year study, and to provide recommendations to protect the watershed that can be implemented by members of the community. Recommended actions are based on the findings of the study team and a comprehensive evaluation of the natural features of the creek and its environs. Recommendations are also based on the concept that activities that have the potential to impact water quality must be viewed from a watershed perspective. Recommendations to residents, landowners, developers, businesses, volunteer associations and civic groups easily take this watershed-wide perspective. Recommended actions for the municipalities in the watershed are more complicated.

The autonomy of a municipality in the Commonwealth is important and necessary to protect the unique character of individual communities. Historically, the municipalities have acted independently in the development of land use regulations. Regional comprehensive planning, open space, and recreation initiatives have begun in recent years to advance objectives and values shared by the municipalities. Protection of the watershed similarly represents a shared objective, and requires communication and coordination between the municipalities. Watershed-wide coordination is particularly important in such areas as stormwater management, soil erosion control, impervious coverage limitations, open space protection, riparian buffer restrictions, and the protection of floodplains, wetlands, woodlands and steep slopes.

This project was conducted in phases. Phase I evaluated existing data and determined what additional studies were required to fully assess the condition of the watershed. In Phase II, fieldwork was conducted to fill the gaps identified in Phase I. In Phase III the Paradise Creek Watershed Management Plan was developed. A summary of the study reports is presented in Chapter One. The full reports may be reviewed on the Paradise Creek Watershed

web site at www.paradisecreekwatershed.org or by contacting the Brodhead Watershed Association.

The Brodhead Watershed Association sponsored this project through a Growing Greener Grant from the DEP. In-kind (donated) services were provided by the Brodhead Watershed Association, the Monroe County Planning Commission, the Monroe County Conservation District, Aquatic Resources Consulting, and Wilkes University. Consultants included the DEP, the Delaware River Basin Commission (DRBC), the United States Geological Survey (USGS), Borton-Lawson Engineering, N.A. Water Systems, Castle Valley Consulting, and EA Engineering. Additional participants and supporters included the Pennsylvania Department of Transportation, Pennsylvania Fish and Boat Commission, Brodhead Creek Regional Authority, Henryville Conservation Club, Brodhead Protective Association, Sanofi Pasteur, Inc., Paradise Falls Lutheran Association, Lake Swiftwater Club, Concerned Citizens of Barrett Township, and Pro Paradise Valley. The project also had the support of all six municipalities in the watershed.

STATEMENT OF NEED

All of the streams in the Paradise Creek Watershed are designated either high quality or exceptional value waters. Proposed discharges within this Special Protection watershed are regulated by the DEP with enhanced restrictions and requirements designed to protect designated uses. The Paradise Creek Watershed Management Plan is similarly focused on protection strategies, as well as restoration strategies.

A River Conservation Plan for the Brodhead Watershed was prepared and the watershed was placed on the Pennsylvania Rivers Conservation Registry in 2002. One of the major recommendations of the Brodhead Watershed Conservation Plan is to develop sub-watershed assessments that will examine existing data to determine water resource trends and recommend future action based on good science. A sub-watershed assessment was prepared for the Pocono Creek Watershed, a sub-watershed of the McMichael Creek. The Pocono Creek watershed is approximately the same size as the Paradise Creek, is contiguous, and faces similar development pressures. The Pocono Creek Watershed project was designed as a pilot study, and much of the Paradise Creek study criteria was derived from that study team's work and experiences.

The Paradise Creek Watershed is one of six major sub-watersheds of the Brodhead Watershed and, like the rest of Monroe County, is under intense development pressure. Groundwater withdrawals, impacts of point and nonpoint sources of pollution, and maintenance of stream base flow are all issues of concern to the area residents and municipal officials. All of the municipalities in the watershed are actively pursuing regional open space and recreation initiatives and many municipalities are involved in regional comprehensive planning. Planning initiatives to protect the watershed require both a comprehensive understanding of existing conditions and the scientific studies necessary to predict impacts associated with new development.

Urbanization, population increases with related increases in housing demands, and rapid development of areas within the Watershed threaten the high quality and exceptional value waters in the Paradise Creek Watershed. Forest Hills Run is currently impaired downstream of Route 611. The Forest Hills Run originates in the vicinity of the shopping plaza parking lots

along Rt. 940 in Mt. Pocono. This modest run then receives effluent from two sewage treatment plants as well as stormwater runoff from Rt. 611 and a large portion of Mt. Pocono Borough. Another headwater tributary, Yankee Run, may also be impaired by nonpoint source pollution. Studies by the Brodhead Watershed Association under a DEP – WRAP grant determined that Yankee Run is being impacted by stormwater runoff from the Mt. Pocono area. Another major tributary, Swiftwater Creek, receives discharges from three treatment plants, and stormwater runoff from Route 611 and the industrial and commercial facilities along that highway. Peat mining, a quarry, an abandoned landfill, and commercial facilities exist in the headwaters of Cranberry Creek. Although no direct evidence of degradation exists, the Cranberry Creek is a Class A Wild Trout Stream that warrants special protection. Portions of the Devils Hole Creek are designated Exceptional Value waters. Evidence exists of potentially damaging erosion and unstable stream banks along the Devils Hole Creek.

Significant new residential and commercial developments are currently under review in the Paradise Creek Watershed. Both Monroe County applicants for casino licenses propose major land developments here. Pocono Manor's planned resort exists in the headwaters of the Swiftwater Creek, and Mt. Airy's proposed resort exists along the Forest Hills Run. Both proposals will involve significant groundwater withdrawals, and will generate large quantities of wastewater and stormwater. Currently proposed residential and commercial development in Mt. Pocono will bring the Borough to near build-out, leaving precious little land undeveloped. Sanofi Pasteur, Inc. is of paramount importance to Monroe County's overall economy. Sanofi Pasteur, Inc.'s expansion needs must be respected, while impacts to the Swiftwater Creek must be minimized.

Research has shown that impervious surface is an important indicator to predict the impact of land development on the health of a stream and its watershed. Roads, parking lots, sidewalks, rooftops, driveways and all other surfaces that shed water and produce runoff are considered impervious surfaces. The Center for Watershed Protection in Maryland has concluded that when the impervious surfaces in a watershed reaches approximately 10 percent of the land area, stream degradation is likely to occur. A study of the land use and impervious surface in the watershed was performed in conjunction with this plan (*Land Use and Impervious Cover in the Paradise Creek: An Initial Assessment*, by James Sheehan, Jr.). Mr. Sheehan reports that approximately 3.6 percent of the watershed is currently covered by impervious surface. The area around the base of the Paradise Creek has the lowest impervious surface (0.85 percent of land area) while the headwater areas draining into the Tank Creek and Yankee Run has the highest (6.3 percent of land area). A build-out analysis performed by the Monroe County Planning Commission provides insight into where future development can occur without damaging the watershed, and where development – including large groundwater withdrawals – may result in water quality impacts.

Depletion of groundwater reservoirs is also a concern in this developing watershed. The Paradise Creek and its tributaries are gaining streams (fed by groundwater), and depend on groundwater to maintain base flows during dry periods. Adequate stream base flows must be maintained to support the existing aquatic habitat and the streams' designated uses. As more individual, public water supply, and commercial wells are developed, and as more stormwater is diverted directly to the Paradise Creek and its tributaries without recharging groundwater, residents and officials must be concerned groundwater will not be available to maintain stream base flow and for human and wildlife consumption.

Finally, members of the Paradise Creek Watershed community understand that the Paradise Creek represents the headwaters for the larger Brodhead Creek and, ultimately, the Delaware River. The water quality of the Paradise Creek influences the water quality of the Brodhead Creek. Before reaching the Delaware River, the Brodhead Creek provides water to the Brodhead Creek Regional Authority, and safe drinking water to many Monroe County residents and businesses. The Brodhead Creek Regional Authority (formerly the Stroudsburg Municipal Authority) now provides water to users all the way north along Rt. 611 to Sanofi Pasteur, Inc. and may, in the future, serve as a source of water to many additional users in the county. Protecting this important drinking water source is critical to the entire county's future. Maintaining a balance of discharges and withdrawals to protect the larger Brodhead must begin with planning on a sub-watershed basis, and must involve cooperation and coordination on a large, regional basis.

FINAL REPORT STRUCTURE

In Chapter One, existing conditions in the watershed are defined by reviewing the results of Phase I and Phase II of the study. Recommendations are provided by individual team members from the limited perspective of their specific investigations. In Chapter Two, these recommendations are melded into an Action Plan for protection of the watershed developed by the whole team to eliminate or minimize various nonpoint sources of pollution. Chapter Three describes the stakeholders in the watershed, those groups who can work together to implement the Action Plan. And Chapter Four describes the Implementation Tools available to make natural resource protection in the Paradise Creek Watershed a reality.

LIMITATIONS

The Paradise Creek Watershed Management Plan proposes actions that can be taken to protect the watershed that focus on *nonpoint sources* of pollution. Point sources are regulated under the federal Clean Water Act and Pennsylvania's Clean Stream Law. This plan does not evaluate the adequacy of either the rules or the regulatory agencies' enforcement of the rules.

The Paradise Creek Watershed Assessment and Protection Plan Project was initially described as "ambitious." Certainly, the project was a huge undertaking for the Brodhead Watershed Association. The amount of data accumulated, while voluminous, is hardly enough to call complete. A full year of monthly sampling and analysis is a mere snapshot of overall stream health, and is not enough to use as evidence of specific sources of pollution. Indeed, even during the three years taken to conduct this study conditions in the watershed changed significantly as the region moved from drought in 2002 – 2003 to flood stage from Hurricane Ivan and subsequent storms. Nonetheless, evidence of impacts from development in the watershed exist, and the recommendations presented in this report are scientifically valid means to protect the watershed's natural resources.

Chapter One

Existing Conditions

During the first two phases of the Paradise Creek Watershed Management Plan, a series of carefully designed research studies were undertaken. These studies were conducted to define existing conditions in the watershed, to establish a base line for monitoring changes in the future, and to make recommendations for needed repairs and improvements. The recommendations include measures to improve a condition, where appropriate, and actions to ensure the long-term viability and health of the watershed. The objective of Phase I was to evaluate the volumes of existing data collected by a variety of organizations, and determine what studies should be conducted to fill any gaps in that information. In Phase II, studies were conducted to fill the identified gaps.

Study participants were not required to follow a standardized format for reporting their findings. The study results presented here are organized to identify each component's objective, results and recommendations, and the team members who performed each task are quoted directly as much as possible. For the full results of each component, as written by individual team members, visit the study web site at www.paradisecreekwatershed.org.

PHASE I

Community Survey

Debra Brady, Project Manager

Objective:

At the outset of the Paradise Creek Watershed Project a survey was mailed to landowners in the watershed to solicit their input and opinions, and to determine their level of understanding of watershed issues. A total of 2,300 surveys were mailed, and 276 were returned, a 12 percent response rate.

Summary and Conclusions:

Forty-eight percent of watershed residents who responded to the project survey believed new growth and development can occur without impacting water supplies and water quality if adequate safeguards are in place. But 41 percent of those surveyed did not believe adequate safeguards are currently in place, and over 48 percent were unsure. The survey results indicated a diverse range of opinions regarding growth in the watershed. Eighteen percent of those surveyed agreed they would be more supportive of watershed protection initiatives in the Poconos if they knew the initiatives would promote continued growth and development, while 53 percent claimed they would be more supportive if they knew these initiatives would slow or inhibit new development.

Over 59 percent of those who responded and indicated they would attend public meetings associated with the study wanted to keep track of how the project team is spending

their tax dollars. Most (91.5 percent) wanted to learn more about the health of the Paradise Creek Watershed. Over half wanted to meet the team of scientists conducting the study, and over 40 percent wanted to learn how to become involved in the study.

The survey also indicated a strong desire on the part of the community for additional educational opportunities. Most survey respondents wanted more education on septic system maintenance and drinking water testing and treatment. But over half also wanted to know more about watershed ecology and stewardship, and almost half wanted to learn more about existing regulatory programs. All of those surveyed obtain drinking water from either private or community wells. Only 88 percent knew that, if their water becomes contaminated, an alternative source of drinking water is not readily available.

Most significantly, with agreement as high as 97 – 99 percent, the survey results established specific goals for the project team. The community wanted the team to develop ways to improve water quality, preserve stream corridors and floodplains, maintain existing stream flows, preserve open space, coordinate watershed planning between all levels of government, develop using conservation design, and consider the economic impacts of new rules. These goals matched those developed for a similar study conducted in the nearby Pocono Creek watershed, and allowed the technical team to integrate the same targets established to accomplish the goals. Those targets include:

- Sustain existing water quality where it is better than state standards
- Improve impaired water quality to meet state standards
- Maintain naturally stable streams
- Re-establish stability to unstable streams
- Provide necessary stream flows to support a natural ecosystem
- Restore or maintain an optimal biological community in each management area
- Implement watershed based planning initiatives
- Implement conservation development practices
- Diversify the County's economy with clean industries, and enhance tourism
- Increase open space

Recommendations:

The Paradise Creek Watershed study team adopted these targets, and they are used as the foundation for the Action Plan in Chapter Two. During the course of this study, seminars and presentations were provided to respond to the community's request for additional educational opportunities. While attendance varied, information was provided on a wide range of topics in cooperation with Paradise Township's outreach initiative called Paradise University. Drinking water clinics are now held each May, providing residents with discounted and convenient opportunities to test their well water. These public outreach and education initiatives should continue with support from all the stakeholders in the watershed.

Land Use and Impervious Cover Survey

James Sheehan, Jr.

Objective:

Before strong planning tools to protect the Paradise Creek Watershed can be developed, existing land uses and county and local land use strategies must be considered. The Monroe County Planning Commission and individual municipalities within the watershed have already developed comprehensive and long-term planning strategies for community development. A

regional plan has been developed for Coolbaugh Township, Tobyhanna Township, Tunkhannock Township and Mt. Pocono Borough. Pocono Township has also participated in regional comprehensive planning. Municipalities in the watershed are participating in regional open space initiatives and park and recreation planning. Efforts to protect the watershed must coordinate with and compliment these efforts, avoid redundancy and conflicts, and ensure efficient use of resources.

Evaluation of existing land uses allows for calculation of the percentage of the watershed covered by impervious materials. Large areas of impervious surface may allow contaminants to be discharged directly into the streams. Increasing amounts of impervious surfaces can reduce the rate at which rainwater recharges groundwater, and can decrease forest cover that protects stream bank stability, water quality and habitat characteristics.

Summary and Conclusions:

James Sheehan, Jr. conducted a Land Use and Impervious Cover Survey with input and advice from Environmental Planner Pam V'Combe of the Delaware River Basin Commission. Sheehan used GIS software in conjunction with low-level aerial photography sponsored by the Collaborative Environmental Monitoring and Assessment Program made available on the Pennsylvania Spatial Data Access website.

In order to facilitate a meaningful representation of conditions in the watershed, and also to develop management strategies for varying conditions later in this study, the watershed was divided into distinct management areas (see Sampling and Analysis Plan, below). The management areas were determined by a sub-committee and based on drainage areas, topography, geology, soils, land uses, zoning, population, and other factors. Mr. Sheehan presented his Land Use and Impervious Cover Survey based on those management areas.

According to Sheehan's report: "Impervious cover for the Paradise Creek Watershed is estimated at 3.63% of the land area. The Tank-Yankee, Upper Paradise, and Upper Swiftwater management units had the highest impervious cover values (5.51 to 6.31 %) and the Lower Paradise and Cranberry management units had the lowest (<2%). In general, the opposite trend is observed for percent forest cover, although the proportion of other land uses is more variable, resulting in the unit with the most impervious cover, Tank-Yankee (6.31%), having the fourth highest forest cover (89.46%). Forest cover is notable in that it is consistently high, with a value of more than 87% for the entire watershed, and ranging from approximately 80% to 95% for the management units.

"A detailed assessment of all land use present in these management units is beyond the scope of this research; however, some general trends are evident. Diversity and types of land use vary across management units. Forest Hills is diverse, with 12 land use categories while Lower Paradise has only four. Management units such as Devils Hole and Lower Paradise are largely contiguous forest; Butz Run and Upper Paradise have more agricultural use; and Tank-Yankee, Forest Hills, and Lower Swiftwater have the most area allocated to residential and commercial use. It is important to note that while Tank-Yankee is dominated by residential development, these areas contribute almost 25% to the overall forest cover of this unit. The distribution of land use relative to waterways is also varied. Most of the development in Tank-Yankee appears to be relatively far from the nearest mainstream (Tank Creek and Yankee Run) while roads and development occur in close proximity to the mainstream in Forest Hills (Forest Hills Run). Devils Hole Creek and Cranberry Creek appear to flow through primarily contiguous forest.

“Impervious cover values as estimated by this analysis are considerably lower than the 10% threshold suggested for the beginning of watershed degradation. Given the primarily forested nature of this region, this is not surprising. While the accuracy of this value needs to be verified, this assessment strongly suggests that this watershed is in good ecological condition with respect to the amount of impervious surfaces. These surfaces will increase rapidly based on current growth projections, however. Continued monitoring of impervious surface cover within this watershed is required for successful preservation of water quality and quantity because mitigation becomes increasingly difficult after degradation caused by impervious cover¹. Several factors must also be considered beyond simply the amount of impervious cover present. The distribution of impervious surfaces, point-source discharges of pollution, the condition and extent of riparian buffers, impacts of other land use such as agriculture, and the appearance of the hemlock wooly adelgid as a major factor in the health of riparian hemlock are all potentially strong influences on the integrity of this watershed.

“In summary, the most important fact from this analysis is that impervious surface has the potential for stream degradation, and increases in population equal an increase in development that yields an increase in impervious surface. The Center for Watershed Protection has determined that when the level of impervious surface reaches approximately 10 percent, stream degradation occurs.”

Table 1. Summary of Results From Impervious Cover and Land Use Analysis

Watershed Management Unit	Area Hectares	Land Cover Percentages		
		Impervious Cover	Other Land Use	Forest Cover
Lower Paradise	1010.978	0.85	4.14	95.01
Cranberry	1910.183	1.96	3.90	94.14
Butz	951.433	2.63	12.51	84.86
Devils Hole	1590.972	2.93	1.85	95.22
Forest Hills	1233.659	3.68	16.21	80.11
Lower Swiftwater	863.816	3.81	13.71	82.48
Upper Swiftwater	1782.631	5.51	11.65	82.85
Upper Paradise	1172.807	5.54	11.48	82.98
Tank-Yankee	828.304	6.31	4.22	89.46
Calculated for Entire Watershed	11,344.783	3.63%	8.47%	87.91%

¹ Giannotti, L. and S. Prisloe. 1998. Do it yourself! Impervious surface build out analysis. Technical Paper #4, NEMO (NonPoint Education for Municipal Officials) Project, University of Connecticut Cooperative Extension System. <http://www.nemo.uconn.edu>.

Limitations and Recommendations:

“This analysis only provides an initial estimate of impervious cover and assessment of land use for this watershed and needs to be validated. In addition, several data limitations beyond those caused by cloud cover exist in the Collaborative Environmental Monitoring and Assessment Program (CEMRI) dataset, likely influencing the results. The dataset does not include all impervious surfaces and land uses within contiguous forest, such as that caused by forest roads, is not measured and some misclassification of land use are apparent when polygons are viewed on ortho-photos. Finally, impervious cover was not determined for some land use categories (e.g., commercial and industrial) necessitating a more qualitative estimate for these areas. Despite these difficulties, the Collaborative Environmental Monitoring and Assessment Program dataset is the most detailed and recent assessment for this region. Continued technological advancement and new data sources hold promise for the refinement of this impervious cover determination and land use classification. For instance, IKONOS satellite data may be useful in accurately detecting the amount of impervious cover present under a dense forest canopy². United States Geological Survey digital ortho-photos are updated on an approximately 5-year schedule and Monroe County is in the process of releasing its own high-resolution aerial photography. These new techniques and data could be used to measure the validity of this initial analysis and should provide new insight for management, assessment and planning.”

As the watershed develops, minimization of new impervious surfaces and protection of forested areas is critical. Minimizing impervious surfaces minimizes the amount of stormwater generated, and minimizes the amount of stormwater that must be managed. Protecting the existing vegetative cover, particularly in the vicinity of streams, ponds, lakes and wetlands provides a natural buffer to filter runoff, and provides shade to cool the streams. Protecting existing vegetative cover requires sound forest management initiatives, and must include provisions to eradicate invasive species.

Build-out Analysis

Monroe County Planning Commission

Objective:

Growth will be a key factor in managing the watershed in the future. If no new development occurred, managing the watershed would be limited to addressing existing problems and developing strategies for protecting the natural resources in the area. However, new development will continue to occur. It is obviously not possible to determine the exact increase in population, housing or commerce for any given period of time. For planning purposes there are methods to estimate the potential increase in the number of new residents, housing units and commerce in the watershed.

Summary and Conclusions:

The staff of the Monroe County Planning Commission had the task of preparing estimates of the potential growth of the population and number of housing units in the eight

² Forney, W., C. Raumann, T. B. Minor, J. L. Smith, J. Vogel, and R. Vitales. 2000. Land use change and effects on water quality in the Lake Tahoe Basin, Nevada and California: Year-1 progress. USGS Open-Field Report 02-014.

municipalities in the Paradise Creek Watershed. The following tables contain these estimates. In addition, estimates have been made for the potential increase in the square footage of new commercial and industrial buildings. It is very important to remember that the data presented on the tables are estimates of the potential growth in the watershed. They are not, nor should they be considered, a target to achieve, nor should they be considered or used as the maximum amount of development that may occur.

Table 2. Paradise Creek Project Demographic Profile

Township	2000 Existing		2020 Projections		Build Out Projections					
	Existing Housing Units in Watershed	Existing Population in Watershed	Projected Housing Units in Watershed	Projected Population in Watershed	Additional Potential Housing Units In Watershed	Build Out Housing Units In Watershed	Additional Potential Population in Watershed	Build Out Population in Watershed	Average Housing Units/Year (1990-1999) in Watershed	Year Build Out is Reached Based on Current Zoning
Barrett	94	237	114	277	56	150	137	374	1	2056
Coolbaugh	620	1895	840	2503	1122	1742	3344	5239	11	2102
Mount Pocono	958	2519	1158	3046	2929	3887	7702	10221	10	2293
Paradise	957	2552	1377	3539	5175	6132	13301	15853	21	2246
Pocono	617	1627	997	2722	7643	8260	20866	22493	19	2402
Price	2	6	2	6	14	16	39	45	0	---
Stroud	1	3	1	3	37	38	100	103	0	---
Tobyhanna	209	653	289	734	561	770	1425	2078	4	2140
Watershed	3458	9492	4778	12829	17537	20995	46914	56406	---	---

Table 3

Industrial/Commercial Vacant Acres and Parcels (as of December 2002)

INDUSTRIAL							
Township	Zone	Developable Acres	Potential Number of New Parcels	Max % Building Coverage	Potential Square Feet of New Building Use	Max % Lot Coverage	Remaining Lot Area Parking, Roads, etc. (Assumed to be impervious)
Barrett	M-1	287.26	57	50	6256440.64	---	1564110.16
	S-1	239.66	47	10	1043940.57	---	260985.14
Coolbaugh	None	---	---	---	---	---	---
Mount Pocono	RLM	12.44	2	50	271042.09	80	162625.25
	M	42.23	21	50	0.00	80	0.00
Paradise	B-2	167.74	183	35	2557414.75	50	1096034.89
Pocono	I	299.96	59	60	7839649.47	---	5226432.98
Price	None	---	---	---	---	---	---
Stroud	None	---	---	---	---	---	---
Tobyhanna	CI	82.25	27	45	1612275.50	---	644910.20
Watershed		1119.10	396	---	19580763.02	---	8955098.63

Table 4

COMMERCIAL							
Township	Zone	Developable Acres	Potential Number of New Parcels	Max % Building Coverage	Potential Square Feet of New Building Use	Max % Lot Coverage	Remaining Lot Area Parking, Roads, etc. (Assumed to be impervious)
Barrett	B-1	26.28	57	50	572379	---	572379
	T-1	41.84	8	25	455634	---	455634
Coolbaugh	C-1	56.84	75	30	742821	50	495214
	C-2	83.79	41	40	1459966	65	912479
	C-3	34.18	198	20	297763	25	74441
Mount Pocono	C-1	14.3	62	50	311512	80	186907
	C-2	138.52	48	35	2111943	80	2715356
Paradise	B-1	281.34	306	35	6853267	50	1838308
Pocono	C	122.45	122	50	2667005	---	2667005
Price	None	---	---	---	---	---	---
Stroud	None	---	---	---	---	---	---
Tobyhanna	C	460.61	501	30	6019251	---	8025667
Watershed		1260.15	1418.00	---	21491541.36	---	17943390.31

Table 5

Commercial/ Industrial Demographics for Paradise Creek Watershed (as of December 2002)

Township	INDUSTRIAL				COMMERCIAL			
	Developable Acres	Potential Number of New Parcels	Potential Square Feet of New Building Use	Total Potential Square Feet of Impervious Surface *	Developable Acres	Potential Number of New Parcels	Potential Square Feet of New Building Use	Total Potential Square Feet of Impervious Surface *
Barrett	526.92	104	7300381	9125477	68.12	65	1028013	2056026
Coolbaugh	0	0	0	0	174.81	314	2500550	1482133
Mount Pocono	54.67	23	271042	433667	152.82	110	2423456	5325719
Paradise	167.74	204	2557415	3653450	281.34	306	6853267	8691575
Pocono	299.96	59	7839649	13066082	122.45	122	2667005	5334011
Price	0	0	0	0	0	0	0	0
Stroud	0	0	0	0	0	0	0	0
Tobyhanna	82.25	27	1612276	2257186	460.61	501	6019251	14044918
Watershed	1131.54	417	19580763	4087117	1260.15		21491541	36934382

* Includes building, parking, access roads, etc.

Recommendations: The number of existing housing units in the watershed was established to be 3,458, with a population of 9,492. At 2020, the Planning Commission anticipates 4,778 housing units and an increased population of 12,829. If build-out occurs based on current zoning, the population in the Paradise Creek Watershed could increase to 56,406 with a total of 20,995 housing units. The Planning Commission also estimates the possibility of 942 additional acres of commercial/industrial impervious surface at build-out. Elected officials and community leaders need to plan for this level of growth. Increases in impervious surface in the watershed could directly impact water quality. Development should be directed away from streams, lakes, ponds and wetlands. Stormwater management plans should implement Best Management Practices. Riparian zones should be protected and controlled through land use restrictions. Regional water resource planning should address water use and wastewater treatment for this anticipated growth.

Limitations: It should be noted that this analysis is already several years old. The analysis should be updated regularly as anticipated growth occurs, providing fresh projections for planning purposes. The project would have benefited from build-out projections based on management areas, as well as by municipality.

Water Quality Data Gap Analysis

Brain Oram, Wilkes University

Objective:

Brian Oram of Wilkes University's GeoEnvironmental Sciences and Engineering Department prepared a comprehensive water quality data gap analysis, drawing historical data from the United States Geological Survey, Monroe County Planning Commission, Pennsylvania Department of Environmental Protection, Paradise Township, Pocono Township, Sanofi Pasteur, Inc., Mount Pocono Municipal Authority, Alliance for Aquatic Resource Monitoring and the Brodhead Watershed Association. Oram also investigated a myriad of existing datasets pertinent to the Paradise Creek Watershed from federal, state, and educational sources. In all, Oram compiled and reviewed over 2000 sampling events in the watershed since 1996. Limited data was available for the smaller subwatersheds, and the data included both seasonal and spatial variations. In terms of data gaps, Oram noted that, "If it were not for the efforts of BWA, there would be no data for Butz Run, Cranberry Creek, and Tank Creek."

Summary and conclusions:

The water quality data gap analysis focused on temperature, pH, dissolved oxygen, nitrate, ammonia, and total phosphorus. These parameters were reviewed to identify trends and to compare the results to Pennsylvania Water Quality Standards. While the regulatory temperature criteria were exceeded in most streams during some sampling events, Oram noted no increasing trends over time. Oram remarks, "From a watershed perspective, there does not appear to be systematic temperature changes that would indicate a long-term problem with increasing water temperature or waters that would not meet the criteria for a cold-water fishery. The available data suggests that Paradise Creek and Forest Hills Run are experiencing the greatest temperature variations. The cause of the temperature variations from a watershed perspective is unclear, but it is likely associated with changes in watershed characteristics, presence of permitted discharges, and proximity to urban/developed areas. From the specific sampling data, it appears that some of the warmer water temperature effects may be associated with discharges from shallow lakes and ponds and local discharges. It is also possible that urban runoff, deforestation/encroachment into the riparian zone, and possible direct stormwater discharge may account for some of the temperature variation."

Without dissolved oxygen in the streams aquatic organisms cannot survive. Dissolved oxygen levels rely on water temperature, aeration, consumption, and both chemical and biological reactions. Within the collection of water quality data available to Oram, only the Forest Hills Run had reported dissolved oxygen levels below the water quality criteria level of 7 milligrams per liter. Oram recommended continuous dissolved oxygen monitoring at selected sites within the watershed to investigate important 24-hour fluctuations in this important water quality parameter.

The Devils Hole Creek is the only stream in the Paradise Creek Watershed designated as Exceptional Value waters. Oram notes that, "The stream appears to have a very pristine water quality, but the low alkalinity indicates that the stream may be vulnerable to rapid changes in pH, increasing metals loading, and decreasing biodiversity."

Oram's assessment of the Forest Hills Run mirrors recent studies conducted by the Pennsylvania Department of Environmental Protection. He states, "The historical data indicates the Forest Hills Run is being impacted. From the available data, it is apparent that Forest Hills Run has and may still be experiencing problems associated with low alkalinity and

elevated nitrates, fecal coliform, biochemical oxygen demand, total dissolved solids, total phosphate and total aluminum. The extent of the impact has not been clearly defined, but it appears to be a combination of activities related to increased fecal coliform, nutrient loading, dissolved solids, and BOD of the water.” [Note: Subsequent to publication of Oram’s report, a reach of the Forest Hills Run downstream of Rt. 611 was declared impaired by the DEP and placed on the Clean Water Act 303(d) list of impaired waters.]

Oram describes multiple sample events demonstrating elevated fecal coliform concentrations, elevated total phosphate concentrations, and decreased alkalinity in the Swiftwater Creek. “Regarding the pH and alkalinity data,” he stated, “the data suggests that there may be a slowly decreasing alkalinity over time. If this is occurring, it would mean that Swiftwater Creek could become more susceptible to rapid changes in pH, increased metals loading, and decreasing biodiversity.”

Deviations from regulatory water quality criteria in the Paradise Creek were found to be sporadic. Oram notes, “From the available data, there does not appear to be any systematic changes in water quality for Paradise Creek. The low alkalinity suggests the potential for decreasing water pH over time. The observed water quality problems in Paradise Creek appear to be event related and not reflective of long-term changes in water quality.”

Recommendations:

Oram offered numerous recommendations. First, he suggested that additional historical data from BWA be incorporated into the existing data sets. Some of the historical data could not be integrated into the current analysis due to lack of information regarding sample site location and methods used for analysis. He also suggested that data available from NPDES reports and other permitted facilities/discharges should be integrated. Oram recommended a routine, comprehensive water quality monitoring program using the management areas already established. He suggested including stream flow data and development of additional permanent and temporary stream gauging stations. He suggested the various volunteer groups attempt to standardize field sampling, monitoring and reporting methods.

Finally, Oram stated, “The volunteer monitoring group, BWA, is a great and valuable resource for the watershed and community. The data that they provide related to pH and temperature was very useful. It would be advisable to provide the Association with the tools to better quantify water quality parameters related to flow (staff gauges), conductivity (probe or pen), pH (probe or pen), dissolved oxygen (Winker Titration), water clarity (turbidity tube), stream habitat, and field testing for ammonia (Hach Kit).” Oram also encouraged stream walks and environmental education initiatives to “identify areas experiencing problems related to stream bank erosion, sedimentation, organic overload, and illegal dumping.”

Below are the recommendations directly from Oram’s report:

“The preliminary evaluation has identified a number of limitations to the existing dataset. The dataset has a large number of sampling events, but for most of the events the only real data is temperature and pH. When comprehensive water quality data is available, it is normally available for only the 3rd quarter of the year. The recommendations regarding additional data or activities are as follows:

1. A routine, probably monthly, comprehensive water quality monitoring program should be developed using a Management Area Strategy. This routine monitoring should use standard and approved field monitoring. The water quality testing should be performed using standard protocols acceptable or comparable to EPA

Methods and “Standard Methods for the Examination of Water and Wastewater.” A field and lab QA/QC program should be established. *[Note: This recommendation was incorporated into the study sampling and analysis plan described below.]*

2. Because of the need to evaluate diurnal changes in water quality, the water quality monitoring should include the use of real-time water quality monitoring or remote monitoring equipment that can collect water quality data at regular or irregular intervals throughout the day. This same equipment could be used to assist in collecting storm event samples and routine water quality monitoring. *[Note: This recommendation was followed, but no evaluation of the data is available. To review the data, please contact the Brodhead Watershed Association Project Manager.]*
3. Sampling sites should be established to evaluate the proposed Management Areas, but sites should also be established to evaluate the effect of permitted point source discharges and stream segments impacted by non-point source pollution, such as: stream segments in transition zones between urban and undeveloped areas. *[Note: This recommendation was followed. Refer to the sampling and analysis plan described below.]*
4. The project should consider compiling information on current land-use, stream stability, growth projections, and current/projected water resource needs for the watershed. *[Note: Refer to Land Use and Impervious Cover Survey and Build-Out Analysis above, and Fluvial Geomorphology study, below.]*
5. Since the project area contains a number of impoundments, it would be advisable to integrate lake and pond water quality into the database. It may be advisable to conduct an impoundment assessment and at least one or more lake trophic status assessments. These assessments can be used as regional case studies to facilitate the education and training of additional grassroots environmental education and monitoring programs. *[Note: Refer to Lake Trophic Study and Lake Crawford Nonpoint Source Loading Study, below.]*
6. The available data has limited information regarding stream flow, base low conditions, and meteorological data. The watershed assessment should include a review of stream flow data and the development of additional permanent and temporary stream gauging stations. *[Note: Refer to Streamflow Statistics, below.]*
7. One of the difficulties in compiling the data was that the various organizations used different formats and orders for storing field observations and laboratory water quality data. In addition, there were no metadata files available and the data had incomplete information regarding testing, sampling methods, and other protocols. If possible, the various volunteer groups should attempt to standardize field sampling, monitoring, and reporting methods.
8. The volunteer monitoring group, BWA, is a great and valuable resource for the watershed and community. The data that they provide related to pH and temperature was very useful. It would be advisable to provide the Association with the tools to better quantify water quality parameters related to flow (staff gauges), conductivity (probe or pen), pH (probe or pen), dissolved oxygen (Winkler Titration), water clarity (turbidity tube) stream habitat, and field testing for ammonia (Hach Kit).

9. The program should encourage steam walks and environmental education to identify areas experiencing problems related to stream bank erosion, sedimentation, organic overload, and illegal dumping. [*Note: Refer to Stream Walk Assessment, below.*]

Biological Data Gap Analysis

Don Baylor, Aquatic Resource Consulting

Objective:

Benthic macroinvertebrate and fish populations are extremely valuable and accurate indicators of stream health. Aquatic biologist Don Baylor of Aquatic Resource Consulting performed an assessment of past sampling within the Paradise Creek Watershed. Since different regulatory and scientific organizations use a variety of different protocols to sample and analyze data, a committee of technical team members met and agreed on a means of interpreting the data using two standard parameters. Baylor used taxa richness and the Hilsenhoff biotic index to compare sampling results across a spectrum of protocols.

Summary and Conclusions:

Historically, the Paradise Creek main stem has exhibited excellent stream health, as have the Devils Hole Creek, Tank Creek, Indian Run, and lower Cranberry Creek. Macroinvertebrate populations indicative of impairment have been found in the Forest Hills Run in the vicinity of Rt. 611, sometimes extending to the former Mt. Airy property, in the upper Cranberry Creek below a peat mine, in the Swiftwater Creek in the vicinity of Rt. 611, and in the upper reaches of the Yankee Run.

Baylor concluded his macroinvertebrate assessment stating, “Benthic macroinvertebrate data were not available for Butz Run. Data were very sparse for Cranberry Creek and for Forest Hills Run from below Mount Airy to the mouth. For Swiftwater Creek there were no usable data available from the upper mile or below Swiftwater Lake. For Paradise Creek, there were little data from the segment from Paradise Falls to the confluence with Swiftwater Creek.

Baylor cites past Pennsylvania Fish and Boat Commission fish surveys that identified excellent wild trout populations on upper portions of Devils Hole and Cranberry Creeks, both of which enjoy the status of Class A Wild Trout streams. Baylor noted additional surveys conducted by a variety of organizations that found wild trout populations in Tank Creek, Yankee Run, lower Devils Hole, Paradise Creek, and Swiftwater Creek – including naturally reproducing rainbow trout above the Swiftwater Inn.

Recommendations:

Baylor concluded, “Now that baseline invertebrate data have been established for these stations on Paradise Creek headwaters, periodic monitoring should be conducted to assess water quality and to detect any changes that may occur over time. A fall sampling would be useful to document species present at that time of year so that future conditions could be compared in spring or fall. Additional stations on Yankee Run should be sampled to assess water quality above and below the large spring above Station 6 since preliminary field investigations suggest a considerable difference in water quality. Surveys of the fish populations at these headwater locations would provide additional baseline environmental data.” [*Note: Refer to sampling and analysis plan, below.*]

As with macroinvertebrate data, no fish population data were available for Butz Run. Baylor also could not locate existing fish population data for Indian Run, the lower Cranberry Creek, the Swiftwater Creek below Lake Swiftwater and above the confluence with Indian Run, the lower portion of Forest Hills Run, and Paradise Creek below Lake Crawford. Baylor's report was used as a basis for new fish surveys during Phase II of the study. [*Note: Refer to sampling and analysis plan, below.*]

Paradise Creek Watershed Sampling and Analysis Plan

Debra Brady, Project Manager

Objective:

The objective of the sampling and analysis plan is to provide sufficient data to achieve restoration and protection goals: to sustain existing water quality where it is better than state standards, to improve water quality to meet state standards, and to restore or maintain an optimal biological community in each management area. The sampling and analysis plan is intended, therefore, to locate impaired areas. The plan is also intended to provide a foundation for planning to protect areas not yet impaired, and so must provide baseline data against which future sampling and analysis can be compared.

Summary and Conclusions:

This study plan described four distinct initiatives. First, water chemistry data would be collected from a sufficiently large pool of sampling sites, and at a sufficient frequency, to establish baseline water quality that is relevant to the watershed, statistically significant, and practical for future sampling and analysis purposes within the capabilities of the Brodhead Watershed Association and other interested parties. Second, macro invertebrate studies in accordance with protocols and methods established by the Monroe County Planning Commission would be conducted at sites throughout the watershed in a manner that invited comparability and objective evaluation. Third, fish studies would be conducted at sufficient sites within the watershed to corroborate the existing stream designations of either high-quality cold-water fisheries or exceptional value waters. Finally, a quality assurance/quality control program would be followed to ensure the data from this study maintained scientific integrity, and provided guidance for future monitoring. Most of the technical components of the Sampling and Analysis Plan resulted from recommendations by Oram and Baylor, above, and can be viewed on the study web site at www.paradisecreekwatershed.org.

The Sampling and Analysis Plan laid out a framework for collecting data and assessing the water quality of the stream. The watershed was divided into nine management areas. Sampling sites were identified with a fixed location that was described using GPS and monumented in the field. The plan contains maps of the management areas with the location of the sampling sites identified. This information is also included in the review of Water Chemistry, below.

PHASE II

Stream Walk Assessments

Darryl Speicher, Monroe County Conservation District

Objective:

As part of the data gathering in Phase II of the Paradise Creek Watershed Assessment, volunteers conducted stream walk assessments of three major subwatersheds: The Devil's Hole Creek, Forest Hills Run and Swiftwater creek. A stream walk is an assessment done by physically walking the length of the stream from mouth to source recording information on standardized data sheets. The volunteers were trained to look for signs of channel instability, invasive species cover, impacts to riparian zones, in-stream habitat and stream bed characteristics. The volunteers located and documented, on topographic maps and aerial photographs, areas of extreme ecological health and aesthetic beauty as well as areas of potential concern. In addition stream walkers also took photographic records of the stream corridors as they existed in the late summer and fall of 2003.

Summary and Conclusions:

In all 16 volunteers contributed 85 hours of time to conduct stream walk assessments on over 20 stream miles in the three subwatersheds. The watersheds were selected due to their ecological condition and land use in the region. The Devil's Hole creek is designated Exceptional Value by the State of Pennsylvania and the Fish and Board Commission has named it a Class A Wild Trout Stream. The lower reaches have been manipulated and flows through Paradise Streams Resort. The Forest Hills Run has recently been officially classified as impaired by the State of Pennsylvania. It receives the effluent from the Mount Pocono Wastewater Treatment facility and flows through the property of the former Mount Airy Lodge. The Swiftwater Creek begins on the property of Pocono Manner and flows through the Sanofi Pasteur industrial complex before entering the Swiftwater Preserve and Lake Swiftwater.

Recommendations:

The data collected by the volunteers was used by others involved in gathering data during Phase II. Although there have been several major storm events that caused severe flooding throughout the watershed since the stream walks were conducted, they are an excellent reference tool on what the conditions were like in the Paradise Creek watershed during the time of this in depth study of the watershed's resources and represent an excellent baseline.

Water Chemistry

Debra Brady and Robert Limbeck

The Paradise Creek Watershed Management Areas

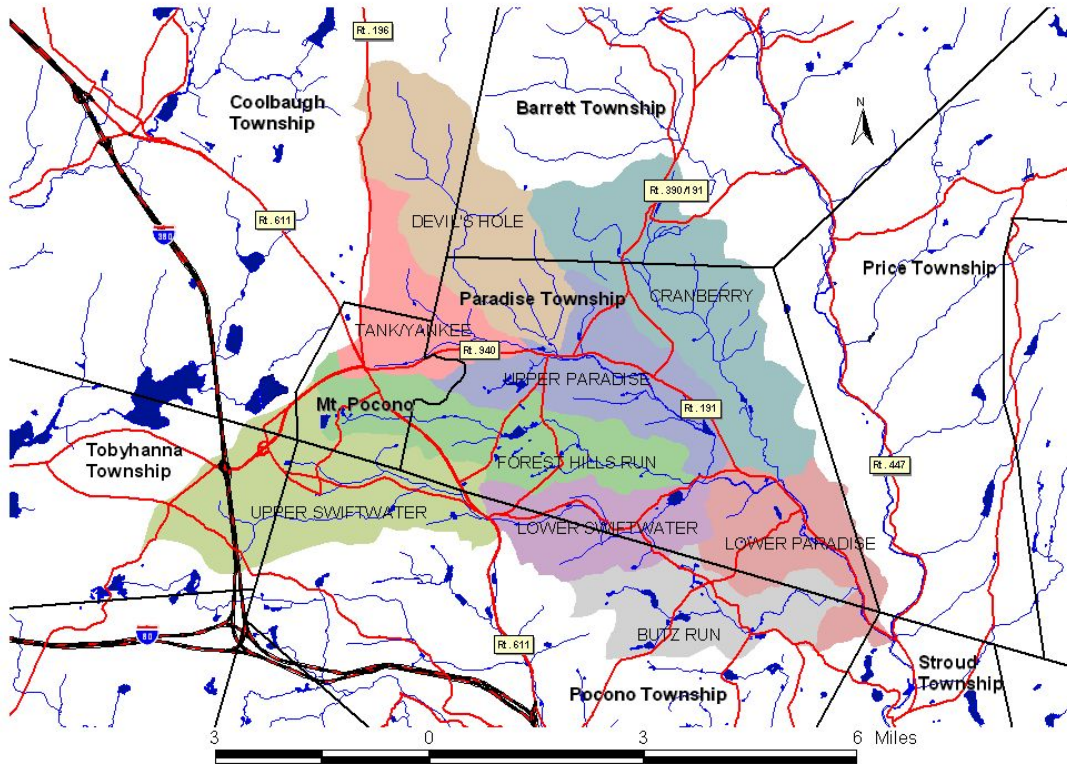


Figure 3

Sampling Sites and Rationale:

Using Geographical Information System (GIS) software, the study team evaluated datasets associated with the watershed to establish the boundaries of management areas. Datasets included eco regions, physiographic regions, geology, soils, topography, land uses, zoning, political boundaries, sub-basins developed for Act 167 regulations in the area, and anecdotal information regarding the locations of significant water withdrawals and potential sources of contamination. Sub-basins were merged using GIS to describe the following nine management areas:

Cranberry Creek Management Area, which includes drainage areas that lead to the Cranberry Creek from upstream of the stream's confluence with the Paradise Creek main stem near Brown's Hill Road to headwaters located in Barrett Township. Sample site CRANCR01 is at the base of this management area near Browns Hill Road.

Devils Hole Creek Management Area, which includes drainage areas that lead to the Devils Hole Creek from the stream's confluence with the Paradise Creek main stem to

headwaters located in Coolbaugh Township. Sample site DEHOCR04 is at the base of this management area on the grounds of Paradise Streams Resort.

Forest Hills Run Management Area, which includes drainage areas that lead to the Forest Hills Run from the confluence with Swiftwater Creek to headwaters located in Mt. Pocono Borough. Sample site FOHIRU01 is at the base of this management area near Lower Swiftwater Road.

Upper Swiftwater Creek Management Area, which includes drainage areas that lead to the Swiftwater Creek from Rt. 611 in Pocono Township to headwaters located in Tobyhanna Township.

Sample site SWIFCR03 is at the base of this management area near the Swiftwater Inn.

Lower Swiftwater Creek Management Area, which includes drainage areas that lead to Swiftwater Creek from the confluence with the Paradise Creek main stem to Rt. 611 in Pocono Township. Sample site SWIFCR02 is at the base of this management area near Lower Swiftwater Road. An additional sample site was added at this location to differentiate between the Swiftwater Creek above and below the confluence with Forest Hills Run. The upstream sample site is SWIFCR06.

Upper Paradise Management Area, which includes drainage areas that lead to the Paradise Creek from upstream of the confluence with the Swiftwater Creek to the base of the Tank Creek/Yankee Run management area. Sample site PARACR01 is at the base of this management area near Lower Swiftwater Road.

Lower Paradise Management Area, which includes drainage areas that lead to the Paradise Creek from the confluence of the Paradise and Brodhead Creeks to the base of the Upper Paradise management area. Sample site PARACR03 is at the base of this management area near the railroad tunnel.

Butz Run Management Area, which includes drainage areas that lead to the Butz Run from the confluence with the Paradise main stem to headwaters located in Pocono Township. Sample site BUTZRU01 is at the base of this management area off Sylvan Cascade Road.

Tank/Yankee Management Area, which includes drainage areas that lead to both Tank Creek and Yankee Run from below the two streams' confluence to headwaters located in Coolbaugh Township and Mt. Pocono Borough. Sample site PARACR04 is at the base of this management area off lower Devils Hole Road.

The base of these nine management areas, and the inclusion of that portion of the Swiftwater Creek upstream of the confluence with the Forest Hills Run, provides ten sampling sites of particular significance to the watershed. These ten sampling sites were monumented and described using Geographical Positioning System (GPS) as fixed sampling sites for this study. Flow velocity and levels were measured at each site during each sampling event.

Additional sampling sites included:

1. Cranberry Creek where the stream crosses Cranberry Creek Road (CRANCR02).
2. Cranberry Creek headwaters in Barrett Township (CRANCR03).
3. Devils Hole Creek below Pocono Farms East in Coolbaugh Township (DEHOCR01).
4. Devils Hole Creek at the State Game Lands boundary (DEHOCR02).

5. Tank Creek, downstream of Devils Hole Road (TANKCR01).
6. Yankee Run, upstream of Devils Hole Road (YANKRU01).
7. Forest Hills Run downstream of Carlton Road (FOHIRU09).
8. Forest Hills Run upstream of the Mt. Airy Lodge parking lot (FOHIRU06).
9. Forest Hills Run above the Mt. Pocono Municipal STP (FOHIRU08).
10. Indian Run upstream of Fairview Avenue (INDIRU01).
11. Paradise Creek upstream of Red Rock Road (PARACR06).
12. Paradise Creek upstream of confluence with Cranberry Creek (PARACR07).
13. Swiftwater Creek near Lake Road (SWIFCR08).
14. Swiftwater Creek upstream of Manor Drive (SWIFCR07).
15. Butz Run at Clubhouse Road (BUTZRU02).
16. Butz Run at Rt. 715, upstream of northern crossing (BUTZRU03).
17. Butz Run at Rt. 715, upstream of southern crossing (BUTZRU04).
18. Swiftwater Creek 200 yards downstream of Sanofi Pasteur (SWIFCR05).

Water chemistry analysis was conducted monthly for one year. Field analysis included flow, temperature, pH, conductivity, and dissolved oxygen. Grab samples were taken and analyzed monthly for one year at the management area base points. Laboratory analysis included pH, nitrite, nitrate, total phosphorus, total suspended solids, and fecal coliform. On one occasion at each management base point, laboratory analysis included alkalinity, total hardness, and metals.

Robert Limbeck, Watershed Scientist with the Delaware River Basin Commission, made statistical comparisons between water quality sampling stations. Statistical analysis were completed using Analyse-It, a statistical add-on package for Microsoft Excel, using the Paradise Creek water quality database developed by the study team. The full descriptive and comparative statistics for each parameter, including gauge height vs. discharge regression analysis is included in the technical appendices for the final report. Data were summarized from 12 monthly samples taken at each site. Values for annual averages for each parameter were reviewed. Insufficient data exist to consider seasonal changes. Information below summarizes Limbeck's findings pertaining to field chemistry.

Insufficient data is available to make statistical comparisons and draw scientifically valid conclusions from the laboratory data, and the raw data is provided here for information only. In the tables showing laboratory analytical results below, pH is in international units. Nitrate, nitrite, total suspended solids (TSS), and total phosphorus are in mg/l. "N.D." stands for "Not Detected" and "wshed" stands for watershed-wide. "Avg" stands for average, "min" stands for minimum, and "max" stands for maximum levels found. If the number of sample results where the analytical parameter was not detected exceeded 20% of the sample pool, they were not included in the calculated watershed average. If the number of non-detect samples was less than 20% of the sample pool, ½ of the detection limit was used to represent those samples in the calculated watershed average. Refer to the Sampling and Analysis plan under Phase I of Study Results on the study website at www.paradisecreekwatershed.org for quality assurance/quality control information, or contact the Brodhead Watershed Association Project Manager.

Limbeck: "Overall water quality in the Paradise Creek watershed is excellent, considering annual average dissolved oxygen, pH, percent dissolved oxygen saturation, and

temperature. Conductivity and total dissolved solids were the most sensitive parameters, able to detect influences of human activity on water quality.”

Lower Paradise Management Area: Between Lower Swiftwater Road and Rt. 191 near Browns Hill Road the Paradise Creek shows a significant rise in specific conductance and total dissolved solids, attributable to elevated concentrations from Swiftwater Creek and Forest Hills Run. Water quality inputs from Cranberry Creek and Butz Run have no significant impact upon Paradise Creek, though Cranberry Creek conductivity and total dissolved solid concentrations are significantly lower than those of the Paradise Creek. Below are results of laboratory testing for pH, nitrate (mg/l), nitrite (mg/l), total suspended solids (TSS) (mg/l) and total phosphorus (mg/l) at sample locations in the Lower Paradise compared to averages for the entire watershed.

Table 6. Lower Paradise Management Area Chemistry

SAMPLE SITE	Frequency	pH	Nitrate	Nitrite	TSS	Total Phos.
PARACR01 AVG	12 MONTHS	6.81	0.35	0.017	1.6	0.14
SWIFCR02 AVG	12 MONTHS	7.04	0.47	0.015	2.4	0.09
PARACR07	10/29/03	6.92	0.11	0.013	<1.0	0.09
CRANCR01 AVG	12 MONTHS	6.36	0.36	0.015	1.6	0.17
BUTZRU01 AVG.	12 MONTHS	6.92	0.29	0.013	2.3	0.08
PARACR03 MIN	12 MONTHS	6.09	0.10	0.005	1.0	0.02
PARACR03 MAX	12 MONTHS	7.65	1.19	0.050	4.0	0.22
PARACR03 AVG	12 MONTHS	6.88	0.35	0.013	2.1	0.10
Wshed min		5.47	0.10	0.005	1.0	0.01
Wshed max		8.19	1.51	0.050	13.0	0.90
Wshed avg		6.85	0.50	0.019	2.7	0.11
#N.D./#samp.		n/a	34/140	46/140	76/140	11/140
Det. Limit		n/a	0.10	0.005	1.0	0.02

Butz Run Management Area: Though Butz Run does not significantly influence the water quality of Paradise Creek, an unknown source causes a large spike in concentration of specific conductance and total dissolved solids in the headwaters near Rt. 715. Downstream concentrations near Club House Road decrease significantly, ultimately becoming statistically similar to concentrations observed at Paradise Creek upstream and downstream of the Butz Run confluence. Below are results of laboratory testing for pH, nitrate (mg/l), nitrite (mg/l), total suspended solids (TSS) (mg/l) and total phosphorus (mg/l) at sample locations in the Butz Run Management Area compared to averages for the entire watershed.

Table 7. Butz Run Management Area Chemistry

SAMPLE SITE	Frequency	pH	Nitrate	Nitrite	TSS	Total Phos.
BUTZRU02	8/13/03	7.07	<0.1	0.01	<1.0	0.06
BUTZRU03	8/13/03	6.84	<0.1	0.005	<1.0	0.03
BUTZRU04	8/13/03	6.82	0.13	0.01	<1.0	0.02
BUTZRU01 MIN	12 MONTHS	6.31	0.10	0.01	1.0	0.01
BUTZRU01 MAX	12 MONTHS	7.29	0.49	0.04	4.5	0.17
BUTZRU01 AVG.	12 MONTHS	6.92	0.29	0.013	2.3	0.08

Wshed min		5.47	0.10	0.005	1.0	0.01
Wshed max		8.19	1.51	0.050	13.0	0.90
Wshed avg		6.85	0.50	0.019	2.7	0.11
#N.D./#samp.		n/a	34/140	46/140	76/140	11/140
Det. Limit		n/a	0.10	0.005	1.0	0.02

Cranberry Creek Management Area: Commercial activity in the headwaters of Cranberry Creek produces a spike in conductivity and total dissolved solids that declines significantly before reaching Cranberry Creek Road. No further changes in water quality were observed along Cranberry Creek. Though Cranberry Creek's water quality is significantly different from Paradise Creek, Cranberry Creek does not change Paradise Creek's water quality. Below are results of laboratory testing for pH, nitrate (mg/l), nitrite (mg/l), total suspended solids (TSS) (mg/l) and total phosphorus (mg/l) at sample locations in the Cranberry Creek Management Area compared to averages for the entire watershed.

Table 8. Cranberry Creek Management Area Chemistry

SAMPLE SITE	Frequency	pH	Nitrate	Nitrite	TSS	Total Phos.
CRANCR02	8/11/03	6.92	0.20	0.01	<1.0	0.19
CRANCR03	8/11/03	7.07	0.53	0.02	1.6	0.11
CRANCR01 MIN	12 MONTHS	3.62	0.12	0.005	1.0	0.02
CRANCR01 MAX	12 MONTHS	7.30	0.76	0.040	2.0	0.90
CRANCR01 AVG	12 MONTHS	6.36	0.36	0.015	1.6	0.17
Wshed min		5.47	0.10	0.005	1.0	0.01
Wshed max		8.19	1.51	0.050	13.0	0.90
Wshed avg		6.85	0.50	0.019	2.7	0.11
#N.D./#samp.		n/a	34/140	46/140	76/140	11/140
Det. Limit		n/a	0.10	0.005	1.0	0.02

Forest Hills Run Management Area: Along Forest Hills Run, conductivity and total dissolved solids start high and gradually fall in concentration from headwaters to confluence with Swiftwater Creek, significantly decreasing between Carlton Road and Lower Swiftwater Road. Forest Hills Run does not significantly change the water quality of Swiftwater Creek, though the combined water quality of Forest Hills Run and Swiftwater Creek significantly

decreases water quality of Paradise Creek by elevating levels of specific conductance and total dissolved solids. Below are results of laboratory testing for pH, nitrate (mg/l), nitrite (mg/l), total suspended solids (TSS) (mg/l) and total phosphorus (mg/l) at sample locations in the Forest Hills Run Management Area compared to averages for the entire watershed.

Table 9. Forest Hills Run Management Area Chemistry

SAMPLE SITE	Frequency	pH	Nitrate	Nitrite	TSS	Total Phos.
FOHIRU06	8/15/03	7.20	0.01	0.01	<1.0	0.14
FOHIRU08	8/20/03	6.62	1.51	<0.005	<1.0	0.14
FOHIRU09	8/14/03	6.93	0.94	0.04	<1.0	0.160
FOHIRU01 MIN	12 MONTHS	6.07	0.14	0.009	1.0	0.009
FOHIRU01 MAX	12 MONTHS	7.63	1.16	0.040	8.5	0.670
FOHIRU01 AVG	12 MONTHS	7.07	0.56	0.019	2.5	0.149
Wshed min		5.47	0.10	0.005	1.0	0.010
Wshed max		8.19	1.51	0.050	13.0	0.900
Wshed avg		6.85	0.50	0.019	2.7	0.110
#N.D./#samp.		n/a	34/140	46/140	76/140	11/140
Det. Limit		n/a	0.10	0.005	1.0	0.020

Lower Swiftwater Management Area: From upstream of the Swiftwater Inn to downstream of the Sanofi Pasteur plant, significant increases in concentrations of specific conductance and total dissolved solids were observed. Elevated levels of specific conductance and total dissolved solids remain at all downstream stations, and cause significant changes to Paradise Creek. Forest Hills Run does not significantly influence water quality of Swiftwater Creek, but combined high concentrations of specific conductance and total dissolved solids from Swiftwater Creek and Forest Hills Run significantly influence downstream concentrations in Paradise Creek. Below are results of laboratory testing for pH, nitrate (mg/l), nitrite (mg/l), total suspended solids (TSS) (mg/l) and total phosphorus (mg/l) at sample locations in the Lower Swiftwater Management Area compared to averages for the entire watershed.

Table 10. Lower Swiftwater Management Area Chemistry

SAMPLE SITE	Frequency	pH	Nitrate	Nitrite	TSS	Total Phos.
SWIFCR03 AVG	12 MONTHS	6.88	0.42	0.012	0.9	0.070
SWIFCR05	8/14/03	7.02	0.59	<0.005	<1.0	0.08
SWIFCR06	12 MONTHS	7.00	0.44	0.017	2.2	0.15
SWIFCR02 MIN	12 MONTHS	6.29	0.10	0.005	1.0	0.02
SWIFCR02 MAX	12 MONTHS	7.53	0.98	0.020	13.0	0.18
SWIFCR02 AVG	12 MONTHS	7.04	0.47	0.015	2.4	0.09
Wshed min		5.47	0.10	0.005	1.0	0.01
Wshed max		8.19	1.51	0.050	13.0	0.90
Wshed avg		6.85	0.50	0.019	2.7	0.11
#N.D./#samp.		n/a	34/140	46/140	76/140	11/140
Det. Limit		n/a	0.10	0.005	1.0	0.02

Upper Swiftwater Management Area: A significant rise in pH was observed in the headwaters of the Swiftwater Creek, possibly due to natural changes in landscape and vegetation characteristics. With decreasing proximity to low gradient, tannic and swampy headwaters where low pH is common, pH at downstream locations rises to become similar to levels observed in most of the lower Paradise Creek watershed. Water quality of Indian Run is significantly different from upstream and downstream locations on Swiftwater Creek, the receiving stream, but Indian Run does not significantly influence water quality of Swiftwater Creek. Reasons are unknown for observed high concentrations of specific conductance, total dissolved solids and low pH, dissolved oxygen, and percent dissolved oxygen saturation in Indian Run. Below are results of laboratory testing for pH, nitrate (mg/l), nitrite (mg/l), total suspended solids (TSS) (mg/l) and total phosphorus (mg/l) at sample locations in the Upper Swiftwater Management Area compared to averages for the entire watershed.

Table 11. Upper Swiftwater Management Area Chemistry

SAMPLE SITE	Frequency	pH	Nitrate	Nitrite	TSS	Total Phos.
INDIRU01	8/14/03	5.47	0.86	<0.005	<1.0	0.21
SWIFCR07	8/14/03	6.53	0.27	<0.005	<1.0	0.14
SWIFCR08	8/14/03	5.93	0.45	<0.005	<1.0	0.12
SWIFCR03 MIN	12 MONTHS	6.39	0.10	0.005	1.0	0.020
SWIFCR03 MAX	12 MONTHS	7.44	0.86	0.040	1.9	0.110
SWIFCR03 AVG	12 MONTHS	6.88	0.42	0.012	0.9	0.070
Wshed min		5.47	0.10	0.005	1.0	0.01
Wshed max		8.19	1.51	0.050	13.0	0.90
Wshed avg		6.85	0.50	0.019	2.7	0.11
#N.D./#samp.		n/a	34/140	46/140	76/140	11/140
Det. Limit		n/a	0.10	0.005	1.0	0.02

Tank Creek/Yankee Run Management Area: Yankee Run is the primary source of total dissolved solids and specific conductance delivered to the Paradise Creek and the Upper Paradise Creek Management Area. Further downstream, Devils Hole Creek significantly improves specific conductance and total dissolved solids concentrations. Reasons for high specific conductance and total dissolved solids observed in Yankee Run are unknown. Below are results of laboratory testing for pH, nitrate (mg/l), nitrite (mg/l), total suspended solids (TSS) (mg/l) and total phosphorus (mg/l) at sample locations in the Tank Creek/Yankee Run Management Area compared to averages for the entire watershed.

Table 12. Tank Creek/Yankee Run Management Area Chemistry

SAMPLE SITE	Frequency	pH	Nitrate	Nitrite	TSS	Total Phos.
TANKCR01	8/11/03	6.64	1.42	0.01	<1.0	0.08
YANKRU01	8/11/03	8.19	0.69	0.01	1.2	0.14
PARACR04 MIN	12 MONTHS	6.55	0.05	0.009	1.1	0.02
PARACR04 MAX	12 MONTHS	6.94	1.49	0.040	8.0	0.17
PARACR04 AVG	12 MONTHS	6.78	0.64	0.013	3.3	0.07
Wshed min		5.47	0.10	0.005	1.0	0.01
Wshed max		8.19	1.51	0.050	13.0	0.90
Wshed avg		6.85	0.50	0.019	2.7	0.11
#N.D./#samp.		n/a	34/140	46/140	76/140	11/140
Det. Limit		n/a	0.10	0.005	1.0	0.02

Devils Hole Creek Management Area: Excellent water quality in Devils Hole Creek has a significant influence on Paradise Creek, mitigating elevated levels of specific conductance and total dissolved solids contributed by Yankee Run and causing a significant drop in these levels at a downstream location near the township park. Devils Hole Creek can serve as a water quality reference stream for future management efforts in the Paradise Creek watershed. Below are results of laboratory testing for pH, nitrate (mg/l), nitrite (mg/l), total suspended solids (TSS) (mg/l) and total phosphorus (mg/l) at sample locations in the Devils Hole Creek Management Area compared to averages for the entire watershed.

Table 13. Devils Hole Creek Management Area Chemistry

SAMPLE SITE	Frequency	pH	Nitrate	Nitrite	TSS	Total Phos.
DEHOCR01	8/13/03	6.37	<0.1	<0.005	<1.0	0.03
DEHOCR02	8/11/03	6.96	0.28	0.02	<1.0	0.12
DEHOCR04 MIN	12 MONTHS	6.25	0.17	0.010	1.0	0.01
DEHOCR04 MAX	12 MONTHS	6.78	1.11	0.040	5.8	0.15
DEHOCR04 AVG	12 MONTHS	6.55	0.42	0.016	2.6	0.07
Wshed min		5.47	0.10	0.005	1.0	0.01
Wshed max		8.19	1.51	0.050	13.0	0.90
Wshed avg		6.85	0.50	0.019	2.7	0.11
#N.D./#samp.		n/a	34/140	46/140	76/140	11/140
Det. Limit		n/a	0.10	0.005	1.0	0.02

Upper Paradise Creek Management Area: Devils Hole Creek significantly improves total dissolved solids and specific conductance concentrations in the Paradise Creek. Devils Hole Creek is heavily forested, with significantly lower concentrations of specific conductance and total dissolved solids than upstream and downstream stations on the Paradise Creek, the receiving stream. Below are results of laboratory testing for pH, nitrate (mg/l), nitrite (mg/l), total suspended solids (TSS) (mg/l) and total phosphorus (mg/l) at sample locations in the Upper Paradise Creek Management Area compared to averages for the entire watershed.

Table 14. Upper Paradise Management Area Chemistry

SAMPLE SITE	Frequency	pH	Nitrate	Nitrite	TSS	Total Phos.
PARACR04 AVG	12 MONTHS	6.78	0.64	0.013	3.3	0.07
DEHOCR04 AVG	12 MONTHS	6.55	0.42	0.016	2.6	0.07
PARACR06	8/13/03	6.93	0.10	0.01	<1.0	<0.02
PARACR01 MIN	12 MONTHS	6.43	0.10	0.005	1.0	0.02
PARACR01 MAX	12 MONTHS	7.33	0.87	0.030	5.2	0.45
PARACR01 AVG	12 MONTHS	6.81	0.35	0.017	1.6	0.14

Wshed min		5.47	0.10	0.005	1.0	0.01
Wshed max		8.19	1.51	0.050	13.0	0.90
Wshed avg		6.85	0.50	0.019	2.7	0.11
#N.D./#samp.		n/a	34/140	46/140	76/140	11/140
Det. Limit		n/a	0.10	0.005	1.0	0.02

Until further monitoring produces a larger pool of laboratory data for nutrients and suspended solids, caution should be used in drawing conclusions about this data. In an effort to make the data of value, the data was normalized to pounds per acre per year. Concentration of nitrite plus nitrate and phosphorus were used along with flow measurements at the site taken at the same time samples were taken, and these values were averaged to produce the flow charts below for the 10 base sites. A chart below also shows average flows in cubic feet per second and each management area's drainage area.

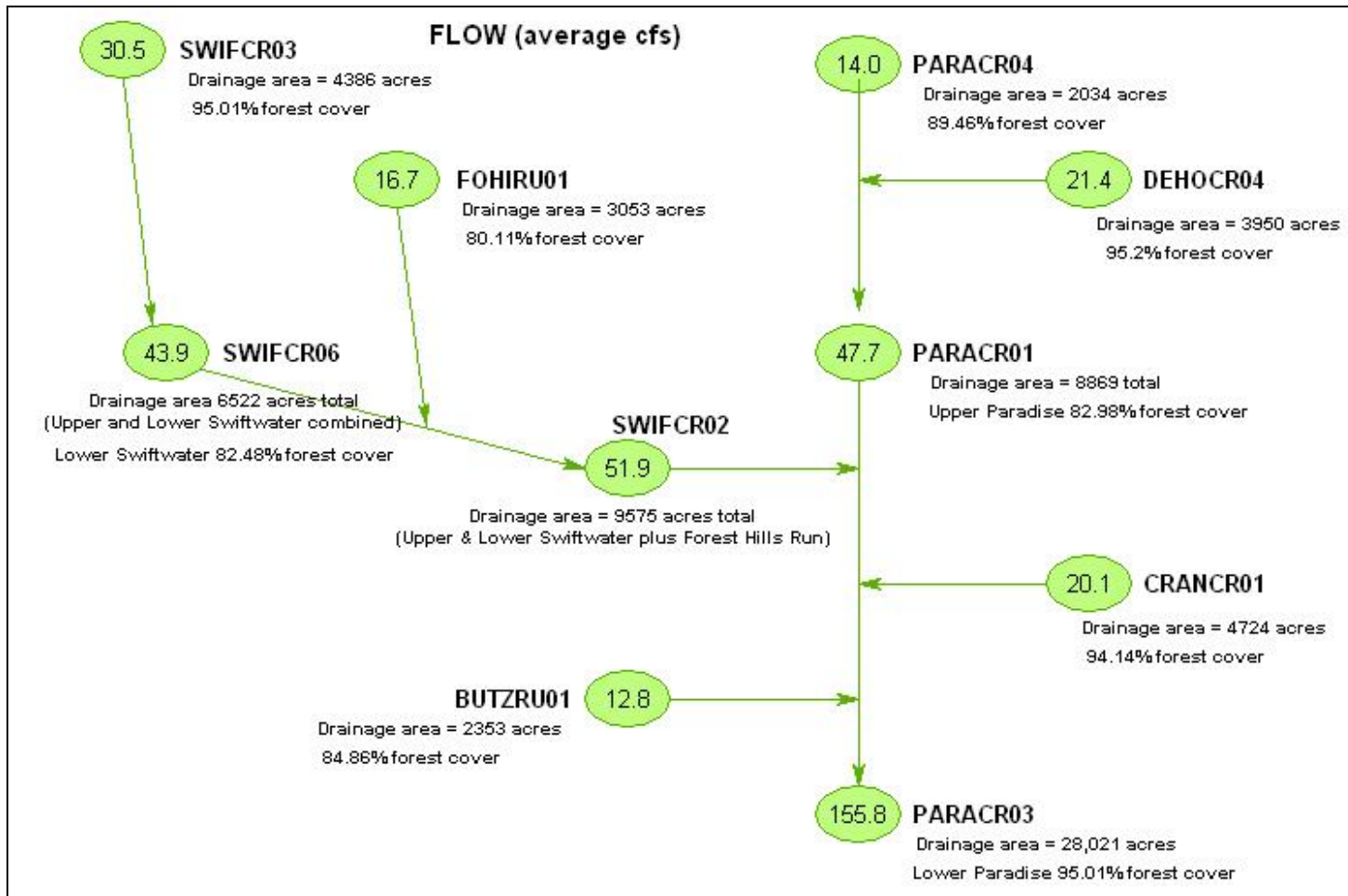


Figure 4. Average Flows

Flows shown on this chart are averages of all flow measurements taken at the base sites monthly for one year, and are shown here to provide perspective. Flows measured at the time samples were taken were used to provide normalized data for phosphorus and nitrate plus nitrite, below. For flow statistics, refer to “Streamflow Statistics” by Ronald E. Thompson, U.S.G.S. and Gregory J. Cavallo, D.R.B.C. summarized below and provided on the study web site at www.paradisecreekwatershed.org.

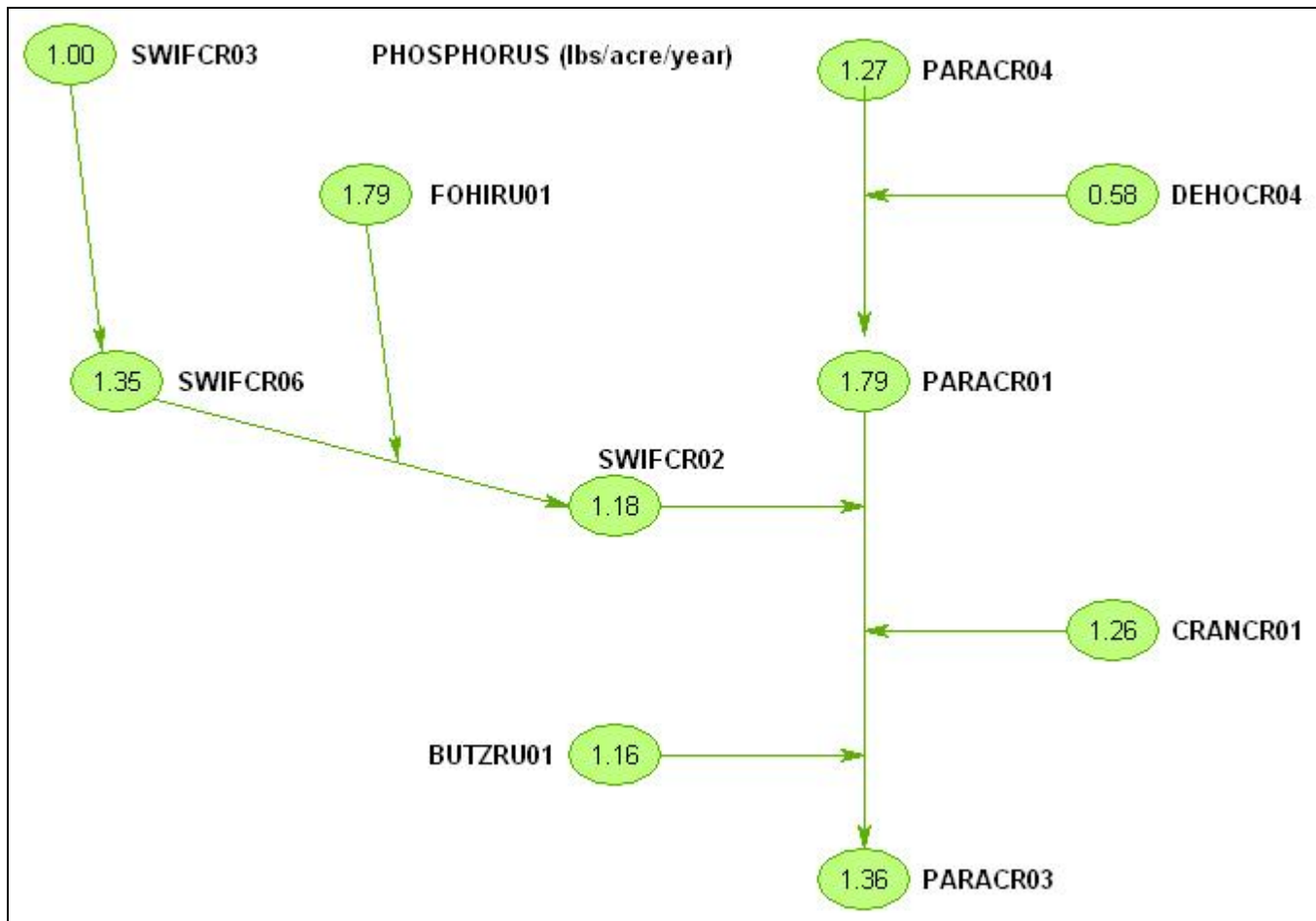


Figure 5. Phosphorus

Phosphorus levels are higher than would be expected in a heavily forested watershed. Paul DeBarry presented typical pollutant loading data results compiled from NURP data (U.S. EPA, 1983) and then refined or regionalized with local data from a nearby EPA Clean Lakes Program Study (Lake Wallenpaupack Watershed Management District, 1983)². Nonpoint source pollutant loading factors presented by DeBarry predict lower levels. The sources of phosphorus in the watershed require additional investigation, and nutrient reduction strategies should be employed throughout the region.

² DeBarry, Paul A. *Watersheds Processes, Assessment, and Management* (John Wiley & Sons, Inc.), 2004.

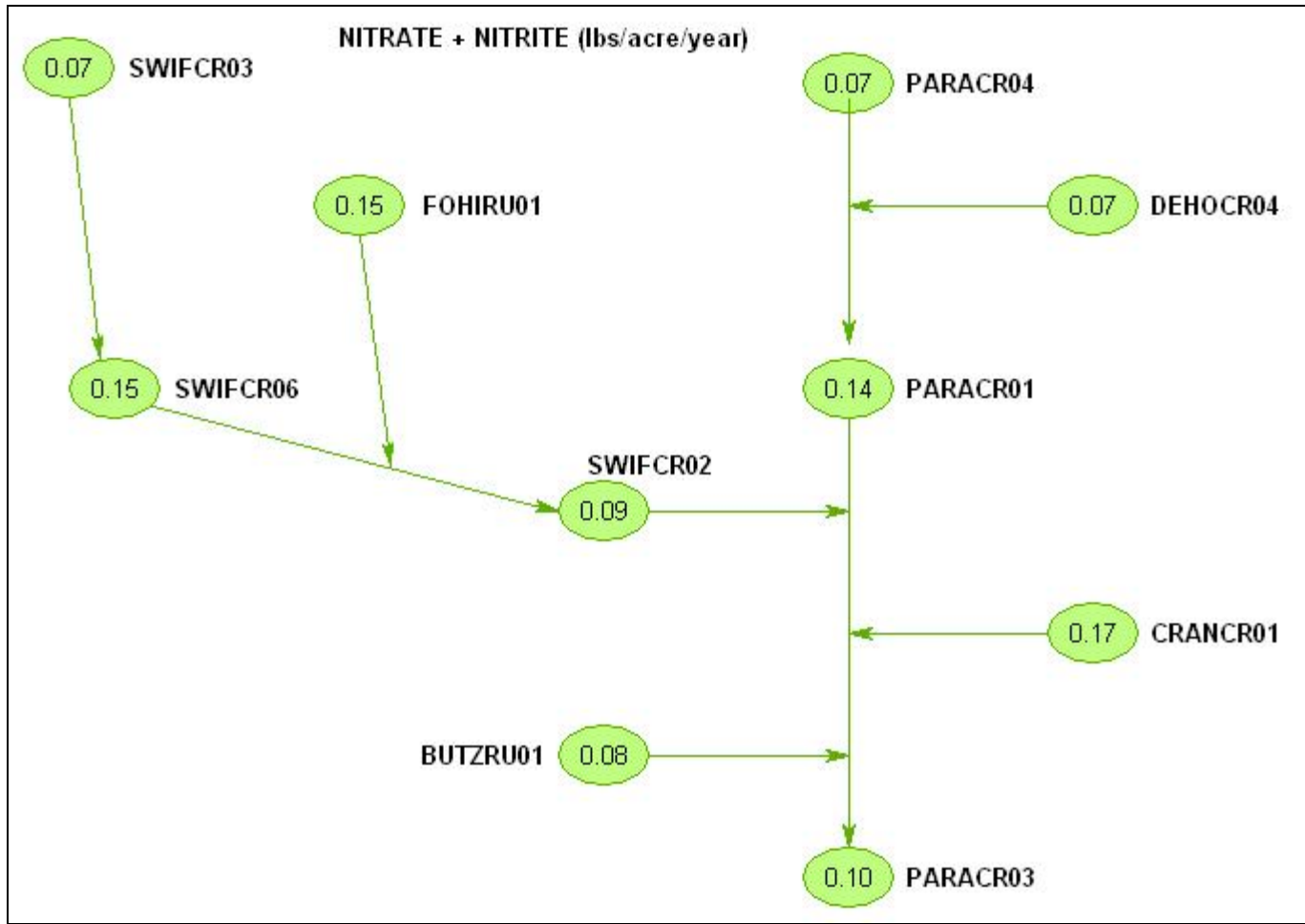


Figure 6. Nitrate plus Nitrite

These nitrogen levels are actually lower than those predicted based on soil type and land use in DeBarry’s book. The values for total suspended solids are similarly low. Control and reduction strategies should focus on phosphorus, and stakeholders should consider developing a phosphorus budget for the watershed.

Of 315 temperatures recorded during a single 12-month period, 42.8% exceeded water quality criteria for high quality cold-water fisheries. The highest percentage of violations occurred in early spring and late fall.

Temperature Violations:

Month	Violations as % of sample pool
January	4%
February	50%
March	92%
April	32%
May	52%
June	23%
July	29%
August	29%
September	14%
October	72%
November	100%
December	15%

The cause of such significant temperature elevations is unclear. In some areas, such as the upper reaches of the Butz Run, numerous shallow ponds and impoundments may be responsible. In other areas, disturbance of the riparian zone and inadequate shading may result in temperature elevations. These temperature results require additional investigation and monitoring.

Fecal Coliform Counts

Fecal coliform counts should remain under 200 per 100 milliliters for designated uses in the watershed. Counts at base sites monthly over a one-year period ranged from 0 to 5700. Results exceeded 200 per 100 milliliters in thirteen percent of samples. In October 2003, result for BUTZRU01 was 4700, for FOHIRU01 was 5700, for PARACR01 was 3600, for PARACR03 was 3600 and for SWIFCR02 was 2800. The balance of results above 200 were nominal (less than 400).

Limitations and Recommendations:

Additional and regular temperature, total dissolved solids, and specific conductance monitoring is recommended, including more intensive water temperature monitoring within a program designed to reduce temperature stress upon trout throughout the watershed. Funding is needed to provide water temperature loggers (these are small, dependable, and inexpensive) to landowners. Such temperature data can be assembled and analyzed to quantify and reduce the effects of impoundments, parking lot runoff, and reduced riparian buffers upon water quality of the Paradise Creek. The objective of such an effort is to maintain a healthy and viable trout population in the watershed, and to reduce the frequency of violation of PA water quality standards, and to maintain or improve coldwater fisheries habitat. A similar effort has been successfully implemented by the Pequannock River Coalition in northern New Jersey (<http://www.pequannockriver.org>).

Nutrient reduction strategies should be employed throughout the watershed. Strategies should include public outreach and education initiatives to address the proper and appropriate use of fertilizers, pesticides and household cleaners, the need for diligent septic system maintenance and operation, lawn care, pet waste disposal, sound forest management skills, and riparian buffer maintenance. Most importantly, strong stormwater management ordinances must be enforced that include water quality components and which require Best Management Practices.

Macroinvertebrate Surveys

Monroe County Planning Commission
Monroe County Conservation District

Objective:

Surveying macroinvertebrates is one of the most effective ways to judge stream health. According to the Monroe County Planning Commission, “Aquatic macroinvertebrates are animals that are large enough to be seen by the unaided eye and live at least part of their life cycles within or upon available substrates in a body of water or water transport system. These include insects such as mayflies, annelids, mollusks, flatworms, roundworms, and crustaceans.” Samples collected allow for a detailed analysis of the aquatic community and a sound measure of the relative stability of the aquatic community.

From the Monroe County Water Quality Study 2003: The sampling technique is a standard kick sample format using a 500 micron mesh size, 1meter x 1meter seine net. Normally one sample (one square meter of substrate) is taken from a riffle in the stream and one sample (one square meter of substrate) is taken from a run. The entire sample is taken to the Monroe County Conservation District office where it is subsampled. A minimum subsample of 100 organisms is desired for a valid analysis.

The following are the metrics used for the macroinvertebrate analysis. Metrics are the various counts, indexes, and ratios computed from the results of the subsamples as described above. Different metrics convey different types of information about the macroinvertebrate community. For example, taxa richness is an index of diversity and the Hilsenhoff Biotic Index measures pollution tolerance. By using a set of metrics that measures multiple aspects of the macroinvertebrate community, a complete picture of a community can be obtained.

Total Individuals is the actual number of macroinvertebrates collected.

Total Taxa (Species richness) is a measure of the variety of taxa (total number of species) present. This generally increases with increasing water quality or habitat. In some situations, organic enrichment may also result in an increase in the number of taxa.

Percent Contribution of Dominant Taxa gives an indication of the balance in the community. A community dominated by relatively few species would indicate environmental stress. An even distribution of all taxa (preferably sensitive species) is more desirable.

Percent Noninsects gives an indication of the balance in the community. Noninsects are generally tolerant species. A community dominated by noninsects would be an indication of

environmental stress. An even distribution of all taxa (preferably sensitive species) is more desirable.

Modified Hilsenhoff Biotic Index (HBI) is a ranking based on pollution tolerance to organic sources values. These values range from 0-10 increasing as water quality decreases. The Biotic Index is an average of tolerance values for all individuals collected from a site.

The following demonstrates the range for Biotic Index:

0.00-3.75	Excellent
3.76-4.25	Very Good
4.26-5.00	Good
5.01-5.75	Fair
5.76-6.50	Fairly Poor
6.51-7.25	Poor
7.26-10.0	Very Poor

EPT Index is a measure of the total number of distinct taxa within the orders of Ephemeroptera, Plecoptera and Trichoptera. This summarizes the taxa richness within the insect orders that are generally sensitive to pollution. The EPT Index generally increases with increasing water quality.

Percent Intolerant Taxa gives an indication of the balance in the community. Intolerant organisms are usually not found associated with organic contaminants and are generally intolerant of even moderate reductions in dissolved oxygen. Intolerant organisms are indicators of clean water only.

The Ratio of Shredders to the Total Number of Insects uses the relative abundance of shredders as an indication of the dominant food or energy source in a small watershed. Shredders are insects that shred coarse particulate detritus for feeding. Shredders represent a distinct functional feeding group that is found predominantly in watersheds less than 10 square miles in size where the primary energy source in the stream is derived from leaf litter and similar detritus entering the watercourse. Shredders should become less abundant as the stream width increases and the canopy cover opens and photosynthesis becomes the primary energy source in the stream.

Scoring Schemes

The County identifies all organisms collected to the family level and all the calculations are performed using family level identifications. The family level of identification was chosen to make data sharing both easier and faster (both the EPA and DEP identify their macroinvertebrate samples to the family level). Identification of macroinvertebrates to the family is easier to perform and yields results that are suitable for our purposes. Another reason for choosing this level of identification was the interest of local watershed groups in performing macroinvertebrate sampling. For these groups genus level identification would be too difficult and time consuming. In order for the County to accept their data, however, the identifier would have to pass a quality assurance program established by the County.

The EPA conducted the statistical analysis needed to determine the metrics and scoring schemes that are used for streams located in the Pocono Plateau and Low Pocono subcoregions. The County with the assistance of the EPA completed the analysis work for the remaining subcoregions and scoring schemes in the County. The metrics employed were selected because of their accuracy in detecting impairment.

A simple process was used to develop the reference conditions for the different stream classes. Within each stream class, minimally impaired reference sites were sampled. Descriptive statistics for each metric were calculated from a group of similar candidate reference sites. Only the candidate reference sites with optimal habitat and intact benthic macroinvertebrate communities were included in the reference condition. Test sites, or sites thought to be impaired, were not used in the development of reference conditions. Thresholds for optimal, slightly to moderately impaired and severely impaired categories were developed for each metric. The data from each metric was compiled and ranked. If a metric increases with impact (HBI for example), the 75th percentile of the reference condition is used as the threshold for the optimal category. The remaining range between that value and the maximum value obtainable for that metric was halved to provide two more ranges for scoring the slightly to moderately impaired and severely impaired categories. If the metric value decreases with impact (taxa richness for example), the 25th percentile of the reference condition is used as the threshold for the optimal category. The remaining range between that value and the minimum value was halved to provide two more ranges for scoring the slightly to moderately impaired and severely impaired categories. For some metrics, this may result in somewhat insensitive scoring. For percent noninsects, for example, the maximum possible is 100%. However, 25% was the maximum encountered in the severely impacted sites for the Pocono Plateau / Glide Pool subcoregion. The scoring was adjusted to reflect the values of that metric generally encountered in impacted streams for this subcoregion, in order to make the scoring for that metric more sensitive.

All candidate reference sites were scored using the scoring scheme for that stream classification. These scores were then ranked. The lower 25th percentile was used to define the lower range of the optimal category. The remaining range between that value and the minimum possible total score was bisected to define two more ranges for the slightly to moderately impaired and severely impaired categories for the total scores.

The following are the tables for the scoring schemes for the Paradise Creek and its tributaries:

Low Pocono, Riffle / Run < 10 square miles

Samples from Spruce Cabin Run and Buck Hill, Rattlesnake, Mill, Poplar Run, Devils Hole, Fall, Poplar and Swiftwater Creeks were used in developing a scoring scheme for this region. Descriptive statistics for the metrics at these sites were calculated, and the resulting scoring scheme was developed as described earlier. The main difference between the metrics from the Pocono Plateau and Low Pocono subcoregions is the inclusion of the percent dominant family for the Low Pocono.

**Table 15. Resulting scoring scheme for the reference condition
for the Low Pocono, Riffle / Run < 10 square miles**

Score Assigned →→→→	5 (Optimal)	3 (slightly to moderately impaired)	1 (Severely impaired)
Metric			
Total Taxa	> = 16	15 - 8	7 - 0
EPT Taxa	> = 11	10 - 6	5 - 0
HBI	< = 4.5	4.6 - 7.3	7.4 - 10
% Dominant Family	< = 42.6	42.7 - 71.3	71.4 - 100
% Intolerant Taxa	> = 55.6	55.5 - 27.8	27.7 - 0
% Noninsect	< = 0	0 - 25.0	25.1 - 100
Shredders / Total	> = 0.11	0.10 - 0.06	0.05 - 0

The reference sites were all scored using this scoring scheme. The 25th percentile of the reference sites scores is 31. The range 30 - 19 will be the slightly to moderately impaired category, and any site with a total score less than 19 will be considered severely impaired.

Low Pocono, Riffle / Run > 10 square miles

Samples collected from the Bushkill, McMichael, Brodhead, Paradise, and Pocono Creeks were calculated and the resulting scoring scheme was developed.

**Table 16. Resulting scoring scheme for the reference condition
for the Low Pocono, Riffle / Run > 10 square miles**

Score Assigned →→→→	5 (Optimal)	3 (slightly to moderately impaired)	1 (Severely impaired)
Metric			
Total Taxa	> = 17	16 - 9	8 - 0
EPT Taxa	> = 10	9 - 5	4 - 0
HBI	< = 5.6	5.7 - 7.8	7.9 - 10
% Dominant Family	< = 46.3	46.4 - 73.2	73.3 - 100
% Intolerant Taxa	> = 35.7	35.6 - 17.9	17.8 - 0
% Noninsect	< = 9.6	9.7 - 25.0	25.1 - 100
Shredders / Total	> = 0.03	0.029 - 0.015	0.014 - 0

The reference sites were all scored using this scoring scheme. The 25th percentile of the reference scores is 29. The range 28 - 18 will be the slightly to moderately impaired category, and any site with a total score of less than 18 will be considered severely impaired.”

Table 17. Macroinvertebrate Trending Results:

Site #	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995
BUTZRU01	29	23								
BUTZRU02		21								
BUTZRU03		13								
BUTZRU04		15								
CRANCR01	29									
CRANCR02		31								
CRANCR03	21	23								
DEHOCR01		31								
DEHOCR02		31								
DEHOCR04	31	31								
FOHIRU01	29	25								
FOHIRU06	25	19	25	29	25	27	27	23	31	
FOHIRU09	15	17								
INDIRU01		31	31	31						
PARACR01	29	29								
PARACR03	33	31								31
PARACR04	33	31								
PARACR06		33					35			
PARACR07										
SWIFCR02	25	27								
SWIFCR03	29	29	25	29	29	17	27	19	27	23
SWIFCR05	33	23	25	29	27	25	29	21	25	19
SWIFCR06	21	23								
SWIFCR07	29	25	29	33						
SWIFCR08		29								
TANKCR01		33								
YANKRU01		29					25			

Recommendations:

According to the Monroe County Water Quality Study 2003, “Cranberry Creek (Paradise Watershed) downstream of Blue Ridge Peat in Cresco shows signs of moderate impairment (biological assessment score of 23). Further upstream sampling should occur to better define the potential source of impairment.

“Butz Run upstream of Route 715 has two branches and both show signs of severe impairment (biological assessment scores of 13 and 15) due to lake effects from the upstream lakes which feed both branches.

“Forest Hills Run downstream of Carlton Road shows signs of moderate impairment (biological assessment score of 17). Further sampling should occur upstream to better define the potential source of impairment.

“Swiftwater Creek downstream of Aventis Pasteur property shows signs of moderate impairment (biological assessment score of 23). This site will need further investigation.

“Swiftwater Creek upstream of the confluence with Forest Hills Run shows signs of moderate impairment (biological assessment score of 23) potentially due to lake effects from Lake Swiftwater.”

According to the Monroe County Water Quality Study 2004, “Forest Hills Run (FOHIRU09) downstream of Carlton Road again shows signs of severe impairment (biological assessment score of 15). Elevated fecal coliform counts were documented at this site. This stream is most likely experiencing impairment due to nutrient enrichment and/or high levels of particulate matter. The dominant taxon in the sample was Hydropsychiadae, a net spinning caddis which feeds on particulate matter. Located upstream of this site are a golf course, lake and a sewer plant which are all potential contributors to the degrading effects by both point and non-point sources. A nutrient management program should be initiated on the property upstream of this site.”

Macroinvertebrate communities are susceptible to pollution in various ways, and to varying degrees. For this reason, these surveys are not only indicators of stream health. They also provide excellent clues as to the cause of any impairment found. These surveys should continue to trend sites in the Paradise Creek Watershed, particularly in areas where actions are taken to improve conditions and in areas of new development. [*Note: A new Growing Greener Grant, and assistance from Monroe County Planning Commission and Monroe County Conservation District will allow this trending in the Paradise Creek Watershed to continue.*]

In order to safeguard and protect those areas with optimal scores, riparian zones must be protected, stormwater management rules must be revised, where necessary, to include Best Management Practices, and open space must be preserved to the extent practicable.

Fish Inventory of Paradise Creek and Tributaries

Jim Hartzler, Aquatic Resource Consulting

Objective:

In order to fill data gaps identified in Phase I, Aquatic Resource Consulting sampled the fish communities of the Paradise Creek and its tributaries – Butz Run, Indian Run, Forest Hill Run, and Cranberry Creek. As with macroinvertebrates, fish populations tell a story about aquatic stability and overall stream health.

Summary and Conclusions:

Electrofishing surveys of Paradise Creek and four tributaries revealed a diverse mix of fish species, reflecting the influence of water temperature, width, depth, sediment load, substrate composition, and habitat features on relative abundance. Eleven taxa were collected at the five stations, with the highest number taken on Paradise Creek (7) and the least on Indian Run (4) and Forest Hill Run (3). Wild brown trout predominated at each sampling site. American eel, longnose dace, and blacknose dace were the next most common species collected. Distribution of wild brook trout and slimy sculpin, two other “coldwater” species with demanding spawning requirements and an even lower tolerance to environmental degradation than brown trout, was limited to Indian Run and Cranberry Creek. Butz Run had the highest number of warm water species.

“Water quality at the five stream areas can be characterized as very good/excellent, based upon the abundance and biomass of brown trout. Fingerling (0+ years) brown trout were found at all five stations, indicative of successful reproduction in the fall of 2002. Total estimated biomass of trout on each stream showed extreme variation as did the relative number of fish in size groups that corresponded to age classes. Forest Hill Run had the highest weight per unit area, nearly 140 kg/hectare (125 pounds/acre), while Butz Run displayed the lowest – 18+ kg/hectare (17 pounds/acre). All the streams except Butz Run had values exceeding the Pa Fish & Boat Commission’s standard for Class A Wild Trout Waters. On Indian Run, weight of wild brook trout nearly equaled that of brown trout. Legal-size brown trout (>200 mm, or 7.8 inches) were abundant on the largest streams – Paradise Creek, Cranberry Creek, and Forest Hill Run – but relatively scarce on the smallest, Butz Run and Indian Run. Average conditions factors of different size (age) groups of brown trout were generally within normal ranges.” A summary is available of historical data on fish populations. In addition, trout biomass was done for all available sites.”

Recommendations:

The source(s) of elevated temperatures in the Butz Run requires additional investigation. The electrofishing surveys in the Paradise Creek Watershed should continue in order to evaluate the effectiveness of actions taken to protect the natural resources (for example, after stream banks are stabilized, new stormwater management facilities are constructed, or after significant deforestation occurs for new development). [*Note: A new Growing Greener Grant will allow the Brodhead Watershed Association to continue electrofishing surveys in the Paradise Creek Watershed.*]

One important study presented at the Hemlock Woolly Adelgid Summit sponsored by the Paradise Creek project at Skytop Lodge demonstrated that the Hemlock stands, found throughout the Paradise Creek Watershed, are extremely important to sustaining existing trout

populations. The riparian Hemlocks shade the streams during hot summer months, and provide insulation during cold winter months. Protection of the riparian zone is critical to maintaining normal and better-than-normal ranges of trout populations in the Paradise Creek Watershed.

Trout and other native fish populations are particularly sensitive to pollution. In order to safeguard and protect fish populations, stormwater management rules must address water quality as well as water quantity and require Best Management Practices. Nonpoint sources of pollution throughout the watershed should be eliminated. Riparian buffers need to restrict earth disturbance near streams, lakes, ponds and wetlands, allowing the natural vegetation to filter pollutants and protect stream banks.

Lake Trophic Study

Eileen Fretz

Objective:

Four lakes, Lake Swiftwater, Lake Crawford, Mount Airy Lake and Alpine Lake were studied to evaluate the level of eutrophication. Common problems with eutrophication include algal blooms, increase in sediment, increase in aquatic plants, oxygen depletion, species changes, and water level changes. Sampling was performed to determine the condition of the following factors: a) temperature and dissolved oxygen, b) total suspended solids and transparency, c) phosphorus, and d) chlorophyll. The Carlson Trophic State Indexes system was used to compile the data.

Summary and Conclusions:

The data gathered from the study was very limited. All of the lakes are shallow, continually recycling, and serving as an interruption in the flow of the streams. Solid conclusions cannot be drawn and trends cannot be established, but the Carlson Trophic indices indicated the potential for eutrophication in all four lakes.

Recommendations:

The data demonstrates the need for lake management programs for the four lakes to improve conditions. Education and outreach initiatives for lake and pond owners should focus on management techniques and restoration measures. The impact of impoundments on stream health was studied more comprehensively in the Lake Crawford study, below.

Lake Crawford Nonpoint Source Loading Study

Edward W. Molesky of Aqua-Link, Inc.

Objective:

Lake Crawford is a 10-acre reservoir on the Paradise Creek in Paradise Township. The lake was created by a rock and earthen dam on property owned by the Paradise Falls Lutheran Association. The following three principle objectives were established for the study:

1. To evaluate and compare non point source loadings to the lake during baseflow and storm flow conditions.

2. To prioritize the two main tributaries to the lake in terms of non point source loadings, and
3. To determine the net removal (retention) of non point source pollutants by the lake itself.

For more information on the methodology used in the study and the data collected, refer to the report that was prepared by the consultant. The conclusions and recommendations of the study are presented below.

Summary and Conclusions:

Water Quality

1. The lake surface area to watershed ratio for Lake Crawford is 869 to 1. This ratio is extremely high and indicates that this impoundment will act like a “run-of-the-river” type of reservoir having an extremely short hydraulic residence time. This short hydraulic residence time (rapid flushing rate) is largely responsible for the reservoir having better than expected transparency values due to the rapid flushing out of phytoplankton.
2. The nutrient (phosphorus and nitrogen) concentrations and the sediment (total suspended solids concentrations) are considered very high and low, respectively, for all stream stations during baseflow and storm flow conditions.
3. The total phosphorus and total nitrogen were generally, slightly lower during storm events (composite samples). Lower mean nutrient concentration during storm events (storm composite samples) are likely related to a dilution effect. In other words, stormwater runoff from the surrounding watershed apparently contains lower amounts of nutrients than the streams typically contain during baseflow conditions.
4. Potential sources of nutrients to Paradise Creek are point source discharges (e.g., treated effluent from wastewater treatment plants), illicit discharges to stormwater sewers, malfunctioning on-lot septic systems and streambank erosion during storm events. Conversely, the major source of nutrients to Hatchery Run is likely from an upstream trout hatchery.
5. The mean nutrient and suspended solids concentrations for the first flush samples are similar to the mean values reported for the composite stormwater samples at all stations. The only possible “first flush effect” that occurred in this study was for nitrogen at Stations PCI and PCO.

Hydrology

1. The most significant source of water to Lake Crawford is Paradise Creek, which accounted for about 80 percent of its total flow.
2. Most of the streamflow at the two main tributaries, Paradise Creek and Hatchery Run, occurred as baseflow during the study period.

NPS Loading

1. Paradise Creek (Station PCI) contributed the highest amounts of nutrients (phosphorus and nitrogen) and sediments (total suspended solids) to Lake Crawford.
2. Hatchery Run (Station HR) also contributed a substantial amount of nutrient to the lake even though its drainage area is significantly smaller than the drainage area for the Paradise Creek Inlet (Station PCI).
3. Nutrients and sediment loadings at Station PCO were greater than the combined loadings for Stations PCI and HR. The differences between the input and output loadings suggest that the lake may actually be serving as a source of nutrients and sediments for downstream waters.

For example, nutrients (as orthophosphorus and ammonia nitrogen) are frequently released via in-lake sediments if severe anoxia occurs at the water – sediment interface (referred to as internal sediment loading). Conversely, higher sediments at the outlet of the lake may be attributed to the production of phytoplankton that are rapidly flushed out of the lake.

Recommendations:

1. Reduce the nutrient loadings to the lake via Paradise Creek. High nutrient loadings during baseflow conditions suggest that point source loadings (e.g., wastewater treatment facilities and possibly illegal discharges to stormwater sewers) are likely very important for this stream. Other sources of nutrients during baseflow conditions may be attributed to malfunctioning on-lot septic systems.
2. Reduce the nutrient loadings to the lake via Hatchery Run. This can possibly involve some modifications to the trout hatchery itself or its operation. For example, waters discharged from the hatchery can be pretreated in order to remove additional nutrients before discharged into Hatchery Run.
3. Create a forebay at the confluence of Paradise Creek. The forebay should be designed to serve as an inline sedimentation basin. Based upon this study, it is expected that bed load and not suspended solids is the major source of sediments to the lake. Field observations confirm that most of the upper lake was filled in with larger cobbles as opposed to finer sediment particles. Thereafter, the lake association should perform maintenance dredging of the forebay on an as-needed basis as opposed to more costly, lake dredging.
4. Stabilize severely eroding banks along Paradise Creek using a natural stream channel design (NSCD) restoration method. It is likely the streambank instability is a significant source of bed load sediments to Lake Crawford via this stream.

Fluvial Geomorphology

Robert Limbeck, Delaware River Basin Commission

Objective: The report *Stream Morphology and Water Quality Based Restoration Plan for the Paradise Creek Watershed* by Robert Limbeck examines the form and structure of each sub-watershed of the Paradise Creek and presents a list of restoration projects. The Paradise Creek and its tributaries begin on plateaus with relatively flat gradients. The transitional area to the

valley bottoms has gradients of between 4 and 10 percent, with some areas exceeding 10 percent where the streams are confined to V-shaped valleys. Downstream, the grade decreases into wide alluvial valleys where the watercourse meanders and the width of stream widens.

The purpose of the study was to identify areas of streams within the watershed that are extremely unstable. “For this report, instability is defined as localized loss of dynamic equilibrium of the stream channel. According to Pennsylvania’s Keystone Stream Team (2002) a stream is in equilibrium of stable when it can carry the sediment load supplied by the watershed without changing dimension (cross sectional area, width, depth, shape), pattern (sinuosity, meander pattern), or profile (longitudinal pattern and slope) and without aggrading (building up of bottom materials) or degrading (incising into the landscape and abandoning the natural floodplain). At the locations identified in this report, field evidence of instability was verified by observation of channel evolution status (See Figure 3; Schumm, Harvey and Watson 1984; Simon and Downs 1995).”

Summary and Conclusions: Using maps and aerial photographs, 260 potential restoration projects were identified. Field investigations eliminated most of potential projects, some because the unstable areas were nearly stabilized through ‘natural healing.’ Other sites were eliminated because bridges, culverts and dams caused the instability. Twenty-eight sites have been identified as priority restoration projects. They were given priority either because total restoration could be accomplished or the infrastructure is in danger. Sixteen sites involve a feature of the transportation system, i.e., bridges, culverts and roadbeds close to the stream. Twelve sites are on the priority list of other causes. This category includes natural instability that threaten infrastructure.

Table 18. Number of potential stream restoration sites in the Paradise Creek watershed.

Sub-Watershed	Source of Instability	
	Transportation Network	Other Causes
Lower Paradise Creek	1	0
Butz Run	0	1
Cranberry Creek	3	1
Lower Swiftwater Creek	5	2
Upper Swiftwater Creek	1	1
Forest Hills Run	2	3
Upper Paradise Creek	3	2
Devils Hole Creek	1	0
Tank Creek & Yankee Run	<u>0</u>	<u>2</u>
	16	12

Recommendations:

1. Gather reference reach data from Butz Run, an E channel, to serve as a design template for future natural stream restoration of low-gradient streams throughout the Poconos. During Spring of 2005, the reference reach will be measured by cooperative efforts of DRBC, MCCD, MCPC, and others using methods described by Harrelson et al (1994). Reference reach data will be analyzed using River Morph Stream Restoration Software (RiverMorph, LLC, Louisville, KY), and distributed to relevant agencies and interested parties. [*Note: This was accomplished as stated.*]
2. Work with the PA Department of Transportation, Monroe County, and municipal road maintenance agencies to install river-friendly bridges and culverts during future infrastructure maintenance and repair. This has been done in some maintenance districts by members of Keystone Stream Team.
3. Educate landowners about protection of the riparian corridor, stormwater impacts, and stream channel maintenance. This can be completed as part of the Paradise Creek project or future grant-funded activity (WREN grants, Coldwater Heritage grants, etc.).
4. Improve and share the assessment data set – this Level I survey only begins to document visual observations throughout the watershed. Recommended ‘next steps’ would be: to collect detailed morphology of known impacted and reference stream segments; improve the GIS layers for the stream network; conduct additional aerial photo surveys; assemble partnerships to design and implement the restoration projects listed herein. It is anticipated that survey of many impacted segments will be conducted during restoration project implementation throughout Pennsylvania, and these data should be shared among restoration practitioners. It became obvious during this survey that the Commonwealth must improve GIS layers of the stream networks – many unmapped channels were found, and those that have been digitized are highly inaccurate.

Stormwater Management Facilities Retrofitting Assessment

Paul DeBarry of Borton Lawson Engineering

Objective: The objectives of this study include examination of existing stormwater collection and control systems to provide recommendations for retrofitting to comply with the Act 167 water quality and groundwater recharge requirements. The majority of the stormwater control systems include detention basins and retention basins. A detention basin is a permanent structure used for temporary storage of stormwater runoff that is designed to not create a permanent pool of water. Detention basins have goals of controlling peak discharge rates but do little to treat runoff for improved water quality. A retention basin is a permanent structure used to retain stormwater runoff which typically infiltrates and removes the majority of the sediment within the stormwater, by settling. It is usually found in a low area or natural drainage way. The basin should be located where stormwater naturally flows or collects.

Summary and Conclusions: Field visits were made to collect the characteristics of the stormwater management facilities in the Paradise Creek Watershed. A total of sixty-seven (67) were assessed for potential retrofitting/redesign options. The immediate surrounding areas were also observed. Pictures of these facilities were taken to provide visual information. The

location and characteristics were entered into Geographic Information System (GIS) database. Points representing stormwater management facility locations were adjusted or added as needed. The additional data collected in the field was tabulated and attached to the updated GIS data layer.

Many of the stormwater management facilities in Paradise Creek watershed were designated as standard detention basins for water quantity control only. That is, they were designed to reduce the post-development peak flow from a development site down to the existing conditions peak rate of runoff. These types of basins typically do little to improve the quality of runoff existing in the basin. These basins typically have the primary outlet, which is usually a small diameter orifice in the outlet structure at the invert or bottom of the basin so that they drain completely after a storm, leaving the basin with a dry grassed bottom between storms. The intent for maintenance for these basins is to have a mowed grass bottom. However, many of the basins were apparently constructed with this primary outlet not at the bottom of the basin, a few inches above the basin outlet. This allows water to pond in the basin, causing wetland conditions. For this and other reasons, the basins were not maintained, allowing dense vegetation, sometimes wetland vegetation to become established. These basins then inadvertently act as water quality best management practices, aiding in groundwater recharge and filtering the pollutants described in this report from the runoff. Plants also uptake the nutrients allowing a “cleaner outflow.” Water quality testing and monitoring would be required to determine exactly how well these inadvertent BMPs are working.

The possible retrofit options were presented for the existing stormwater management facilities. These facilities were grouped based on the proposed structural BMP design. Proper retrofits (upgrades and/or repairs) to the stormwater management facilities in Paradise Creek watershed would improve the water quality of the effluent.

Recommendations: It is recommended that funds be obtained to perform a design of the recommended sites below. A retrofit design would involve obtaining original design drawings and storm water management (including basin volume and routing calculations), surveying as-built conditions, design and preparation of documents suitable for contractor bidding. The Paradise Creek watershed is what we call an upside-down watershed. Typically the most urbanized area of a watershed is near its mouth. However, most of the urbanization and water quality problems occur in the Paradise’s headwaters, around Mount Pocono. Therefore, the majority of the sites are also in this vicinity. In addition, some of the sites were actually uncontrolled impervious areas, as opposed to basins, since they are contributing non-point source pollution. The following sites are in the top of the list for retrofitting based on the prioritization process in Section IX.

- 1. Ames Plaza – Mount Pocono Borough (WQ65)** – The shopping center was apparently developed before any stormwater management requirements as shown in Figure XII-1. The runoff from the impervious area drains directly to the Route 940 right-of-way and then directly into the stream.
- 2. Mount Pocono Intersection (WQ66)** – The intersection of Routes 611, 940 and 191, extending approximately 2,000 feet in all directions from this intersection is a large area of untreated stormwater runoff as shown in Figure XI-2. Since a retrofit in this area is complicated due to the existing development, it is recommended that a feasibility analysis be performed in this area to determine where new BMPs could possibly be located.

3. **Route 611 Expansion – Forest Hills Run Area (WQ67)** – PennDOT has plans to widen Route 611 in the area where it crosses Forest Hills Run. There is a proposed development in the same area. The Brodhead Association has reported that the Mount Pocono Municipal Authority indicates that Route 611 is contributing to pollution of Forest Hills Run. Due to the timing of these various projects, the timing is right to install BMPs as part of the design process as shown in Figure XI-3.
4. **Henryville Post Office (WQ01)** – The Henryville Post Office basin is a typical stormwater detention basin in a highly visible area. It would make the ideal demonstration area for a BMP retrofit. Figure VII-1 illustrates the retrofit recommendations for this facility.
5. **Paradise Township Building (WQ07)** – A large portion of the runoff from the parking lot and maintenance yard flows untreated off site or to the swale that traverses the property. Evidence indicates that flows in the swale do infiltrate due to porous soils. The runoff from the site could be treated and the infiltration capability of the soils be taken advantage of. Figure XI-4 illustrates this facility.
6. **Stables (WQ63)** – There is an Association documented stormwater runoff and quality problem at the riding stable across from the intersection of Route 940 and Carlton Road near the Devils Hole Creek confluence with the Paradise Creek and the Paradise Creek crosses under Route 940. A new water quality BMP could be designed to capture the stormwater runoff from the pastures and treat it before discharged. Figure XI-5 illustrates this facility.
7. **Mount Airy Lodge Streams (WQ64)** – The stream that traverses Mount Airy Lodge does not have a forested buffer. The stream survey showed some stream bank erosion above the Mt. Airy parking lot. A forested buffer would provide stream bank erosion capabilities and keep the temperature of the water cooler. Figure XI-6 illustrates this facility.
8. **Swiftwater Post Office (WQ62)** – The Swiftwater Post Office is publicly owned. The runoff from the post office roof and parking lot enters inlets on the site which discharges via storm sewers untreated. Retrofits may include infiltration measures, converting the inlets to catch basins, inlet device supplements to separate solids, etc. Figure XI-7 illustrates this facility.
9. **K-Mart (WQ16 and WQ17)** – The basins behind K-Mart collect runoff from a large parking lot and road area and were designed for quantity control only. They could be retrofitted into water quality BMPs by excavation, baffling and wetland plantings. Figure XI-8 shows this facility.

Retrofitting the above facilities to act as water quality and quantity control facilities will require hydrologic analysis and design. For the site design, field visits and surveys will be required to collect all characteristics of these facilities. The immediate surrounding areas of these facilities will be observed for problems that may have been caused by the basins such as flooded or eroded conditions. All retrofit options will be considered comprehensively. Final determination of the projects to undertake should be determined by the Brodhead Watershed Association. *[Note: A new Growing Greener Grant from the DEP will provide the resources for stormwater retrofits at four of these sites beginning in 2006.]*

Streamflow Statistics

Ronald E. Thompson, U.S.G.S and Gregory J. Cavallo, D.R.B.C.

Objective: “Streamflow statistics are needed in the Paradise and Pocono Creek watersheds and in surrounding parts of Monroe County, Pa., to quantify surface-water resources and as input to ground-water models. Subbasin yields for the Paradise and Pocono Creek watersheds also are needed for various purposes. In order to fulfill these objectives, the U.S. Geological Survey, the Delaware River Basin Commission, and the Brodhead Watershed Association cooperated in a study to determine the needed streamflow statistics

Summary and Conclusions: “This report presents observed and predicted streamflow statistics for selected streamflow-gauging (stations) in Monroe County, Pa., and subbasin yields for the Paradise and Pocono Creek watersheds. The report also discusses the methods used to determine the streamflow statistics, and an analysis of the prediction methodology, and limitations of the methods and the statistics. Thirty-six streamflow statistics were computed for 7 continuous-record stations and predicted for 12 partial record stations. The statistics computed at the continuous-record stations are referred to as “observed” in this report. Sub-basin yields were determined at 29 sites in the Pocono Creek watershed during 2000 and 2001 and at 11 sites in the Paradise Creek watershed during 2003.”

“Monroe County is in the Pocono Mountains of northeastern Pennsylvania. Surficial geology includes glacial deposits, sandstones, conglomerates, siltstones, shales, and small amounts of carbonate rock. Areas where porous glacial deposits are connected to the water table typically yield higher stream base flows per unit of drainage area during dry periods than nonglacial parts of Pennsylvania.

“Different approaches have been used previously by researchers to predict low-flow statistics at locations in Pennsylvania and other states without daily mean flow data. For this study, observed streamflow statistics for continuous-record stations were computed from daily mean flows retrieved from U.S. Geological Survey databases. Predicted statistics for the partial-record stations were obtained by correlating intermittent measurements made at partial-record stations with concurrent daily mean flows from seven continuous-record stations operated in Monroe County.

“Relative subbasin yields for the Paradise and Pocono Creek watersheds were consistent during each measurement period with few exceptions. One exception was a losing reach along the Pocono Creek main stem. Another exception was the high subbasin yield for Swiftwater Creek in the Paradise Creek watershed that probably reflects surface-water discharges from treatment facilities upstream.

“A suite of 36 streamflow statistics were computed for 7 continuous-record stations and predicted for 12 partial-record stations in Monroe County, Pa. The statistics for each station ranged in magnitude from a high-flow duration equaled or exceeded only 1 percent of the time (D1) to the 7-day, 20-year recurrence-interval low flow (Q7,20) or the low-flow duration equaled or exceeded 99 percent of the time (D99). Low standard errors and high coefficients of determination (R^2) indicate good agreement in using intermittent measurements at partial-record stations and concurrent daily mean flows at continuous-record stations to predict low-flow recurrence-interval statistics for the partial-record stations.

Limitations: “The study and the resulting statistics are limited to streams in Monroe County. All the observed, predicted, and subbasin-yield statistics are estimates affected by the time and measurement errors. The comparison of predicted and observed statistics for the continuous-record stations indicates the predicted methodology used in the study may have application potential for predicting high- and intermediate-flow statistics, not just for low-flow statistics as done in previous investigations. Although all the statistics contain error, as discussed herein, these statistics do constitute the results needed by Delaware River Basin watershed groups for planning purposes and input for ground-water modeling.”

Recommendations: The flow statistics provided in this study were used directly by NA Water Systems for the Groundwater Withdrawal Evaluation (below). These statistics should be used for planning purposes, and may be used in the future as important data for models, such as one being developed in the Pocono Creek study to anticipate potential water quality and water reserve impacts from new development.

Groundwater Withdrawal Evaluation

by David Yoxtheimer, NA WaterSystems

Objective: “This report presents a theoretical analysis of the available groundwater resources based on existing stream base flow data and published reports. This report is intended to assist in determining the amount of groundwater that is sustainably available so the watershed’s groundwater can be utilized while not excessively withdrawing groundwater from the aquifer and adversely impacting stream base flow.”

Summary and Conclusions: “This evaluation indicates that the Paradise Creek Watershed currently has relatively abundant groundwater resources; however some localized impacts to groundwater supply and stream base flow could be realized in the future. The future impact that decreased base flow could have on stream habitat loss and trout populations, especially during drought periods, is difficult to predict; therefore a conservative approach was used in this evaluation.

“Under current conditions, approximately 1000 gpm of additional groundwater that could theoretically be withdrawn from the Paradise Creek Watershed, while still leaving 90 percent of groundwater for base flow under 25-year low base flow conditions. This level of additional groundwater withdrawal is expected to occur before 2020 using current population projections. This additional 1,000 gpm of available groundwater supply could be accounted for quite rapidly if several industrial or commercial facilities moved into the area combined with continued population growth. Therefore the groundwater budget could be significantly changed in a relatively short period of time if significant industrial or commercial occurs.

Limitations and Recommendations: “This evaluation does not account for the return of water via wastewater treatment plants and on-lot septic systems; however the quality of this effluent will be somewhat degraded and will likely have some water quality impacts. Groundwater resource management is seldom a straightforward process; however, much can be done to ensure the long-term protection of the groundwater resources and aquatic health of the Paradise Creek Watershed, including the following:

- 1) Implementation of stormwater management practices that promote groundwater infiltration.
- 2) Reuse of treated wastewater for irrigation.

- 3) Implement routine septic system inspections and pump outs.
- 4) Inventory wells to determine use and construction (well depth, presence of grouted casing to ensure contaminants and water-borne pathogens do not enter the aquifer, etc.)
- 5) Enforce minimum well construction standards and yield testing to ensure that new wells have adequate yield on a perennial basis. Wells should have sufficient casing depth with grout seal, and short term pumping tests should be conducted to prove that the well could sustain a yield greater than 2 gpm.
- 6) Riparian vegetation buffers can be utilized.
- 7) Zoning regulations that promote groundwater protection, and stream base flow protection (e.g., avoid large, localized groundwater withdrawals to protect stream base flow, and minimize intensive development with high impervious surfaces).
- 8) Public education can increase awareness of groundwater protection issues.”

Chapter Two

Action Plan

The study team was able to provide numerous recommended actions to protect the watershed based on the results of the preliminary phases of the study, some of which were implemented even as the project proceeded. A new Growing Greener Grant has been awarded to the Brodhead Watershed Association to implement others, and a new application has been submitted to the DEP for additional work in the future. But the Brodhead Watershed Association cannot accomplish all the goals and targets necessary to protect the watershed alone. A coordinated, interdisciplinary effort must be made by all the stakeholders in the region to properly protect the watershed.

The goals of this study were to determine how to improve water quality, preserve stream corridors and floodplains, maintain existing stream flows, preserve open space, coordinate watershed planning between all levels of government, develop using conservation design, and consider the economic impacts of new rules. In order to achieve those goals, the study team adopted the following specific targets:

- Sustain existing water quality where it is better than state standards
- Improve water quality to meet state standards
- Maintain naturally stable streams
- Re-establish stability to unstable streams.
- Provide necessary stream flows to support a natural ecosystem
- Restore or maintain an optimal biological community in each management area
- Implement watershed-based planning initiatives
- Implement conservation development practices
- Diversify the County's economy with clean industries, and enhance tourism
- Increase Open Space

Targets:

Sustain existing water quality where it is better than state standards
Improve water quality to meet state standards

ACTION ITEMS:

- 1) **Continue Monitoring:** In order to sustain or improve existing water quality, a sound understanding of existing conditions had to be developed. This was accomplished in Phase I of the study, when scientists reviewed all available data to define data gaps, and in Phase II of the study when fieldwork was accomplished to fill the gaps. Water quality was found to meet or exceed state standards in most areas. Several areas of concern were identified, and all study participants echoed the need to continue monitoring so that trends could be established and so that the effectiveness of actions taken could be evaluated. Funds to continue the monitoring are being provided through a Growing Greener Grant awarded to the Brodhead Watershed Association in 2005. Macroinvertebrate surveys at selected sites in the watershed will also continue

with assistance from the Monroe County Planning Commission and the Monroe County Conservation District. The results of the continued monitoring will be added to the study database, and presented on the study web site.

- 2) **Implement Improved Stormwater Management Rules:** Uncontrolled stormwater runoff, or stormwater controls that do not address water quality, are the most significant sources of nonpoint source pollution in any watershed. Years of development without stormwater management rules in place, and additional years with stormwater management rules that do not address water quality, have resulted in impacts to streams like the Yankee Run and Tank Creek that drain much of the Mt. Pocono and Coolbaugh areas near the five-point intersection in Mt. Pocono. New stormwater management facilities must be required to address water quality, and existing facilities must be upgraded to address water quality. Borton-Lawson’s “Stormwater Management Facilities Retrofitting Assessment” report submitted during Phase II of the study provides an inventory of existing stormwater management facilities in the Paradise Creek Watershed that are inadequate, including sites without any stormwater controls. The report recommends retrofits, and was the basis for a new Growing Greener Grant sponsored by the Brodhead Watershed Association to design and permit adequate controls at four of the sites. This report illustrates the need for stormwater management ordinances that mandate Best Management Practices, and should be used as a tool to address all of the inadequate facilities in the future.
- 3) **Protect the Riparian Zone:** Protection of the riparian buffers – the vegetated lands near streams, lakes, ponds and wetlands – may be one of the most efficient and effective ways to protect water quality in the watershed. Riparian buffer protection reduces flooding downstream, provides groundwater recharge, keeps water temperatures lower, filters nutrients and pollutants, provides wildlife habitat and helps to preserve stream banks. Much of the outstanding condition and health of the Paradise Creek watershed can be attributed to the intact riparian forest cover throughout the region. In some areas forested buffers need to be reestablished.
- 4) **Protect the Floodplain:** Like the riparian zone, protection of the 100- year floodplain does more than just protect private property and structures. Floodplains that are protected and left intact and without encroachment provide wildlife habitat, groundwater recharge, flow attenuation, and stream bank protection.
- 5) **Assist and Support Streamwatch Volunteers:** To augment this monitoring, the Brodhead Watershed Association continues to seek improved tools and equipment for Streamwatch Volunteers. These invaluable volunteers are commended for their diligent monitoring efforts. The study developed a database for organizing and storing the collected data, and to improve quality assurance. The study is also developing an internet interface to allow volunteers to load the data directly and to review results from other volunteers.
- 6) **Continually Update Build-Out Analysis and Land Use Survey:** Existing conditions in the watershed were also better defined through the Build-Out

Analysis and Land Use and Impervious Cover Survey performed during Phase I of the study. As municipal ordinances are revised, as open space is protected, and as new development in the watershed takes place it is important that these baselines are reviewed and revised.

- 7) **Sustain Adequate Stream Base Flow:** Water in a stream consists of both surface water and groundwater. Surface water provides most of the flow during wetter periods and groundwater provides a more constant stream flow year-round. During a drought, most stream flow comes from groundwater. The flow provided by groundwater is called base flow, and without adequate base flow water quality and aquatic habitats suffer. Maintaining adequate flow in streams requires regional planning focused on the hydrologic budget. Zoning regulations should promote groundwater protection and stream base flow protection by prohibiting large, localized groundwater withdrawals and intensive development near streams, unless the developer can demonstrate base flows are protected.
- 8) **Implement Regional and Municipal Open Space Plans:** Open space planning initiatives should focus on riparian areas, both to protect the riparian buffer from unwanted disturbance and to provide access to the streams for the public. Most riparian areas in the Paradise Creek Watershed are in private ownership, and many residents are unaware of aesthetic and environmental value of the streams.
- 9) **Continue Public Education and Outreach:** Topics appropriate for continued public education and outreach include landscape management, household hazardous waste disposal, riparian buffer protection, forest management techniques, septic maintenance, fertilizer and pesticide use, water conservation concepts, invasive species, private well maintenance, groundwater concepts, pet waste management, surface drainage guidelines, composting and recycling.
- 10) **Eliminate nonpoint source contributions:** Proper forest management, lake and pond management, landscape management, riparian zone protection and floodplain protection will help to reduce nonpoint source pollution. Watershed residents must be educated regarding disposal of household hazardous waste, landscape management, dirt and gravel road construction and maintenance, septic system maintenance, recycling and composting. Municipalities need to ensure sanitary sewers are not leaking, stencil storm sewers, enforce litter and dumping rules, and support source water protection initiatives.
- 11) **Implement Watershed-Based Planning:** Environmental Advisory Councils may be the most efficient way for municipalities in the watershed to share planning tools and initiatives. The watershed will be protected only if elected and appointed officials understand the importance of maintaining the hydrologic budget, and make decisions based on a perspective that goes beyond individual municipal borders.
- 12) **Eliminate NonPoint Source Contribution to Impairment on Forest Hills Run:** The Forest Hills Run downstream of Rt. 611 has been included on the list of impaired streams under the Clean Water Act 303(d) list, both for impacts associated with the discharge from the Mt. Pocono Municipal Authority sewage treatment plant, and from runoff from Rt. 611. In an effort to assist in the

improvement of water quality in this part of the Forest Hills Run, Borton-Lawson Engineering was contracted to conduct a stormwater retrofit feasibility study. The goal of that study was to determine what Best Management Practices could be used to eliminate the impact of stormwater runoff from the highway. The report is included in the technical appendix, and has been presented to the Pennsylvania Department of Transportation District 5-0 Administrator for review and consideration.

- 13) **Eliminate NonPoint Source Contribution(s) to Potential Impairment of Forest Hills Run:** The Forest Hills Run downstream of Mt. Airy Lodge had macroinvertebrate survey scores at the very lowest end of the “moderately impaired” category for two years. According to one DEP biologist, it was impossible to determine whether the signs of impairment were a result of the Mt. Airy sewage treatment plant, the lack of Best Management Practices on the 18-hole golf course, discharge from Mt. Airy Lake, other unknown sources, or some combination of the above. The former Mt. Airy Lodge has been demolished. Improvements have been made to the wastewater treatment plant, and new wastewater collection and water distribution systems are proposed for the new resort. Most importantly, the developer’s proposal complies with Paradise Township’s conservation land development and zoning rules and includes over 500 acres of greenway land that will be permanently protected. The proposal includes a maintenance plan for the greenway, including lake management criteria and Best Management Practices on the golf course. Continued monitoring of this site will document whether these improvements remediate the observed impairment.
- 14) **Water Quality Investigations:** Temperature elevations and fecal coliform contamination observed in the watershed require investigation. Phosphorus levels appear elevated in many areas of the watershed, and a nutrient reduction plan should be developed to address nonpoint source contributions.

Targets:

Maintain naturally stable streams

Re-establish stability to unstable streams

ACTION ITEMS:

- 1) **Maintain an Inventory of Unstable Reaches:** A preliminary inventory of unstable stream reaches is provided by Limbeck in his stream morphology report. This inventory can be updated with additional stream walks in the future. The steps necessary to repair unstable stream reaches is complex, and best undertaken by trained professionals. The Brodhead Watershed Association recently submitted a new Growing Greener Grant application to begin design of one repair along the Paradise Creek main stem near Red Rock Road. Once design and permitting are accomplished appropriate funding sources for construction can be determined.

- 2) **Provide Support and Technical Assistance to Privately-Funded Stream Improvement Projects:** Riparian ownership comes with riparian responsibilities. Private land owners should be educated about riparian zone maintenance and stream bank protection. Landowners should become partners in efforts to protect and repair unstable stream banks. Riparian owners in the watershed are frequently willing and able to take on stream improvement projects but lack the technical guidance necessary to obtain needed permits and develop an appropriate strategy.
- 3) **Organize and Support Volunteer Stream Improvement Activities:** Many volunteers assisted in the Paradise Creek Watershed project. College students, high school students, scouts and local residents enjoyed participating in stream-related activities. This participation should extend to stream improvement projects based on recommendations in this report in the future.
- 4) **Work with PennDot on Stream Crossing-Related Instabilities:** Borton-Lawson Engineering prepared a “Stormwater Retrofit Feasibility Study” associated with Rt. 611 improvements just south of Mt. Pocono. The report makes excellent, practical recommendations for reducing nonpoint source pollution to the Forest Hills Run and the Swiftwater Creek. The Brodhead Watershed Association continues to work to develop a process through which the Pennsylvania Department of Transportation can participate in these projects. Sixteen of the unstable reaches identified by Limbeck were associated with areas where roads crossed the streams. The Rt. 314 bridge across the Swiftwater Creek above Lake Swiftwater is one example of instability associated with a crossing that does not span the floodplain. Limbeck suggests the Brodhead Watershed Association work with the PennDOT, the county, and municipal road crews to install river-friendly bridges and culverts during future infrastructure maintenance and repair.
- 5) **Implement Improved Stormwater Management Rules:** This action item is as important to stream bank stability as it is to water quality, as noted above.
- 6) **Protect the Riparian Zone:** This action item is as important to stream bank stability as it is to water quality, as noted above.
- 7) **Protect the Floodplain:** This action item is as important to stream bank stability as it is to water quality, as noted above.
- 8) **Assist and Support Streamwatch Volunteers:** This action item is as important to stream bank stability as it is to water quality, as noted above. Having volunteers in the streams for sampling on a regular basis provides a resource for updating the inventory of unstable stream reaches, above.
- 9) **Sustain Adequate Stream Base Flow:** This action item is as important to stream bank stability as it is to water quality, as noted above.
- 10) **Implement Regional and Municipal Open Space Plans:** This action item is as important to stream bank stability as it is to water quality, as noted above.
- 11) **Continue Public Education and Outreach:** This action item is as important to stream bank stability as it is to water quality, as noted above. **Eliminate Nonpoint Source Contributions:** This action item is as important to stream bank stability as it is to water quality, as noted above.

- 12) Implement Watershed-Based Planning:** This action item is as important to stream bank stability as it is to water quality, as noted above.

Targets:

Provide Necessary Stream Flows to Support a Natural Ecosystem

Restore or Maintain an Optimal Biological Community in Each Management Area

ACTION ITEMS:

- 1) **Maintain the Hydrologic Balance:** Protecting and providing stream flows necessary to support a natural ecosystem and to maintain an optimal biological community requires a watershed perspective on the part of elected and appointed officials on the municipal level. Planning for future growth must include an understanding of the hydrologic balance and how development, including water withdrawals and generation of stormwater and wastewater, impact available water resources.
- 2) **Monitor Water Withdrawals:** Large water withdrawals are monitored by the DEP and by the Delaware River Basin Commission. Smaller withdrawals are not monitored, but can accumulate into significant demands on water reserves. Municipalities in the watershed should begin monitoring withdrawals for all non-residential users in order to anticipate future impacts on water supplies. This inventory of withdrawals could occur on a regional or county level, providing a resource for all Monroe County municipalities.
- 3) **Continue Monitoring:** This action item is as important to maintaining stream flows and an optimal biological community as it is to water quality, as noted above.
- 4) **Implement Improved Stormwater Management Rules:** This action item is as important to maintaining stream flows and an optimal biological community as it is to water quality, as noted above.
- 5) **Protect the Riparian Zone:** This action item is as important to maintaining stream flows and an optimal biological community as it is to water quality, as noted above.
- 6) **Protect the Floodplain:** This action item is as important to maintaining stream flows and an optimal biological community as it is to water quality, as noted above.
- 7) **Implement Regional and Municipal Open Space Plans:** This action item is as important to maintaining stream flows and an optimal biological community as it is to water quality, as noted above.
- 13) **Continue Public Education and Outreach:** This action item is as important to maintaining stream flows and an optimal biological community as it is to water quality, as noted above.
- 14) **Eliminate Nonpoint Source Contributions:** This action item is as important to maintaining stream flows and an optimal biological community as it is to water quality, as noted above.

- 15) Implement Watershed-Based Planning:** This action item is as important to maintaining stream flows and an optimal biological community as it is to water quality, as noted above.

Targets:

Implement Watershed-Based Planning

Implement Conservation Development Practices

Increase Open Space

These targets are actually action items, as noted above. Only by understanding the importance of the hydrologic budget and maintaining a watershed-wide perspective that goes beyond individual municipal boundaries can elected and appointed officials protect the Paradise Creek Watershed. Environmental Advisory Councils can be extremely important in this pursuit. These councils can communicate with each other, ensuring that shared values and goals are considered in future ordinance revisions and planning initiatives.

- 1) **Create Environmental Advisory Councils in all Municipalities**
- 2) **Schedule Opportunities for Environmental Advisory Councils from All Municipalities to Meet Together Periodically**
- 3) **Update the Build-Out Analysis**
- 4) **Update the Land Use and Impervious Cover Survey**
- 5) **Dedicate a Portion of Tax Revenue to Open Space Acquisition, Conservation Easements, and Purchase of Development Rights**
- 6) **Share Ordinance Language regarding Conservation (Low Impact) Development, Stormwater, Floodplain Management, Riparian Buffers, Erosion and Sedimentation, and Natural Feature Protection**
- 7) **Establish and Maintain Inventory of Non-Residential Water Withdrawals**
- 8) **Update Existing Act 537 Plans Encouraging Land Application of Treated Wastewater**
- 9) **Ensure Diligent and Rigorous Sewage Enforcement**
- 10) **Support and Participate in Public Education and Outreach Initiatives**
- 11) **Support Local Source Water Protection Plans**

Targets:

Diversify the county's economy with clean industries, and enhance tourism

Consider economic impacts of new rules

ACTION ITEMS:

Environmental protection in the Paradise Creek Watershed is essential to a viable economic base, because it is the natural beauty of the environment that is the heart of the tourist industry. The growth expected in the number of houses and businesses can make protection of the natural environment challenging, but it is important to remember that the natural beauty in the Paradise Creek Watershed is a major reason people and businesses are moving here.

The natural beauty is not the only reason that businesses, particularly clean industries, move to the Poconos. The pristine condition of the water resources also attracts commerce and industry (like pharmaceutical and manufacturing concerns). Protection of the existing high quality of the water resources is paramount to sustainable growth and a viable economy.

Updating and revising ordinances costs money. In some cases, as with rules pertaining to timber harvesting, wellhead protection, and well construction standards municipalities may need to hire consultants who are experts in their respective fields. Engineering and legal review are also important. Costs associated with specific projects recommended in this plan cannot be estimated except on a case-by-case basis. Public education and outreach activities are usually free except for the nominal costs of using public meeting places like the municipal buildings.

A cost-benefit analysis is provided in Chapter 5.

Chapter Three

Implementation Tools

In his book, “Watersheds Processes, Assessment, and Management”³ team member Paul A. DeBarry explains:

“Watershed management can be undertaken in two ways: the proactive approach and the reactive approach. Humans typically react to floods, water quality problems, and stream bank erosion. Once an event or series of events creates a problem, then people react to fix the problem they created. People build in the floodplain, then build levees to protect their buildings. A flood greater than the levee capacity occurs, and the government pays for the cleanup and to make the levees higher. However, as we are slowly learning, taking a proactive approach - performing a watershed assessment and putting a watershed management plan in place to strive to maintain the natural hydrologic regime - prevents flooding, maintains groundwater quantity and quality, maintains stream flow and quality, prevents stream bank erosion, preserves environmentally sensitive areas, and so on.”

Note that DeBarry wrote this extraordinary paragraph in his book before Hurricane Katrina devastated the Gulf Coast and breached the levees protecting New Orleans. DeBarry continued:

“Natural, undisturbed watersheds are in geologic equilibrium. As humankind alters the land surface, the landform, hydrologic budget, and stream processes are ultimately affected. Improper use of our natural resources causes a number of problems, including flooding, erosion and sedimentation, stream bank erosion, water quality problems, and reduction of groundwater and base flow augmentation. The goal of any watershed management plan should therefore be to maintain the hydrologic budget. In order to properly manage a watershed, the comprehensive picture or holistic approach must be followed.”

The Paradise Creek Watershed is the perfect place to develop a comprehensive picture and follow the holistic approach DeBarry recommends to protect and manage water resources. But the political boundaries that fragment the watershed make this approach particularly challenging. Eight independent, autonomous municipalities are responsible for development of the land use and storm water controls in the Paradise Creek Watershed.

³ DeBarry, Paul A. *Watersheds Processes, Assessment, and Management* (John Wiley & Sons, Inc.), 2004.

Coolbaugh Township, Tobyhanna Townships, and Mt. Pocono Borough are fully engaged in regional comprehensive planning. Pocono Township has developed a regional comprehensive plan with its neighbors to the south and east. Paradise and Barrett Townships have not developed regional comprehensive plans. So this regional comprehensive planning, while on-going in some areas, completely ignores the watershed boundaries. These municipalities do not even share common state legislative districts. Those portions of Price and Stroud Township that exist in the Paradise Creek drainage area are so small they have little impact on the watershed. Most of the land in these townships exists in the upper Brodhead drainage area. Land in Pocono Township outside the Paradise Creek Watershed is in the Pocono Creek drainage area. Large portions of Coolbaugh and Tobyhanna Townships are in the Tobyhanna Creek Watershed, and in an entirely different river basin (this watershed drains to the Lehigh River). Many of the actions described here to protect the Paradise Creek Watershed are applicable in other watersheds in the region.

The municipalities are managed by Boards of Supervisors in the townships, and by a Borough Council in Mt. Pocono, made up of local citizens. These elected officials are expected to be masters of all trades, overseeing day-to-day operations, finances, capital improvements, litigation, planning, insurance, employees, economic development, infrastructure, and citizen complaints. Many of these elected officials have been residents and municipal managers for many years, with a strong understanding of local history and citizen concerns. Some of them are very new, either to the area, or politics, or both. They face the challenges of municipal governing in an area of Monroe County under intense development pressure, and at a time of unprecedented demographic and cultural diversification.

Most municipal actions are dictated by the Borough Code, the Second Class Township Code (classes are dependent on population), and the Pennsylvania Municipalities Planning Code. But the municipalities' actions are also constrained by a growing body of case law. All the municipalities have the support of a municipal solicitor. All the municipalities are struggling to comply with ever-new state and federal mandates - most of which do not come with funding necessary for implementation. And all the municipalities exist within the Pocono Mountain School District, which recently took claim to a portion of the earned income tax previously dedicated to the municipalities. These funds represented a small fraction of the Pocono Mountain School District budget, but represented a significant portion of the local budgets.

All the municipalities have Planning Commissions made up of citizens who review proposed development plans. Planning Commission members have the support of both a solicitor and an engineer. But subdivision plans, land development plans and storm water management plans can be highly technical, and can involve voluminous amounts of data, drawings and information. Most Planning Commission members, as well as the supervisors and council members who ultimately approve the plans, rely on the engineer to ensure proposals are technically sound. And most rely heavily on the lawyer to ensure the municipality is protected from expensive litigation. The question is not whether these elected officials want to protect the environment and implement sound water resource planning. The challenge is to provide them with the incentive and the tools to achieve those goals.

Throughout the Action Items outlined in Chapter Two are myriad tasks that can be taken by local officials. The Monroe County Commissioners, the Monroe County Planning Commission, the Monroe County Conservation District, and state and federal agencies also have roles to play. Certainly, residents and landowners with future development interests in the

watershed also have important responsibilities. However, implementation of many of the important ingredients to successful protection of the Paradise Creek Watershed listed below require action on the part of Barrett, Coolbaugh, Paradise, Pocono and Tobyhanna Townships, and Mt. Pocono Borough. To their credit, many of these actions are either being planned or are already being implemented. Residents, voters and tax payers in the watershed need to involve themselves in this process, attend municipal meetings, support officials working toward these goals, and keep tabs on the progress being made.

IMPORTANCE OF THE HYDROLOGIC BUDGET

As described by DeBarry, the *hydrologic cycle* is, “the exchange of water between the earth’s surface and the atmosphere, fueled by energy from the sun through processes such as condensation (cloud formation), precipitation, runoff, infiltration, evaporation, and transpiration (from plants and animals). The hydrologic cycle could be considered the complete cycle through which all water on earth is continuously moving.” DeBarry then goes on, “Under natural conditions, this cycle, called the *hydrologic* or *water balance*, is in equilibrium and accounts for the amount of water in storage and in transit at any point in time within the hydrologic cycle...In the long term, all water entering the watershed under natural conditions would balance water leaving the system...As with human accounting procedures alteration of the cycle may put the system or budget out of balance. Watershed planning would strive to put the system back into balance through management measures.”

DeBarry goes on to point out, “The hydrologic cycle could be described as the *hydrogeologic cycle*, because surface water and groundwater are interconnected by recharge of groundwater through infiltration and stream base flow augmentation from groundwater.” In a completely natural state, the watershed is constantly changing to reestablish its hydrologic balance in response to changes in weather. In a watershed changing due to man-made influences, where development in one area can profoundly impact watershed characteristics in another area, the community must strive to ensure this hydrologic balance is not disrupted. This can only be accomplished by managing the water budget. Withdrawals from the system must be balanced by deposits. Land development must therefore focus on ensuring that water taken from the system is replenished. This is most effectively accomplished through sound land use planning and enforcement, and requires a regional perspective. The *quality* of surface and groundwater supplies can be protected through the control of point and nonpoint sources described in Chapter 1.

LAND USE PLANNING

Conservation Development (Low Impact Development)

Conservation-based zoning requires that design of new subdivisions and land developments consider the existing characteristics of the land. Using conservation-based zoning, the natural features of the tract proposed for development dictate what can be built where. Before lot lines are drawn and buildings and parking lots are located, a developer must investigate the environmental conditions that exist and prepare an inventory of areas that warrant special protection. This investigation also allows the developer to understand where recharge and infiltration of water can occur most efficiently, and use those areas most effectively.

A developer's rights to use the land are respected, while wetlands, flood plains, steep slopes and other environmentally sensitive areas are protected. Because this results in concentration of earth disturbance and impervious surface in smaller areas of a tract, the developer saves money in infrastructure needs. Fewer miles of road are required, utility runs are minimized, maintenance costs are reduced, smaller storm water management facilities are needed, and less overall earth disturbance is necessary. As important to developers, the value of the property they develop increases due to the enhanced aesthetics.

At the same time, streams, lakes and ponds are protected. Runoff is reduced and recharge can be maximized in an economic manner. Innovative wastewater treatment techniques can be used cost-effectively, and direct discharge of treated effluent to surface water bodies becomes unnecessary. Natural vegetation can not only be protected, but also used effectively to filter pollutants prior to reaching water bodies. Riparian buffer areas can be protected and managed without restricting an owner's right to develop the land.

A variety of model ordinances exist to assist municipalities in implementing conservation design and low impact development. Paradise Township successfully used the National Lands Trust Growing Greener model, highly customized to meet the needs of this heavily forested, resort-oriented township.

Open Space Operation and Maintenance

Open space protected in conservation zoning developments, and open space purchased by local or regional groups, require stewardship. Dirt roads, woodland trails, riparian buffers, stream banks, lakes and ponds, security, and recreation facilities all must be managed to protect these "greenway" areas. Sometimes this can be accomplished through a conservation easement (described below) and the involvement of a conservation organization like Pocono Heritage Lands Trust, the Nature Conservancy, or Wildlands Conservancy. Even left in private ownership, open space lands require a comprehensive operation and maintenance plan. Open space lands created through the conservation development process should require operation and maintenance plans reviewed and approved by the municipality, and adequately funded in perpetuity.

Stormwater Management

Proposed developments in the Brodhead Creek Watershed have been regulated by stormwater management rules under Act 167 since 1991, and in the McMichaels Creek Watershed since 1988. The rules were supposed to be revised and updated every five years. In 1999, the Monroe County Commissioners asked the Monroe County Planning Commission and the Monroe County Conservation District to update the rule. The revision was completed and given to the Commissioners in 2003. The Commissioners then delayed approval of the revision while debate took place, primarily about riparian buffers. The Commissioners approved of the revised plan two years later (12/05). The plan then had to be reviewed and approved by the DEP. The revision proposes a model ordinance for each municipality to enact to implement the findings of the plan. The model should be customized to meet each individual municipality's particular characteristics.

Riparian Buffers

Riparian buffers are vegetated areas in the vicinity of streams, creeks, runs, lakes, ponds and wetlands. The natural vegetation in these buffer areas filters and removes pollutants before runoff from roofs and parking lots and roads can reach the water bodies. Restrictions on earth

disturbance within these buffer areas is one of the most effective and efficient means of protecting both water quality and quantity.

Protection of riparian buffer areas is extremely important to safeguard water quality in all streams, and of paramount importance in the forested, headwater streams in the Paradise Creek Watershed. According to DeBarry, “Forest riparian buffers provide shade to aid in keeping stream temperatures low; filter, absorb, and adsorb pollutants; provide an area for sediment deposition; promote microbial decomposition of organic matter and nutrients; minimize or prevent stream bank erosion; provide terrestrial, stream bank, and aquatic habitat and species biodiversity; open wildlife corridors; provide infiltration, which replenishes groundwater and cool stream base flow; and provide flood flow attenuation. Fallen trees and logs create pools, which provide microhabitat for macro invertebrates and other aquatic life. The tree canopy provides shade, thus keeping stream temperatures low.”

What is an appropriate riparian buffer? Respecting this debate, but recognizing the need to protect riparian buffers, the Brodhead Watershed Association applied for a grant in 2005 to produce a riparian buffer overlay throughout the entire Paradise Creek Watershed. As proposed, the project would not have resulted in an arbitrary distance for riparian buffer protection. The project would have produced a model for calculating an appropriate riparian buffer based on a wide variety of site-specific parameters. These parameters would have included soil types, topography, hydraulics, flora, fauna and existing stream bank conditions to decrease a riparian buffer area in locations where the distance could safely be minimized, and increase the buffer area in locations where site conditions warranted protection of wider areas. Until such time as a tool for making such determinations is developed municipalities in the Paradise Creek Watershed are strongly urged to enact the riparian buffer provision of the proposed Act 167 revision.

Best Management Practices

An important component of the revised Stormwater Management Plan for the Brodhead Watershed is the requirement for Best Management Practices for storm water quality. This revision to the former Act 167 rule is not only necessary to protect streams, ponds, lakes and wetlands, it also makes the Act 167 rule compatible with National Pollution Discharge Elimination System (NPDES) permitting requirements and the Delaware River Basin Commission’s Special Protection Waters program. Without the update, developers must sometimes obtain waivers from existing municipal rules in order to comply with state requirements under the Clean Water Act. Enactment of the revised Act 167 rule is crucial to provide developers with guidelines for design that are not contradictory, time consuming and costly.

Best Management Practices (BMPs) for storm water consist of environmentally sound techniques for managing stormwater from new development that promotes groundwater recharge, reduces pollutant loads, protects stream channels, prevents overbank flooding, and safely conveys extreme floods. These techniques can be either structural or non-structural. Non structural BMPs use the natural soil, topography and geology to direct runoff to areas where the water can seep back into the earth and recharge the groundwater reserves. Structural BMPs attempt to accomplish the same goals, but require earth disturbance and construction to direct the runoff efficiently. While non-structural BMPs are most efficient, and usually less expensive, the land characteristics do not always allow their use. The DEP is preparing a Best Management Practice Manual for controlling storm water. The BMP Manual will provide a menu of acceptable BMPs depending on individual site characteristics, and municipal storm water rules should reference the manual as a resource for developers.

Operation and Maintenance of Stormwater Facilities

During Phase II of the Paradise Creek Watershed project, numerous existing storm water management facilities in the watershed were found to be inadequate. These inadequacies were frequently the result of a lack of maintenance. Stormwater rules enforced in past years by the municipalities and the state focused on flood control, and rarely addressed water quality concerns. Typically, an engineer would locate the lowest area of a tract of land proposed for development and design a basin to detain runoff from the site. These detention basins exist all over Monroe County. But operation and maintenance plans for the basins were rarely prepared, almost never funded, and the care for the basins was usually left to private land owners. Without a formal operation and maintenance plan in place, and without escrowed funds to pay for implementation of the plan, the municipalities have no means of assuring these activities take place.

Reviewed and approved operation and maintenance plans for all storm water management facilities, and funding for implementation of the plans, must be a priority for the regulatory agencies. As BMPs for storm water control evolve and become more innovative, the community will see fewer basins. But the infiltration technology that will provide greater recharge of runoff may require more intense maintenance. Left unattended and without proper monitoring, these facilities will stop functioning properly. Improper maintenance decreases the efficiency of BMPs, and may also detract from the aesthetic qualities of the facility. Proper operation and maintenance provisions within a storm water ordinance can ensure that the design facilitates easy maintenance and that regular maintenance activities are completed. Language in storm water management ordinances should include specification of the entity responsible for long-term maintenance and reference regular inspection visits.

Erosion and Sedimentation Controls

A comprehensive program for the enforcement of erosion and sediment control measures is essential for protection of the watershed. This responsibility lies with both the municipalities and the Monroe County Conservation District. The construction phase of any earth disturbance project, when land is cleared of vegetation and graded to create a proper surface for construction, represents a serious potential threat of sediment pollution to waterways in the area. The removal of natural vegetation and topsoil renders the exposed areas susceptible to erosion. Sediment control is the process of retaining eroded soil onsite, preventing it from entering watercourses.

While the Monroe County Conservation District enforces erosion and sedimentation rules diligently, many small projects fall outside the criteria for review of plans in advance. Municipalities can and should require District review of plans for these smaller projects. In the absence of District review and approval, municipalities must look at these plans very carefully. The cumulative impacts of erosion and sedimentation from many smaller projects can be very damaging to the watershed. Municipal engineers should inspect sites, when necessary, to ensure proper controls are in place during construction.

Impervious Cover Limitations

Impervious surfaces increase the temperature of runoff, increase the amount of runoff, and decrease the amount of water allowed to infiltrate back into the ground. Limiting the amount of impervious surface mitigates these dangers and also benefits the developer by limiting the amount of storm water that must be managed. Most municipal ordinances set

maximum building coverage standards. Setting reasonable limits on the amount of impervious surface (lot coverage) is also important.

Municipalities are urged to review existing ordinances to ensure standards for streets and parking areas are minimized instead of maximized. Typically, transportation engineers and road masters prefer maximizing these standards, to provide the greatest flexibility for maintenance and ingress/egress. While these components of new subdivision and land development design are extremely important, reductions in street widths and the number of required parking spaces can sometimes be reasonably reduced. Parking lot design standards are also important. Properly designed vegetated buffers and islands in parking lots can provide significant infiltration of runoff. Design standards contained in municipal ordinances should be reviewed to ensure these buffers and islands are encouraged, and not prohibited.

WATER SUPPLY PLANNING

Section 301(b) of the Pennsylvania Municipalities Planning Code recognizes the importance of water supply planning: “The comprehensive plan shall include a plan for the reliable supply of water, considering current and future water resources availability, uses and limitations, including provisions adequate to protect water supply sources.” Section 503.1 requires every municipal subdivision and land development ordinance contain a provision that if water will be supplied by a water distribution system, the system must comply with all applicable local and state requirements. Both the state, through the State Water Plan, and the Delaware River Basin Commission (DRBC) control and monitor large water withdrawals. The DEP monitors water quality in public supply wells.

Without the resources of the DEP and DRBC, municipal officials can do little to predict “future water resources availability, uses and limitations.” Flow studies conducted by the United States Geological Survey (USGS) and the DRBC for the Paradise Creek Watershed study supported a groundwater withdrawal evaluation performed by N.A. Water Systems. That project component concluded, “This evaluation indicates that the Paradise Creek Watershed currently has relatively abundant groundwater resources; however some localized impacts to groundwater supply and stream base flow could be realized in the future.” The evaluation used a very conservative approach, and concedes that impacts associated with decreased base flow are difficult to predict. Nonetheless, the evaluation estimated that approximately 1000 gallons per minute of additional groundwater could theoretically be withdrawn from the watershed and still leave 90 percent of groundwater for base flow under 25-year low base flow conditions. This increase in withdrawal was predicted to occur in 2020 based on the build-out analysis conducted by the Monroe County Planning Commission. The problem is that along with continued increases in residential growth, the development of several new industrial or commercial facilities that use large quantities of groundwater could significantly change this water budget.

Municipal officials and concerned citizens are left without hard numbers to use to limit growth, but with sound recommendations for safeguarding water supplies in the future. These recommendations include promoting infiltration of storm water, reusing treated wastewater for irrigation, protecting vegetated riparian buffers, and using zoning regulations to avoid large, localized groundwater withdrawals near the streams, to minimize concentrated developments near the streams, and to avoid large impervious surfaces near the streams. In order to safeguard water quality, routine septic system inspections and pump outs should be required, well

construction standards should be enforced, and the Source Water Protection Plans for all local water supply entities should be supported.

Well Head Protection and Source Water Protection

Drinking water in the Paradise Creek Watershed comes largely from wells. The Brodhead Creek Regional Authority provides water along Rt. 611 to the Sanofi Pasteur, Inc. facility, and draws a portion of that water from the Brodhead Creek as well as from groundwater wells. American Water provides water from public water supply wells to much of Mt. Pocono and Coolbaugh Township. Preventing the source of drinking water from becoming polluted is referred to as Source Water Protection.

The underlying principle of Source Water Protection is that it is much less expensive to protect a water resource than it is to try to restore it after it has been contaminated. One way to protect water drawn from wells from becoming contaminated is called wellhead protection, and limits land uses in proximity to the wells. Discrete zones are defined where contaminants could seep down and pollute the groundwater tapped by the well. Land uses are then identified that could result in surface or subsurface contamination, and such land uses are either prohibited or closely monitored within those zones. Pump tests are conducted by public water suppliers to fully define these zones. But much of the Paradise Creek Watershed is served by private residential wells, and smaller community and non-community well owners that cannot afford these expensive tests.

Both Mt. Pocono Borough and Paradise Township have wellhead protection ordinances in place. Additional studies should be conducted to better define the zones in those ordinances. The community should fully support the Source Water Protection Plans developed by the Brodhead Creek Regional Authority and American Water. And public outreach initiatives to educate private well owners of their responsibility to monitor the quality of their drinking water should be routine.

Well Construction Standards

Because the entire population in the Paradise Creek Watershed is vulnerable if the groundwater becomes contaminated, no new wells should be constructed without complying with standards established by the American Water Well Association. These standards establish criteria for grouting around the casing that is placed inside a drilled hole to create a well. That grouting ensures contaminants do not use the otherwise porous media on the outside of the casing as a conduit for contamination and water borne pathogens to travel from the surface to the groundwater. Paradise Township enforces well construction standards through certification from the licensed well drillers.

Impact Studies for New Development

Proposed developments that will withdraw large quantities of water could have an impact on water supplies and stream base flows. Studies that include testing and monitoring wells should be performed early in the review process for such proposals. Municipalities should determine withdrawal levels that warrant such studies below the thresholds that trigger the need for such tests by the DEP and/or DRBC. Placing the burden on the developer to ensure adequate water supplies remain available in the future is appropriate.

WASTEWATER PLANNING

Act 537 Plans and Enforcement

All municipalities in the watershed need strong, up-to-date Act 537 Plans to manage wastewater. Pocono Township recently revised its Act 537 Plan and proposes to construct a new wastewater treatment plant to serve the businesses and residents along the Rt. 611 corridor. Small sewage treatment plants exist throughout the watershed, primarily to serve local resorts and schools. Larger treatment plants serve Sanofi Pasteur, Inc. and Mt. Pocono Borough. But most of the watershed is treated by on-lot septic systems, including in-ground systems and elevated sand mounds.

According to Dean Woodling, Sewage Enforcement Officer for Paradise Township, there is no better way to renovate and cleanse residential wastewater than to let soils and nature do the work. Systems are designed so that by the time wastewater reaches the groundwater it has been fully treated and can be safely reused. But malfunctioning or improperly designed septic systems represent a serious threat to groundwater quality, and a threat to drinking water quality for watershed residents. This makes the local sewage enforcement officer one of the most valuable and important tools available to protect drinking water. Since the groundwater discharges to streams in the Paradise Creek Watershed, strong, competent enforcement of sewage treatment standards also protects the quality of our streams, lakes and ponds.

In some areas of the Paradise Creek Watershed lots were created that either cannot support an on-lot septic system, or do not have sufficient space to safely support both an on-lot septic system and a drinking water well. Unfortunately, this information is not automatically relayed at tax and/or sheriff sales, and a few unscrupulous owners and realtors still try to sell these as buildable lots. Today, lots cannot be created unless definitive proof is supplied to the municipality that the parcels created can support both septic system and well. In Paradise Township, new lots cannot be created unless they can support both a primary septic system and an area for a back-up secondary septic system in case the first one malfunctions.

The DEP is allowing the use of alternative technology septic treatment systems in some cases. These systems do not always require the soil composition necessary to support a conventional on lot disposal system. While the technology may be sound, there is nowhere for residents to go if the system fails. With no back-up alternative, the use of these alternative technology septic treatment systems may not be in the best interests of future new residents or the municipalities, and may represent a danger to the watershed.

Regional Considerations

The Mt. Pocono Municipal Authority (MPMA) sewage treatment plant has been scrutinized for years. An abundance of testing has indicated that the Forest Hills Run downstream of the plant is being impacted by the discharge. The Paradise Creek Watershed study did not test in this area simply because so much testing had already been accomplished - and was on-going - by the MPMA and the DEP. During the course of the Paradise Creek Watershed study this downstream reach of the Forest Hills Run was declared officially impaired (placed on the Clean Water Act 303(d) list). The Paradise Creek Watershed study assisted in the evaluation of the stream in an attempt to identify the causes of the impairment, and the community should applaud the efforts of the Pocono Mountain Water Quality Committee established to find a solution to the problem, including the DEP, the MPMA and the Brodhead Protective Association.

The Forest Hills Run originates in Mt. Pocono Borough near Rt. 940 - in fact, the very headwaters can be traced to the parking lots of a large commercial complex and other shops and businesses along that stretch of the highway. The Forest Hills Run is a modest little creek, and perhaps it is not large enough to accept the full MPMA discharge. There are few easy solutions and MPMA continues to pursue options to direct discharge.

A contributing source of impairment to the Forest Hills Run was found to be nonpoint source runoff from Rt. 611. This largely uncontrolled storm water runoff drains a large part of Mt. Pocono from the five points intersection down the entire Rt. 611 corridor. Increases in temperature and contaminants carried in the storm water are believed to be contributing to the degradation of water quality in the stream. As a result, the Paradise Creek Watershed study funded an evaluation of existing conditions and a feasibility study to determine what could be done to mitigate this contribution to the problem.

The results of this study, performed by Borton-Lawson Engineering, has been forwarded for review to the Pennsylvania Department of Transportation District 5-0 Administrator. While the recommended storm water retrofits cannot be automatically included in the budget for the on-going improvements to the highway in this area, it is hoped that future work by PennDOT, with support from MPMA, DEP and the Brodhead Watershed Association, can implement these suggested improvements and eliminate the nonpoint source contribution to the impairment of the Forest Hills Run.

The sewage treatment plant proposed to serve portions of Pocono and Hamilton Townships has no direct influence on the Paradise Creek Watershed. But indirect influences exist and must be acknowledged. First, the project stops at the Pocono/Paradise Township line, and provides no service to that portion of Paradise Township along Rt. 611.

Second, local and regional officials must use a watershed prospective for such large plans, and consider the hydrologic budget. This sewer line proposes to serve the Pocono Mountain School District campus in the future, as well as Sanofi Pasteur, Inc. Both of these facilities exist in the Paradise Creek Watershed. While Sanofi Pasteur is provided water by the Brodhead Creek Regional Authority in East Stroudsburg, and returning wastewater to the same area where it is withdrawn makes sense, the Pocono Mountain School District draws water from on-site wells.

An assessment should be made to define the impacts these plans may have on the hydrologic budget for the entire watershed, and ensure that the export of water from proposed users like the school district will not impact stream base flows in the Swiftwater Creek sub-watershed. Monroe 2020 spoke to the benefits of decentralized collection and treatment of sewage, and noted that alternatives to direct discharge were the best way to maintain the hydrologic regimes and protect the existing ecological conditions in the streams.

Maximizing Land Application

Infiltrating both storm water and wastewater to the groundwater throughout the watershed is possible, practical and cost-effective. Discharges of storm water and treated wastewater to streams and creeks and wetlands are proposed by engineers resorting to traditional methods that lack imagination. In many instances, these proposals are actually more expensive for the developer. Public education and outreach initiatives can help to change this trend to more environmentally sound practices. But municipal officials, including planning commissions, boards of supervisors and council members can make a huge impact by making these preferences clear when subdivisions and land developments are first introduced as sketch

plans. Act 537 plans, subdivision and land development ordinances, and storm water management ordinances need to contain language making this the preference of choice for each of the municipalities in the watershed.

NONPOINT SOURCE CONTROL

Open Space Initiatives

The Paradise Creek Watershed is blessed with an energetic group of volunteers on regional open space committees. Within the watershed hundreds of acres of precious open space has already been conserved. But there will never be sufficient funds to purchase all of the vulnerable lands. Along with open space preservation through acquisition and easements, zoning techniques can be used to require open space as part of the development process. By requiring low impact conservation designs, municipalities can protect the watershed as well as protect development interests. These designs typically lower the costs associated with the development by requiring fewer miles of roads and utility runs, thus creating a win-win situation for developers and environmentalists.

Benefits of preserving the land include limiting the amount of impervious surfaces, maintaining an adequate level of infiltration of stormwater, decreasing flooding and erosion, decreasing nonpoint source pollution, maintaining habitat and biodiversity, providing recreational opportunities, protecting quality of life for area residents and increasing property values.

EAC Sharing

Environmental Advisory Councils can act as extremely important liaisons between municipalities. Act 148 of 1973 authorized municipal governing bodies to establish Environmental Advisory Councils to advise the agencies of the community on the protection, conservation, management, promotion, and use of natural resources including air, land, and water. The Townships of Barrett, Coolbaugh and Paradise have Environmental Advisory Councils serving their communities.

Under the Act, the Environmental Advisory Councils have the following responsibilities:

- To keep an index of all open space areas, publicly or privately owned, including but not limited to flood-prone areas, swamps and other unique natural areas, for the purpose of obtaining information on the proper use of such areas;
- To identify environmental problems and recommend plans and programs to the appropriate agencies for the promotion and conservation of natural resources and for the protection and improvement of the quality of the environment;
- To make recommendations as to the possible use of open land areas;
- To advise local government agencies in the acquisition of property;
- To promote a community environmental program.

The Environmental Advisory Councils in the watershed, by meeting together on a regular basis, could help define the goals and values shared by the individual municipalities, and help foster the cooperation and coordination necessary to provide a watershed-wide perspective.

Lake and Pond Management

Lake ownership is a responsibility. As demonstrated by Molesky's report on Lake Crawford, lakes and impoundments impact water quality in a watershed. Many of the impoundments that exist in the Paradise Creek Watershed are considered "in-stream" and are little more than interruptions in the water flow. While the lakes can act as sinks for sediment and nutrients, they can also discharge significant quantities of pollutants if they are not maintained properly. In order to maintain the health of both the streams and the lakes, management plans should be developed for all impoundments in the watershed.

Forestry

Education and outreach associated with sound forestry principles should be two-fold. First, open spaces protected through conservation (low impact) zoning, and through acquisition and/or conservation easements need to be properly managed. Educating the public and open space committees about sound forestry management skills is a fundamental component of open space operation and management in a heavily forested watershed like the Paradise Creek Watershed.

Second, the importance of maintaining the forest canopy and protecting the aesthetics associated with this crucial aspect of the character of the watershed cannot be underestimated. The vast extent of the forest cover is probably the single most important natural feature in the Paradise Creek Watershed. Soils in a forest typically have a rather high capacity for absorbing rainwater. The litter layer on the forest floor aids in the absorption of water and protects the soil from erosion.

Cutting of timber occurs for generally one of two reasons. Timber harvesting is done to remove trees for processing into lumber or for making paper. Trees can be selectively removed from a forest, or the forest can be clear-cut (remove all the trees). Clear-cutting obviously has the greatest impact on the forest and both the quality and quantity of water in the watershed. When trees are harvested selectively, the forest regenerates and eventually returns to a mature state. The US Department of Agriculture and the Pennsylvania Department of Conservation and Natural Resources have established Forest Stewardship Programs to assist owners of wooded property to prepare forestry management plans using best management practices.

Landscape Management

Maintenance of the landscape is the responsibility of all property owners, including residential, commercial, institutional and municipal owners. Landscape management can have a significant impact on water quality and quantity in the watershed. Best Management Practices for individual property owners include:

- Use of native plants for landscaping
- Use of stormwater best management practices for drainage
- Use of porous pavement
- Use of gutter and downspout splashguards and infiltration beds
- Proper pet waste management
- Removal of invasive plants
- Restoration, stabilization and management of riparian zones
- Minimization of impervious surfaces
- Use of best management practices associated with wetlands
- Minimization of mowing

Riparian Owner Outreach

A list of riparian owners in the watershed should be developed, and outreach initiatives should be tailored for their benefit. Extensive literature exists to help educate these private property owners regarding their responsibility to protect riparian areas.

Household Hazardous Waste

The DEP defines household hazardous wastes as those wastes produced in our households that are hazardous in nature, but are not regulated as hazardous waste under federal and state laws. According to DEP statistics, each person in the Commonwealth produces an average of four pounds of household hazardous waste annually. Approximately 25,000 tons per year of household hazardous waste is generated statewide. Pain and paint related products, pesticides, pool chemicals, drain cleaners, degreasers, motor oil and some car care products are the primary sources of hazardous waste. If these materials are not used and disposed of properly they can cause a serious threat to the environment and to public health.

The primary means of addressing this potential threat is proper use, storage and disposal of these products. Education is important. Household hazardous waste programs should be on a multi-municipal or county level that includes periodic collection opportunities for homeowners. The DEP has a matching grant program for funding such programs.

Dirt and gravel roads

Pennsylvania has over 28,000 miles of unpaved dirt and gravel roads serving rural residents. While not quantified, many dirt and gravel roads exist in the Paradise Creek Watershed. If not properly constructed and maintained, these roads can become a significant source of dust and sediment that can wash into the streams. The proper construction of these roads includes an adequate crown to direct runoff, as well as maintenance of drainage ditches and surfaces. Dirt and gravel road construction, repair and maintenance should be the focus of future public education and outreach initiatives.

Invasive Species

Plant life in the Poconos is changing according to Jerilynn Jewett-Smith, Project Manager for the Brodhead Watershed Invasive Species Management Plan project, sponsored by the Brodhead Watershed Association and funded by a grant from the Department of Conservation and Natural Resources. “The cattails that used to grow near water have been crowded out by a tall feathery, non-native grass. Our native plants have been overwhelmed along roads by garlic mustard weed in spring and Japanese stiltgrass in summer. The woods that used to have an understory of laurels and ferns instead are besieged by Japanese barberry. Stream banks are lined with Japanese Knotweed,” she claims. According to Jewett-Smith, the invasive species are crowding out natives, destroying food sources, changing habitats, harming wildlife, and damaging the streams and waterways. Other invasive species include critters, like gypsy moths and the hemlock wooly adelgid that represent a direct threat to riparian hemlock stands which provide substantial protection to stream banks and water quality.

The Brodhead Watershed Association advises all municipalities to include a list of plants that developers should avoid – and a list of plants that are recommended – in municipal subdivision and land development ordinances. This recommended list was mailed to municipalities in February 2006, and includes valuable contact information for resources at the Penn State Master Gardeners program and the Department of Conservation and Natural Resources.

Chapter Four

Stakeholders

This management plan for the watershed is being put forward as a tool. It is a tool that has a number of components addressing various aspects of the watershed and how to maintain the high quality of the environment of the area. The chapter on the existing conditions illustrates how complex the watershed is and the many factors that affect the quality of the water in the streams and the quality of life. The tools for maintaining and improving conditions in the watershed and the players involved are equally as complex.

The list of stakeholders runs the gamut from State, County and municipal agencies, the business community to every resident of the watershed. In other words every governmental agency that has some jurisdiction and everyone who owns a business or lives in the watershed is a player and has a role in implementing this management plan.

Environmental Protection Agency

The mission of the Environmental Protection Agency is to protect human health and the environment. Since 1970, EPA has been working for a cleaner, healthier environment for the American people. In addition to its primary responsibility of developing and enforcing environmental regulations, the agency provides financial assistance for environmental programs. The Region 3 office of EPA is located in Philadelphia.

Delaware River Basin Commission

The Delaware River Basin Commission was established in 1961 when President Kennedy and the governors of Delaware, New Jersey, New York and Pennsylvania signed a compact. DRBC was charged with managing the Delaware River without regards to political boundaries. Commission projects include water quality protection, water supply allocation, regulatory review, water conservation initiatives, watershed planning, drought management, flood control, and recreation. The DRBC played significant roles in the preparation of the *Pocono Creek Pilot Study*, the *Brodhead Watershed Conservation Plan*, and with this Plan. Robert Limbeck, Watershed Scientist, with DRBC prepared *Stream Morphology and Water Quality Based Restoration Plan for the Paradise Creek Watershed*, an important component study of this Management Plan.

Commonwealth of Pennsylvania

- **Department of Environmental Protection**

“The Department of Environmental Protection’s mission is to protect Pennsylvania’s air, land and water from pollution and to provide for the health and safety of its citizens through a cleaner environment.” DEP is also responsible for all land and water management programs in the Commonwealth.

- **Department of Conservation and Natural Resources**

The Department is charged with maintaining and preserving the 116 state parks; managing the 2.1 million acres of state forest land; providing information on the state’s

ecological and geologic resources; and establishing community conservation partnerships with grants and technical assistance to benefit rivers, trails, greenways, local parks and recreation, regional heritage parks, open space and natural areas.

- **Department of Transportation**

The stated mission of PennDOT – “Through the active involvement of customers, employees and partners; PennDOT provides services and a safe intermodal transportation system that attracts businesses and residents and stimulate Pennsylvania’s economy.” The Department is responsible for maintaining the state highway system. Through a planning system that includes municipal, county and regional planning agencies and governments, administers a program for making major improvements to the highway system and the construction of new roads.

- **Pennsylvania Fish and Boat Commission**

The Commission, an independent agency, has fisheries management jurisdiction over the waters of the Commonwealth. The jurisdiction includes approximately 83,000 miles of rivers and streams, almost 4,000 lakes, reservoirs and ponds, and over 300,000 acres of wetlands. The Commission is responsible for protecting and managing fishery resources and regulating recreational fishing and boating on Pennsylvania waters.

- **Pennsylvania Game Commission**

The Game Commission is the management agency for the wildlife resources throughout the Commonwealth. Its programs for managing wildlife include monitoring populations, establishing regulations, setting seasons and bag limits, improving habitat, efforts to protect wildlife, and providing education programs. The Commission also manages the State Game Lands program that encompasses 1.4 million acres. Specific management plans are prepared for each area.

State Legislators

- State Representative Mario M. Scavello

Representative Scavello’s district includes Coolbaugh, Jackson, Paradise, Pocono and Stroud townships and East Stroudsburg, Mount Pocono and Stroudsburg boroughs.

- State Senator Robert J Mellow

Senator Mellow represents the Twenty-second Senatorial District which includes all of Lackawanna County, the boroughs of Avoca, Dupont and Duryea in Luzerne County, and in Monroe County Mount Pocono Borough and Barrett, Coolbaugh and Paradise townships.

- State Senator Raphael J. Musto

Senator Musto represents the Fourteenth Senatorial District, which includes Luzerne County and Pocono and Tobyhanna townships in Monroe County.

Monroe County

- **Monroe County Commissioners**

As the governing body of Monroe County, the Commissioners are responsible for all countywide initiatives and programs. Among the many county departments and programs there are several that are related to and have some bearing on the implementation of this Watershed Management Plan. The relevant departments are: the Planning Commission, Vector Control, Highway Sanitation, Recreation and Parks, Conservation District and the Land Preservation Program. The Commissioners can also lend their support (financial and/or endorsement) to environmental initiatives of municipalities and environmental organizations. One environmental program the Commissioners have a direct responsibility for are stormwater management studies and plans prepared under Act 167 of 1978. Under the Act, the County has the responsibility to conduct the study and prepare a model ordinance that is recommended to the involved municipalities for adoption. Currently, there is a model ordinance that is pending for the Brodhead Creek and McMichaels Creek prepared by the Conservation District. After the model ordinance is enacted by the municipalities in the watershed it will be a valuable tool for protecting the water quality of the streams.

Monroe County Comprehensive Plan – In 1999 the County Commissioners adopted the Monroe County Comprehensive Plan Monroe 2020. The Plan presents a series of goals for accommodating the projected growth while preserving and enhancing the quality of life for the residents of the County. The following are the goals of the comprehensive plan:

- Preserve and enhance the most environmentally valuable natural features, including:
 - a) water resources, quality and quantity; b) the best land for agricultural use; c) critical wetlands and wildlife habitats; and d) unique scenic views and areas of visual quality.
- Establish more efficient, compact patterns of land use while maintaining and upgrading the County’s visual character.
- Diversify the County’s economy and expansion of existing Monroe County businesses.
- Attract new enterprises that create jobs with good pay, contribute to the tax base, and balance the burden homeowners and businesses now face for financing public facilities and services.
- Locate new development on sites served by existing infrastructure (water, sewer, roads, etc.) or where existing infrastructure can be extended economically.
- Create more places for community activities.
- Expand recreational opportunities and sites to serve more local resident participation.
- Create greenways, trails, and more facilities for safe pedestrian and bicycle travel, both on and off existing roadways.
- Maintain and enhance the school system as an organizing element and a focus for community activity.
- Encourage multi-municipal planning and zoning activity (aided by the County).

- Encourage joint municipal agreements on operation of services.
- Develop required infrastructure to support economic development.

Municipal Partnership Program – This program was established to promote the implementation of the County Comprehensive Plan through cooperation between the County and the municipalities. The County provides technical support and shares data with the municipalities in preparing comprehensive plans and ordinances that enhance the environment and provide for balanced economic growth.

Monroe County Open Space Plan – In 2001, the County Commissioners adopted the Plan that the subtitle describes as an action guide to preserving and enhancing Monroe County’s green infrastructure. The Plan addresses heritage resources, Growing Greener (a zoning technique that gives priority to preserving natural resources), parks and recreation in the County, greenways and open space acquisition. The Plan promotes the preparation of municipal open space plans. This goal was accomplished with the preparation of six regional plans that involve all of the municipalities.

Open Space Bond Referendum – In 1998 the residents of the County approved a referendum for the Commissioners to issue a \$25,000,000 bond issue for the preservation of open space. Under the program, money is provided to municipalities, regional groups, and to the County for open space planning and for the purchase of land and/or conservation easements.

Agricultural Easement Purchase Program – In 1990 the Agricultural Land Preservation Board was established to preserve prime agricultural land in the County. The Pennsylvania Department of Agriculture’s Bureau of Farmland Preservation and the Monroe County Open Space Bond provide funding for the purchase of land and conservation easements.

- **Monroe County Planning Commission**

The County planning commission has responsibilities assigned to it by the Pennsylvania Municipalities Planning Code. Responsibilities relevant to the watershed include the review of all proposed subdivision and land development plans and all proposed amendments to municipal comprehensive plans and ordinances. In addition, the planning commission is a resource for professional planning assistance in a variety of ways to municipal officials.

Watershed management implementation roles:

- Review proposed subdivision and land development plans, address environmental issues
- Advocate a county policy on natural resource protection
- Provide educational material on the protection of natural resources
- Maintain current aerial photographs of the county
- Maintain and expand a Geographic Information System for planning and monitoring programs, and assist municipalities with a system

- Provide professional planning assistance to municipalities
 - Continue stream monitoring programs
 - Have periodic household hazardous waste collection
- **Monroe County Conservation District**

The Monroe County Conservation District is a legal subdivision of state government, responsible under state law for conservation work within the boundaries of Monroe County. The Conservation District is governed by a Board of Directors appointed by the County Commissioners. Under a delegation agreement with the State Department of Environmental Protection the Conservation District administers Title 25, Chapters 92, 102 and 105 of the Pennsylvania Code. The Conservation District reviews erosion and sediment control plans on proposed developments processes DEP General Permits for minor wetland impacts.

In addition to the regulatory role it plays, the Monroe County Conservation District is involved in many projects to promote the wise use and conservation of the county’s soil and water resources through planning, intergovernmental cooperation and environmental education.

Projects

The Conservation District has participated in several projects that build bridges of cooperation between the public and private sector. The types of projects they are involved in include: Act 167 Stormwater Management Planning on a watershed basis in the Brodhead, McMichaels and Tobyhanna watersheds, Flood Plain Monitoring, Dirt and Gravel Road Maintenance, the Annual County wide Water Quality Study, the Delaware River Basin Planning Committee, DCNR Rivers Conservation Plans for the Brodhead Creek Watershed, the Cherry Creek Watershed and the Lehigh River, the Pocono Creek Goal-Based Management Plan, the Pocono Creek Sustainability Study, the Paradise Creek Watershed Assessment and Management Plan, the Lake Wallenpaupack Watershed Management District Board, the Pocono Mountains Chamber of Commerce Environmental Committee, the Monroe County Watershed Alliance, the Monroe County Litter Control and Beautification Board and the Monroe 2020 Executive Committee.

Environmental Education Center

The Conservation District in Monroe County also boasts a nationally-recognized Environmental Education Center. The EE Center and Conservation District offices are located on the 166-acre Kettle Creek Wildlife Sanctuary in Bartonsville, Pa. The mission statement of the EE Center is, “Conservation through Education.” To fulfill its mission the EE Center strives to:

- Provide areas in our County for outdoor laboratories where plants, animals and entire ecosystems can be studied;

- Sponsor and participate in educational programs, ecological research, and classroom teaching;
- Cooperate with other agencies and organizations concerned with environmental education and;
- Provide leadership training programs in the field of conservation, environmental education and natural history.

Today the Monroe County Environmental Education Center is under contract with all of the public school districts in county. The 5 full time environmental educators reach approximately 25,000 school children annually. In addition to school programs, the staff also provides opportunities for the general public to participate in a wide variety of natural history and conservation programs.

Watershed Specialist

The Conservation District has a Watershed Specialist staff position. This person is dedicated to assisting county residents, municipal officials and other governmental agencies in understanding watershed conservation issues. The Watershed Specialist participates in watershed assessments, conservation planning and water quality monitoring. They are also responsible for providing outreach and education of water resource protection and watershed conservation issues through out the county

Stormwater

The County Conservation District has had the responsibility of assisting the Monroe County Planning Commission in preparing stormwater management plans under Act 167 of 1978, the Pennsylvania Stormwater Management Act. Recently, a new Stormwater Management Plan update for the Brodhead Creek and McMichaels Creek was completed. The District has stated that it believes “this is the first Model Ordinance in the state to comprehensively incorporate the Department’s Stormwater Policy, Smart Growth Initiatives and NPDES Phase II – during and post construction – requirements.” The model ordinance is an important tool for the municipalities in the Paradise Creek Watershed for the protection of the water quality of the streams.

- **Monroe County Municipal Waste Authority**

The Authority’s recycling project is located on a small 3.87-acre parcel in an existing industrial business park in Tobyhanna Township. The facility utilizes innovative automated materials handling equipment for the recyclables, as well as advanced security measures to enable the site to operate without having staff on-site. The facility enables the Authority to minimize the hauling and handling costs associated with the recyclables, thereby making the entire process more efficient and profitable for the Authority. Materials that can be recycled are collected in Blueboxes throughout the County. The material is then taken to the recycling center.

- **Penn State Cooperative Extension Service – Monroe County**

The Cooperative Extension is a department of the Pennsylvania State University that extends its campus resources to communities through offices in counties staffed by university professionals. The agency provides the latest research and technical information of the university to county residents. Priority is given to the economic, social and environmental topics related to the families and community.

Watershed management implementation roles:

- Provide environmentally sound lawn care management literature and programs
- Provide assistance to farmers on good conservation practices
- Assist property owners with good forestry stewardship programs.
- Master Gardeners provide assistance on the use of native plants, the control of invasive plants and forestry stewardship.

Municipalities

The municipalities in the watershed are the most important and involved stakeholders in the management of the watershed. Under the laws of the Commonwealth it is the municipalities that have the authority to plan for and regulate land use activities. The comprehensive plan, zoning ordinance and subdivision and land development ordinance are the three primary tools for dealing with land use. All three are subject to the provisions of the Pennsylvania Municipalities Planning Code (Act 247 of 1968). Municipal land use regulations have evolved to the point where the protection of natural resources and the environment is the guiding principle of the plans and ordinances.

Watershed management implementation roles:

- Use environmentally sound land use planning techniques that are oriented to the watershed.
- Implement open space plans and initiate preservation programs.
- Maintain current water supply planning and enact protection programs.
- Use environmentally sound planning and management for wastewater programs.
- Enact and enforce stormwater best management practices.
- Coordinate all land use planning programs and ordinances with the other municipalities in the watershed.
- Appoint an environmental advisory council and include the council in the review process for subdivisions and land developments.
- Develop and maintain Geographic Information System files on infrastructure, buildings and other pertinent information, and tie in with the County system.
- Sponsor educational programs on good land use practices.
- Hold periodic household hazardous waste collection.
- Establish management programs for on-lot septic systems.

- **Barrett – Mt. Pocono – Paradise Regional Open Space Advisory Committee**

In June of 2002, the Boards of Supervisors of Barrett and Paradise Townships and the Council of Mt. Pocono Borough adopted the *Open Space and Recreation Plan* for the three communities. The Plan identifies how the three municipalities acting independently and jointly can preserve open space, protect natural features and create new recreational facilities. The Plan inventories existing facilities, surveys the natural resources and does a needs-assessment. Based on the analysis, an open space and recreation plan is presented. The Plan contains goals, recommendations for establishing greenways, preserving open space, protecting natural resources and for enhancing park and recreation facilities. Adoption of the Plan made the municipalities eligible for applying for funding through the Monroe County Open Space Program.

The goals of the Plan that are most relevant to this Management Plan are:

- Protect primary greenway corridors along the Paradise Creek and Upper Brodhead Creek that have the potential to connect with greenways that may be established outside our three-community region.
- Supplement the primary greenway corridors by establishing local greenway segments with unique natural characteristics worthy of conservation.
- Strengthen existing local zoning and subdivision regulations to conserve more natural land and historic resources during subdivision and land development.
- Work with conservation organizations to preserve areas with fragile ecosystems.
- Work with private clubs and other large landowners to help ensure continued conservation of the large tracts of privately held land in the region.

Environmental Organizations

- **Brodhead Watershed Association**

The watershed association has the role of being the guardian and overseer of the watershed. While the Association has no regulatory authority, it is in a position of monitoring the state of the watershed. It is an advocate for maintaining the quality of the area and takes an active role in that regard. Another role of the Association is to provide educational programs and material on the proper management of the watershed. As it did with the initiation of this Plan, the Association can and should engage in developing programs and projects and seeking funding to accomplish them.

Activities of the Brodhead Watershed Association include:

- Native plant sale – The second annual native plant sale was held in 2005. The purpose of the sale is to promote the use of plants that are native to the area. The plant list in 2005 included nine varieties of trees, five varieties of shrubs and twelve herbaceous plants.
- Streamwatch Volunteers – The Streamwatch Volunteer Program is the first and longest running project of the Association. The program involves volunteers who are the monitors and stewards of the streams near their homes. The volunteers monitor approximately 100 sites. Water samples are taken once a

month at the sampling sites and the data is entered into a database that provides a continuous record of the conditions of the streams.

- Stream Name Sign Program – In partnership with municipalities in the watershed and the Pennsylvania Department of Transportation, stream name signs have been installed at many road crossings.
- Streambank Restoration and Planting – In conjunction with Paradise Township and Penn State Master Gardeners, the Watershed Association planted native plants along the bank of the Paradise Creek at a Township park. Through this program a brochure, “*Going Native in Paradise*” was published that discusses the benefits of using native plants.
- Paradise Headwaters Project – With funding from a Coldwater Heritage Grant, BWA had several studies done of Paradise headwater streams. BWA also received grant funding to stabilize a section of streambank along the Paradise Creek and improve in-stream trout habitat. The study revealed the fish population in most of the Paradise headwaters exceed the Pennsylvania Fish and Boat Commission’s requirement of “Class A Wild Trout” designation – their best designation. One of the sites had four times the amount of fish required for the designation. Signs were erected at the Paradise Township Park and nearby explaining the project.
- Invasive Species Management Plan – This is a new project that will map locations of invasive species in the watershed and develop a plan for control in problem areas. A grant in the amount of \$40,000.00 was received for the study from the Pennsylvania Department of Conservation and Natural Resources.
- The BWA has prepared River Conservation Plans for the Brodhead and Cherry Creeks. The Brodhead Watershed Conservation Plan was the basis for this sub-watershed study.

Watershed management implementation roles:

- Be the lead agency in administering and advocating for the implementation of this Management Plan.
 - Serve as a liaison with municipalities in the promotion of environmental programs and initiatives.
 - Continue to conduct stream monitoring.
 - Advocate for improvement projects for lakes and impoundments.
 - Initiate lake management programs.
 - Advocate retrofitting existing stormwater facilities.
 - Provide educational programs and materials for residents.
 - Work with the school district on providing educational programs on environmental topics.
- **Pocono Environmental Education Center**

The Pocono Environmental Education Center (PEEC), located within the Delaware Water Gap National Recreation Area, is a special place for students, teachers, families, Scouts, birders, botanists, photographers, hikers, and everyone else interested in learning about the natural world in a beautiful and informal setting.

The study of nature and natural systems is the focus at the Environmental Center, its proximity to a quarter of a million acres of public lands, including the National Recreation Area and numerous state parks, forests, and game lands offers a world of opportunities to explore:

- Shady Hemlock gorges
- The wild and scenic Delaware River
- Diverse lowland and upland forests
- Fields blooming with wildflowers
- Rushing waterfalls and streams
- Unique flora and fauna of boreal bogs
- Fossils as old as 400 million years

- **Kettle Creek Wildlife Sanctuary**

The Sanctuary is a 120-acre preserve near Bartonsville owned by the County and managed by the Monroe County Conservation District. As an educational facility it has an old field, mature deciduous forest, evergreen stands and a pond. In addition, there are two and one half miles of trails that are open to the public. The Monroe County Conservation District's Environmental Education Center is in the sanctuary. The Education Center provides environmental education programs for all ages in the Center on the outdoor areas of the Sanctuary.

- **Pocono Heritage Land Trust**

The Land Trust is a private non-profit organization formed in 1984 for the preservation of land in Monroe and Lackawanna counties. The preservation efforts of the Trust have been primarily focused in Barrett, Paradise and Pocono townships. Over the years the Trust has preserved approximately 1,400 acres through fee simple acquisitions and the purchase of easements. In the fall of 2005, an executive director was hired and there were approximately 600 acres of land that the Trust was in the process of preserving.

In its continuing efforts in the area of Paradise Township, the Trust is in the early stages of organizing an initiative in the Brodhead and Paradise creek watersheds to prepare a greenway plan. The objective will be to prepare a plan for the establishment of a permanent greenway along these two streams and their tributaries. The Trust intends to involve the municipalities in the watersheds as well as the property owners and the fishing clubs.

Watershed management implementation roles:

- Continue its efforts to preserve properties in the watershed in cooperation and in conjunction with county, municipal and other conservation organizations.
- Pursue the preparation and implementation of a greenway plan for the Watershed.

- Continue to be an advocate for the preservation and protection of the natural environment in the Watershed.

Business Community

Businesses, whether they are in retail, industrial, or service, are part of the community within the watershed. Therefore, they are stewards of the watershed along with everyone else who lives and works in the area. Existing businesses have an obligation to maintain their properties to prevent things that will be a detriment to the watershed and to improve facilities that are not in the best interest of the streams. New businesses must be aware of current regulations and best management practices so they will have minimal impact on the environment. Some businesses serve primarily the local population, while many are oriented to serving the tourist trade. The natural scenic beauty of the Paradise Creek Watershed is the primary attraction to the area. Therefore, the success of the business community is tied directly to maintaining the scenic beauty that is provided by the natural features in the watershed.

Watershed management implementation roles:

- Retrofit existing stormwater facilities
- Use best management practices for stormwater facilities
- Maintain stormwater management facilities
- Preserve and maintain riparian buffers
- Maintain on-lot wastewater facilities
- Be responsible in the use and storage of hazardous materials
- Understand the importance of the watershed
- Be an advocate for maintaining the quality of water in the streams and the scenic beauty of the Watershed – be a member of and support local conservation organizations
- Employ mass media coverage of programs supporting the stewardship of the watershed.

Civic and Community Organizations

Civic and community organizations also have a stewardship role in maintaining the quality of life in the watershed.

Watershed management implementation roles:

- | | |
|--------------------------|--|
| Fishing clubs: | Maintain riparian buffers |
| | Plant trees and shrubs to reestablish riparian buffers |
| | Support conservation and educational programs |
| Community organizations: | Support conservation and educational programs |
| | Initiate and sponsor conservation projects |

Residents

The last group of stakeholders in the watershed, and one of the most important, are the people who live in the area. They have a vested interest in the area and are deeply concerned with the quality of life and environment. Some individuals in the Paradise Creek Watershed are the third or fourth generation of their family to live here; others have chosen to live here only recently. Regardless of the length of residency or their family history, they have roles to play in the management of the watershed. All of the categories of players listed above, with the exception of the State agencies, are composed of residents, either entirely or to some degree.

Watershed management implementation roles:

- Use good management practices for lawn care
- Follow good management practices for on-lot sewage system
- Follow wise forest management practices
- Maintain riparian buffers properly, and reforest where appropriate
- Dispose of household hazardous wastes properly
- Be an active member and supporter of conservation organizations
- Be well informed on the importance of the watershed and its environment
- Serve on municipal or county boards and commissions
- Support environmental education programs in elementary through high school
- Use good management practices for animal care – domestic and livestock

Chapter Five

Long-term Watershed Management

Some form of institutional infrastructure is necessary to implement the Paradise Creek Watershed Management Plan. Without the oversight and promotion by an organization, the Plan is likely to share the fate of many other well-intentioned plans, i.e., forgotten on a shelf gathering dust. The recommendations and actions in this Plan are rather diverse and involve a number of municipalities, agencies and groups.

This Plan identifies actions intended to protect and enhance the natural resources of the watershed and to maintain the quality of the water in the streams. These actions call for partnerships between public and private agencies, as well as State, County and municipal agencies. The Brodhead Watershed Association, the sponsor of this Plan, is the appropriate agency to oversee the implementation of the recommendations of this document.

Implement the Watershed Management Plan

Functions of the Brodhead Watershed Association directed towards implementation of the Plan include:

- Acting as an advisory body to existing decision-making bodies
- Continuing the watershed planning process
- Helping to resolve citizen's problems by serving as a liaison between government agencies and the public
- Resolving conflicts between parties and addressing contentious issues
- Acting as a repository for watershed information, and a source of information on enhancement techniques
- Raising funds to further watershed management and enhancement
- Increasing public awareness of environmental matters by involving citizens in enhancement projects and educational programs
- Evaluating progress toward watershed management goals
- Acting as an advocate in support of watershed management goals
- Coordinating volunteer activities
- Promoting the establishment of management programs for on-lot septic systems.

The Watershed Association has a broad membership that includes all stakeholders in the watershed. In this context, a stakeholder means all individuals, businesses or groups that have an interest in the watershed. A stakeholder's interest might be that they own land, a home or a business in the watershed. The municipal and the county governing agencies are stakeholders. So are government agencies with responsibilities for environmental management in the watershed, such as the Department of Environmental Protection. Non-profit groups with social or environmental interests in the watershed are stakeholders too.

The key concept underlying this organizational model is that watershed improvements can best be made by obtaining the prior agreement of all stakeholders. The advantage of this approach is that it capitalizes on the widespread desire to manage natural resources wisely. The

Watershed Association's influence should derive from its independence and its ability to present itself as a representative of all interests in the watershed.

Many of the implementation tools suggested by this plan are the responsibility of public agencies. The primary improvement needed is better coordination of public agency actions that affect the watershed. All jurisdictions would benefit from coordinated regulations that better reflect the hydrology of the watershed. The Watershed Association is in a position to provide the necessary coordination.

The Brodhead Watershed Association is a well-established non-profit, all volunteer organization that is dedicated to protecting the environment in the watershed.

“The mission of the Brodhead Watershed Association is to protect the environment and water quality within the watershed. Strategies to achieve the mission include education to enhance public understanding of water issues, data collection, community activism, and legislative review.”

Foster Development Of A Watershed Stewardship Ethic

Significant improvements to the watershed environment and protection of existing conditions are unlikely to occur without the active participation, or at least awareness, of most residents and property owners. Thus, an important part of the plan is to develop an awareness that all actions in the watershed are interconnected and that it is in everyone's interest to treat the watershed's natural resources with respect.

Establish the Paradise Creek Watershed Information Clearinghouse and Library

The Brodhead Watershed Association should continue to maintain a single location for the collection of reports, studies and other materials relating to the preparation of this Plan and all materials related to the watershed. The web site of the Paradise Creek Watershed is an invaluable tool for the dissemination of information to anyone living, working or doing business in the watershed.

Develop and Implement a Public Education Program

The Watershed Association should develop and implement an education program designed to increase public awareness and understanding of the effects of various activities on the natural resources of the two watersheds. This program will take advantage of existing sources of information and cooperate with other government and agency programs. Its focus will be to promote land preservation, adoption of best management practices for stormwater management and reduction of non-point sources of pollution. Education activities might include:

- Lecture series describing the natural resources and history of the watersheds.
- Presentations to neighborhood groups and service clubs.
- Material and informational support for cooperative teaching programs with schools, and school participation in other educational activities.
- Workshops for streamside property owners on the importance of riparian buffers and other topics.

- Workshops on the proper maintenance of on-lot wastewater disposal systems.
- Field trips to private properties that provide good examples of environmentally-sensitive landscaping.
- Information to new landowners in the watershed providing a full explanation of environmental regulations that apply to their property.
- Keep residents apprised of the “State of the Watershed” and the progress of the plan through a newsletter.

Organize and Support Volunteer Stream Improvement Activities

It is expected that volunteer activities will play an important role in implementing the Plan. Many small stream clean up, bank and riparian corridor enhancement and fish habitat improvement projects will need to be implemented by volunteers. Both the municipalities and the Brodhead Watershed Association should assist in the planning and organizing of these projects. The Association can maintain a registry of potential volunteers and volunteer organizations. An outreach program to schools, service clubs, scouts, etc., can be implemented to recruit volunteers. The Association could coordinate activities with other groups with similar goals.

Provide Technical Assistance to Privately-Funded Stream Improvement Projects

Most of the Paradise Creek and its tributaries flow through privately owned lands. Consequently, successful enhancement of the stream corridors will depend on the active participation of private landowners. The Brodhead Watershed Association and the municipalities can provide technical information and guidance to landowners wishing to enhance natural vegetation on their property. For example, if a property owner wishes to replace lawn extending to the stream bank with a more natural complex of vegetation, the Association can assist in the development of a landscape plan, provide guidance on sources of native plants, and may be able to provide volunteer assistance with the construction.

The U.S. Department of Agriculture, Natural Resources Conservation Service, Department of Conservation and Natural Resources, and the Conservation District can provide technical assistance and information to landowners. These organizations also sometimes have grant funding available for stream enhancement projects. The Watershed Association should work with these agencies to provide coordinated landowner assistance. The Watershed Association should also organize periodic workshops on stream bank revegetation and enhancement for streamside property owners.

Chapter Six

Cost – Benefit

The purpose of this document is to present a plan and a management strategy for maintaining the quality of the Paradise Creek watershed and its tributaries. In subjective terms, the watershed is a beautiful place. The steep gradients and meandering lengths of the creek, its rugged wooded terrain and gently sloping valleys make the Paradise Creek watershed an outstanding area of natural beauty in the Pocono Mountains. Because of the natural beauty and the many opportunities it presents, the Watershed has been an attractive place for people to visit for leisure time activities, and for others to make the area their home.

During the latter part of the twentieth century, the Pocono Mountains and the Paradise Creek Watershed became an even more desirable place to live and as a destination for tourists throughout the year. Between 1990 and 2000, Monroe County was one of the fastest growing counties in the Commonwealth in terms of percentage increase in population. The tourist industry in the area continued to prosper and grow, as well. By all indications the trend will continue through at least the first decade of the twenty-first century. Protecting the high quality of the natural environment is of the highest priority regardless of the level of development pressure. Since the natural environment is one of the primary reasons for the attraction of tourists and new residents, it is also imperative from an economic perspective to have an aggressive program for protecting the watershed. Thus, the business community and the residents of the watershed have a vested interest in the implementation of the goals and objectives of this plan to ensure that the scenic beauty and the environmental health of the area will be maintained and enhanced where appropriate.

Protecting natural resources in an area that is experiencing growth in the number of houses and businesses can be a difficult task. Achieving a balance between the desire for jobs, land for homes and businesses and the protection of the environment is a challenge. But economic development and environmental protection share goals in the region. Environmental protection in the Paradise Creek Watershed is essential to a viable economic base, because it is the natural beauty of the environment that is the heart of the tourist industry, and because pristine water quality will continue to attract clean industries.

The continuation of existing monitoring programs will have costs associated with them that include maintenance and upkeep of equipment, laboratory analysis of samples, and personnel. The cost of each monitoring program is very specific to the equipment, personnel and testing that is required for gathering and analyzing the samples. Municipalities and the business community should share in these costs.

The implementation strategies presented in this plan have costs associated with them that range from volunteer time to projects costing thousands of dollars. Some of the strategies are the responsibility of municipal and county governments that will be paid for with tax dollars, staff time and/or grants. Other strategies will be the responsibility of residential and commercial developers with projects in the watershed.

- **Governments** – Municipal and county governments have the greatest responsibility for many of the implementation strategies. Some of the tasks consist of routine operating expenses, while others are special projects that will be dealt with on an individual basis. The governments will fund the projects through staff time, general operating expenses, and specific budget items. Grants are available for some tasks. State agencies also play a role in the implementation of the Plan as the administrator of grants, the provider of services and through the enforcement of state laws and regulations.
- **Developers** – Residential and commercial developers with projects in the watershed will bear the cost of some of the implementation strategies. Costs for developers include additional information and data with plan submissions, more thorough analysis of site conditions and the use of best management practices for stormwater management. In many cases, cost benefits will be realized through reductions in infrastructure investments and use of non-structural BMPs.
- **Conservation Organizations** – The role of conservation organizations ranges from being an advocate for the watershed, to managing monitoring programs, to coordinating stream improvement projects and presenting educational programs. Funding for these groups comes from general revenues, sponsors for particular projects and grants.
- **Business owners** – The business community, both those that have been in the area for years and the recent establishments, have an obligation to be good stewards of the watershed. Property maintenance is a key component for businesses. Maintaining stormwater facilities, the proper handling and storage of hazardous materials, and the safe storage and disposal of waste material. Business owners should be active sponsors and supporters of conservation organizations.
- **Residents** – The residents living in the watershed will have the least cost to bear in terms of implementing the recommendations of the Plan. Nevertheless, they have an important role to play. It is important all residents be advocates for and stewards of the watershed by properly disposing of household hazardous wastes, and maintaining their on-lot sewage disposal system. They must be aware of the pollution potential of lawn care products and the management of domestic animals. Residents can also donate some of their time to municipal commissions and to environmental and conservation organizations in the watershed.

Conservation (Low Impact) Development: Because a developer's density (the number of house lots) is protected in conservation designs, total assessed tax values are generally the same as for traditional subdivisions. Since people pay more for park-like settings, homes on the smaller lots created in conservation subdivisions are worth more than similar homes on larger lots in traditional subdivisions. The developer creates higher value homes at less cost (resulting from fewer miles of roads and utility runs). Numerous successful conservation subdivisions have been created in Pennsylvania resulting in thousands of acres of permanently protected open space.

Stormwater Best Management Practices: As the development community learns to move away from traditional stormwater controls that simply collect and concentrate the runoff, a cost savings is being realized. By focusing on methods to infiltrate the stormwater, engineers are seeing the benefits associated with allowing the land to work for them. By using the soils and

natural topography to treat and recharge stormwater to the groundwater, far less earth moving is necessary. Stormwater that is allowed to flow slowly over permeable areas is reduced in volume requiring smaller structural controls. Because pollutants are mitigated naturally expensive treatment facilities are unnecessary. Stormwater infiltration areas can sometimes be designed as recreational and/or landscape areas adding value to the property, instead of large, ugly basins that lower the property's value.

Floodplain Management: Protection of the floodplain mitigates flooding, but also protects a community's right to flood insurance. Sanctions for inadequate floodplain management include loss of flood insurance availability through the National Flood Insurance Program, loss of federal grants, loss of federal disaster assistance, and loss of federal mortgage assistance and loan guarantees.

Forests and Riparian Buffers: According to the US Department of Agriculture (www.na.fs.fed.us) healthy, mature trees add 10 percent to a property's value, reduce air conditioning costs by 30 percent, and save 20-50 percent on heating costs. Protecting and properly caring for forested areas reduces the probability of catastrophic wildfires, improves air and water quality, and protects wildlife habitat. Allowing excessive earth disturbance in riparian areas diminishes their natural ability to treat pollutants. Trading vegetated buffers for impervious surfaces increases the volume of stormwater runoff, increases peak flows, increases peak flow durations, increases stream temperatures, decreases base flows, increases sediment loading in the streams and risks loss of habitat and fish communities. The cost of treating a polluted stream is far in excess of simple steps that can be taken to protect forests and riparian zones.