

# Brodhead Watershed Conservation Plan

FINAL REPORT

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**With:** BLOSS Associates



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The Watershed Partners were the backbone of this planning process. Their commitment to preserving and protecting the watershed underlies this entire plan.

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# **Executive Summary**

This river conservation plan describes a vision of the Brodhead watershed that can be shared by all who are concerned with what a healthy river means for the residents of our watershed and for our friends and neighbors downstream.

The purpose of the Brodhead Watershed Conservation Plan is to create a plan to help guide and prioritize conservation actions on a watershed-wide basis. Rather than being a one-time, comprehensive study of the watershed, the BWCP is a long-term and continuous management commitment – a broad-brush plan that encourages municipal authorities to commit to the long-term process of implementing the goals and management objectives outlined in this plan.

The Brodhead watershed drains an area of about 285 square miles, or close to half of Monroe County, emptying into the Delaware River just north of where the Delaware River flows through the dramatic cut in Kittatinny Mountain known as the Delaware Water Gap. In addition to being an important source of recreation and habitat, the Brodhead watershed provides the drinking water supply for area residents and visitors.

## ***Critical Decisions***

The Brodhead watershed is at a critical juncture. Monroe County's population has nearly doubled in the last twenty years and is expected to increase by 60 percent over the next twenty. Growth occurs with little consideration of its impact on both the quality and quantity of surface and groundwater. As rooftops, parking lots and streets spread across the landscape, replacing forests and fields, streams suffer. Rain and snowmelt run rapidly off these man-made surfaces instead of soaking into the ground. This stormwater runoff carries pollutants into the streams, accelerates streambank erosion, and raises stream temperatures. Future development and planning should take watershed protection into consideration.

## ***Foundation: The Public Involvement Process***

Through meetings with the public and watershed partners, significant natural, recreational, economic, cultural, and scenic resources were identified. In addition, watershed-specific problems, issues, and concerns were identified.

The biggest issues and concerns within the watershed were found to be unplanned growth, dirtier stream water, polluted stormwater runoff, development on wetlands, and municipal regulations not protective enough of watershed resources. From the issues and concerns identified through the public involvement process, five broad issue categories

were developed and using these categories, five goals were established for the Brodhead Watershed Conservation Plan:

1. ***Water Quality and Quantity*** – Maintain and improve water quality throughout the watershed and insure that an adequate quantity of surface water and groundwater is maintained.
2. ***Watershed Awareness*** – Achieve greater environmental education for all age groups to address water quality, planning & regulations, and habitat.
3. ***Policy, Planning & Regulation*** – Encourage the development of local, state, and federal planning and regulations to collectively facilitate stated watershed management goals.
4. ***Fish and Wildlife Habitat*** – Manage natural habitat to promote biodiversity and to maintain, protect, and enhance natural systems.
5. ***Historic & Cultural Resources*** – Ensure that the historic resources of the Brodhead watershed are preserved and interpreted as educational examples of the area's heritage.

### **Vision Statement**

*Residents and visitors to the Brodhead watershed care about clean water. The pure streams and safe drinking water the watershed enjoys are viewed as precious assets and all are aware of how important it is to continually maintain and protect this resource. Planning at all levels of government continues to point to the importance of maintaining and enhancing this resource as a critical goal for supporting the quality of life within the watershed. Due to this acute awareness, actions are taken that assure that the streams in the watershed will remain healthy for future generations. Both individual actions and municipal policy decisions are made with the knowledge of how these actions affect the health of the watershed and with the understanding that we are all stewards of the natural and cultural resources that affect the health of the watershed. As a result of this understanding and many appropriate follow-up actions future generations are assured of a watershed that continues to sustain its human and natural residents.*

*Water in the watershed is not only clean and plentiful but many of the streams continue to support pristine trout fisheries. The stream corridors also provide an appropriate sense of place as greenway buffers have been maintained and enhanced in a continuous network or green infrastructure that supports other important ecological and cultural functions. In addition to trout habitat, a rich diversity of land and aquatic species are supported. Also residents and visitors alike are connected to much of this network by a series of trails that provide access to nature, interpret the rich history, and provide alternative routes of transportation.*

## ***Critical Actions***

Through a review of the draft action items by steering committee members and municipal leaders, fifteen action items surfaced as “critical”. These critical issues have a “most important” priority ranking in the management options tables found in *Section 3, Recommended Actions & Management Options*. These action items should be addressed first:

- *Strengthen land use ordinances to minimize effects of impervious surfaces.*
- *Develop sewage management programs to better manage on-lot septic systems.*
- *Promote and develop greenways to link important natural, recreational and wildlife habitat areas in cooperation with willing landowners.*
- *Use incentive-based approaches to protect, restore, and conserve important fish and wildlife habitat and direct development away from important habitat areas.*
- *Encourage DEP to take prompt action on known sewage treatment plant violations.*
- *Use open space funds and other monies to protect critical riparian areas.*
- *Increase public access to fishing waters.*
- *Develop educational programs about protecting sources of drinking water in the Brodhead watershed.*
- *Organize watershed awareness raising activities, especially activities that involve children.*
- *Develop programs to protect existing and potential future sources of drinking water.*
- *Strengthen land use ordinances to better protect groundwater recharge. (Locate, delineate, and map significant recharge zones throughout the watershed.)*
- *Strengthen land use ordinances to better protect floodplains.*
- *Develop education programs to encourage landowners and citizens to plant native species, plant or maintain riparian buffers and improve stream habitat.*
- *Restore in-stream habitat in areas degraded by flooding, channelization, loss of riparian buffer, and increased runoff.*
- *Encourage riparian landowners to create and maintain forested stream buffers.*

## ***Action Plan Summary***

The following are summary recommendations for achieving the vision of the Brodhead Watershed Conservation Plan. *Section 3, Recommended Actions & Management Options* provides a detailed listing of strategies and actions required to realize the plan.

### **WATER QUALITY AND QUANTITY**

- To achieve the goal of maintaining and improving water quality throughout the watershed and insuring that an adequate quantity of surface water and groundwater is maintained, municipalities need to strengthen land use ordinances

to better protect floodplains and groundwater recharge areas and to minimize the amount and impact of impervious surfaces. Municipalities should also adopt ordinances consistent with the updated Brodhead / McMichael stormwater management plan. Critical riparian areas should be protected by fee simple purchase or purchase of development rights.

- Municipalities and DEP will promote alternatives (such as land application) to stream discharges from sewage treatment plants where feasible, and lands for land disposal of treated wastewater should be utilized where environmentally sound and economically feasible. DEP will be encouraged to take prompt action on known sewage treatment plant violations. Steps should be taken to develop sewage management programs to better manage on-lot septic systems.
- Riparian landowners should be encouraged to create and maintain forested stream buffers. Partnerships should be organized to restore impacted and eroding streambanks using bioengineering and natural stream design approaches.
- Water quality monitoring efforts should be revamped, including hiring a professional streamwatch coordinator, reviewing current monitoring plans, and encouraging new gauging stations. Projects need to be developed to decrease non-point source pollution from existing developed areas and highways. Water suppliers and municipalities should develop programs to protect existing and potential future sources of drinking water.
- A biomonitoring protocol should be developed to assure that the DRBC standard of “no measurable change” at the Brodhead Boundary Control Point is met in the future. Headwaters areas should be protected.

## **WATERSHED AWARENESS**

- The educational goals of the Brodhead Watershed Conservation Plan can be realized by publishing information about watershed issues on a regular basis in the local media (including newspapers, radio, and television), organizing watershed-awareness raising activities – especially those that involve children, creating a speakers bureau to inform local organizations about watershed issues, and by presenting the Watershed Conservation Plan at municipal meetings. As an awareness-raising tool, a video can be created about the Brodhead watershed.
- Educational programs must be developed to encourage landowners and citizens to plant native species, plant or maintain riparian buffers, and improve stream habitat. Programs should also be developed to educate citizens about protecting sources of drinking water in the watershed.
- Riparian landowners and watershed stakeholders can share information about watershed issues and actions through a watershed information clearinghouse or

become involved through a “community conservation corps” designed to encourage riparian neighbors to work together.

- Landowners should be encouraged to conserve privately owned woodlots, or to use sustainable forestry practices, where applicable. Interested landowners should also be encouraged to place conservation easements on open land through donation or purchase.
- The Brodhead Watershed Association should acquire a full-time staff person to oversee and/or implement the recommendations of this plan.

## **POLICY, PLANNING AND REGULATION**

- Municipalities need to promote conservation of important habitat areas through conservation-based ordinances and codes (e.g. Conservation Subdivision Design / *Growing Greener*), promote and develop greenways to link important natural, recreational, and wildlife habitat areas in cooperation with willing landowners, and review proposed land development plans for their impact on outstanding and unique features. Municipalities should also develop ordinances to maintain a minimum percentage of forest cover and establish Environmental Advisory Councils.
- Funding must be pursued to prepare subwatershed assessments (similar to the Pocono Creek Pilot Study) for each of the remaining subwatersheds within the Brodhead watershed. A water budget should be developed for each subwatershed to assure that surface and groundwater withdrawals do not exceed levels necessary to maintain adequate stream base flow. An analysis of impervious coverage and a build-out analysis should be conducted for the entire watershed.
- The Pennsylvania Department of Environmental Protection should require sewage treatment plant permittees and/or operators to maintain in-stream habitat below sewage treatment plants through bio-monitoring.

## **FISH AND WILDLIFE HABITAT**

- To achieve the goal of managing natural habitat to promote biodiversity and to maintain and protect natural systems, municipalities should use incentive-based approaches to protect, restore, and conserve important fish and wildlife habitat and direct development away from these areas. Inventory studies may be needed to identify Important Bird Areas and other critical habitat areas.
- Open space and other funds should be used to purchase lands from willing sellers to provide public access to fishing waters. Fisheries inventories should be conducted in high priority stream areas, and current fish stocking

programs should be reviewed. New approaches for more effective management of deer, geese, and other nuisance wildlife, and of exotic and invasive species should be developed.

- Restoration of in-stream habitat in areas degraded by flooding, channelization, loss of riparian buffer, increased runoff, or any other cause of stream degradation is also called for. Restoration of previously relocated or channelized stream segments should also be explored.

## **HISTORIC & CULTURAL RESOURCES**

- To achieve the goal of ensuring that the historic resources of the Brodhead watershed are preserved as educational examples of the area's heritage, municipal ordinances need to be amended to encourage creative reuse of historic structures consistent with maintaining the historic character of the building; likewise, permits should be required for demolition. Clear and reasonable design review standards for renovations to historic structures should also be incorporated into municipal codes.
- A plan must be developed for identifying, protecting, and interpreting important historic structures and areas in the watershed. All eligible historic structures should be added to the National Register of Historic Places to ensure their protection.
- Specific projects include: Determine the feasibility of restoration of the historic Henryville House and/or acquiring the site to develop a facility for interpretive use, consider acquiring the 24-acre property containing Marshalls Falls and nearby Titania House as a local park/open space, maintain the historic Double Arch Stone Bridge as necessary to preserve original features, and restore the Creekside Park at the Delaware Water Gap Train Station for historical interpretation and tourism.

## ***Implementation***

An important outcome of this plan is the petition for inclusion of the Brodhead watershed on the Pennsylvania Rivers Conservation Registry. The plan has been developed with assistance from the Pennsylvania Rivers Conservation Program, administered by the Pennsylvania Department of Conservation and Natural Resources (DCNR), and has incorporated a significant public involvement effort. With the endorsement of agencies and municipalities, the registry of the Brodhead watershed entitles projects and programs of the types recommended in this plan to eligibility for implementation funds from the Commonwealth through the River Conservation Program. This will allow a number of organizations, municipalities, conservation districts, county planning organizations, and

community organizations to leverage up to \$50,000 per year to implement the recommendations in this report.

# **Introduction & Background**

## ***Plan Purpose***

The purpose of the Brodhead Watershed Conservation Plan is to create a conservation plan to help guide and prioritize conservation actions in the Brodhead watershed. This document will also be used to petition the commonwealth to have the Brodhead Creek put on the Pennsylvania Rivers Conservation Registry. After obtaining this status, the Brodhead watershed will be eligible for matching funds for the implementation of projects that are directly related to the actions and strategies identified in this plan. Thus, municipalities, the County, the conservation district, and non-profit conservation groups will be able to leverage funds for these purposes.

Ultimately the plan is a means to assemble and focus planning efforts on a watershed-wide basis and identify specific water-related conservation and restoration projects. While much inventory information was gathered and collected from prior related plans and studies, other information was obtained through meetings with the public and watershed partners regarding significant resources within the watershed. The identification of watershed-specific problems, issues, concerns, and constraints was a major focus of the public involvement process performed in developing the plan.

The plan was produced with financial assistance obtained under the *Rivers Conservation Program* administered by the Pennsylvania Department of Conservation and Natural Resources (DCNR), and matching funds and in-kind services from the many partners acknowledged herein. The Brodhead Watershed Association (BWA) has spearheaded the development of the plan. Formed in 1989 as a non-profit, non-governmental, educational organization, BWA was awarded a DCNR River Conservation Planning Grant and on March 25, 1999 signed a contract with DCNR to develop the Brodhead Watershed Conservation Plan. The mission of BWA is to inform and involve watershed residents and visitors about the watershed and ways to protect and conserve watershed resources and values.

A Steering Committee composed of a diverse array of partners and stakeholders, including local, regional and federal representatives, riparian landowners, and members of the public at large, provided advice and assistance throughout the development of the plan and served to underpin the planning process. These partners have worked diligently for more than two years to produce this conservation plan. Their commitment to preserving and protecting the watershed bolsters the plan.

During the implementation phase of this plan, BWA will encourage municipalities, non-profit groups, and other appropriate grantee organizations to apply for funding to implement the strategies and actions included in this conservation plan. Implementation projects will bring this document to life. The BWA and its partners are committed to supporting local communities in the watershed as they begin to implement this plan.

Also, BWA will continue to partner with other organizations, entities, and government agencies to assist in the implementation of the recommendations herein.

## ***The Brodhead Watershed***

The Brodhead watershed drains an area of about 285 square miles, almost half of Monroe County, emptying into the Delaware River just north of where the Delaware River flows through the dramatic cut in Kittatinny Mountain known as the Delaware Water Gap. The Brodhead enters the Delaware River at the southern end of the Delaware Water Gap National Recreation Area, which encompasses a forty-mile reach of the River and is one of three reaches of the Delaware River that are included in the National Wild and Scenic Rivers System.

The Brodhead watershed includes the Brodhead Creek and its major tributaries: Marshalls, McMichael, Paradise, and Pocono Creeks, extending from Barrett Township and Mount Pocono in the north to Brodheadsville in the west to the Delaware River. The watershed includes all or part of 17 of Monroe County's 20 municipalities and part of Greene Township, Pike County.

In addition to being an important source of recreation and habitat, the Brodhead watershed provides the drinking water supply for area residents and visitors. The boroughs of Stroudsburg and East Stroudsburg and surrounding areas are served by public water systems which draw on the Brodhead and Sambo creeks and nearby wells. Most of the rest of the watershed population uses groundwater drawn from private wells.

Much of Monroe County's recent growth has occurred with little consideration of its impact on both the quality and quantity of surface and groundwater of the watershed. As rooftops, parking lots and streets spread across the landscape, replacing forests and fields, streams suffer. Rain and snowmelt run rapidly off these man-made surfaces instead of soaking into the ground. This stormwater runoff carries pollutants into the streams, accelerates streambank erosion, and raises stream temperatures. Future development and planning need to take watershed protection into consideration.

## ***Challenges***

Although the Brodhead watershed currently enjoys excellent water quality overall, there are existing problems and threats to maintaining this state. The case for protection of the Brodhead Watershed is therefore apparent. Major challenges known in the watershed at the start of the planning process include the following:

- ***Water Quality and Quantity*** – Although water quality is generally excellent in most areas, impacts have been documented below some sewage treatment plants and in some built-up areas. In the future, development must consider the quality and quantity of surface and groundwater so that we will have sufficient clean

water for in-stream aquatic life and for human consumption. Sewage treatment plants and on-lot septic systems must be maintained in proper working order so that wastewater does not degrade surface or groundwater. Both point and non-point sources of pollution must be mitigated. Continued use of streams for discharge of effluent from sewage treatment plants should be discouraged and opportunities for beneficial use of discharges explored.

- ***Stormwater and Flood Control*** – Uncontrolled stormwater runoff degrades streams by carrying pollutants, including sediment, to streams and by eroding streambanks causing more sediment to be washed into streams. Uncontrolled stormwater is also lost as a potential resource for recharge of groundwater. Stormwater runoff should be managed to decrease stream pollution and maintain groundwater recharge. Although municipal ordinances do require stormwater management for new developments, they do not require control or treatment of pollutants that stormwater carries, nor do they encourage or require infiltration systems so as to use stormwater to recharge groundwater. The revision to the Brodhead Stormwater Management Plan currently underway will address these concerns if municipalities adopt, and vigorously enforce, ordinances to implement the plan. Still to be addressed is the impact of runoff from existing development. Wetlands play a vital role in storing, treating and slowly releasing stormwater and should be protected from filling or other encroachments. Development on high-risk areas such as floodplains, wetlands, and steep slopes increases stormwater runoff impacts and should be discouraged.
- ***Watershed Protection and Land Conservation*** – The current interest in “*Growing Greener*” and “*Growing Smarter*” techniques for future land development is encouraging. This kind of planned growth recognizes the connections between land use and water resources and attempts to minimize impacts of development on the land and water resources of the Brodhead watershed. Such planned or “smart” growth will help protect land and water habitat for diverse species of flora and fauna. County and regional open space planning efforts can incorporate protection and connections of riparian areas both to provide public access to streams in some areas and to protect those riparian areas from development. Special consideration should be given to the protection of endangered species and habitat types already existing within the watershed.
- ***Recreation*** – Rapid growth has created a need for increased recreational areas in Monroe County. More and affordable recreational opportunities are needed near where people live. Educational opportunities are abundant in the Brodhead watershed and should be expanded. The four school districts within the watershed as well as the Monroe County Conservation District and East Stroudsburg University use the watershed to teach concepts of biology, chemistry, ecology, and conservation “in the field.” The Tannersville Cranberry Bog, a Natural National Landmark, is used for study of its unique bog habitat. The Cranberry Bog, as well as other areas used as outdoor classrooms, should be protected from encroaching development by expansion of the area into public, or

private protected, ownership. Historical resources should also be preserved and made accessible and affordable. Cultural resources unique to this area should also be catalogued and preserved. The development of a system of greenways and trails would also help further the recreation opportunities.

- ***Economic Development*** – Economic development that sustains communities and natural systems should be encouraged throughout the watershed. A principle economic development goal of the Monroe County Comprehensive Plan (Monroe 2020) is to “conserve the environmental quality that is the County’s principal attraction for visitors and residents alike (p. 100).” The Brodhead Watershed Conservation Plan is complementary to the Monroe 2020 planning effort and assumes that economic development and environmental quality go hand in hand.

# Identifying Issues, Concerns & Constraints

In order to identify the issues and concerns of watershed residents, several methods of gathering public input were employed. The Brodhead Watershed Association (BWA) collected information by holding a series of public meetings and soliciting written responses to two citizen surveys, including an EXPO<sup>1</sup> Survey and a Riparian Landowner Survey. Issues identified through an extensive review of prior studies were also included. The Recommended Actions and Management Options listed in *Section 3, An Action Plan for the Brodhead Watershed* have been designed around these public issues. For a complete summary of the public involvement process, see *Appendix A, Public Involvement*.

## *Identifying and Ranking Issues & Concerns*

Issues and concerns were identified through citizen surveys, public opinion solicited at a set of public meetings, and examination of prior studies. An extensive review of available data was conducted prior to preparation of this Plan to help identify some of the key issues in the watershed and potential future impacts of concern. Abstracts of prior studies used to identify issues and concerns are included in this Plan as *Appendix F, Prior Studies*.

These issues and concerns were then ranked in order of importance:

The following issues were identified as “*Most Important*”:

- Unplanned growth;
- Dirtier stream water;
- Polluted stormwater runoff;
- Development on wetlands;
- Municipal regulations and actions not protective enough of streams; and
- Preservation of open space.

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<sup>1</sup> Monroe County Chamber of Commerce’s annual business Expo held at the East Stroudsburg University field house.

The following issues were identified as “*Very Important*”:

- Lower stream flow levels;
- Eroding stream banks;
- Lack of groundwater recharge;
- Pollution of groundwater;
- Need for environmental education and greater public involvement;
- Preservation of animal habitat;
- Increased flooding;
- Loss of biodiversity; and
- Fewer insects.

The following issues were identified as “*Important*”:

- Enforcement of existing laws;
- Lack of regional conservation planning;
- Sewage treatment plant discharges;
- Forest management;
- Invasive species;
- Trash & littering;
- Fewer fish;
- State agencies not doing enough to regulate sewage treatment plant discharges;
- Hazardous materials shipments;
- Commercial export of water resources;
- Insufficient public access to streams;
- Off-road vehicle use (ATVs and dirt bikes);
- Game management; and
- Fisheries management.

### ***Identifying Special Places***

The BWA also wanted to know what is positive about the watershed and what residents are concerned about preserving for the future. In order to protect the resources of the watershed, it is necessary to inventory what is already here that is valuable. Watershed residents were asked to identify “special places” in the watershed.

Not surprisingly, the clean lakes, streams, springs, and drinking water supplies of the watershed were mentioned most frequently:

- Exceptional Value streams (2 mentions)
- Undeveloped headwaters - Barrett Township
- Pocono Creek (above Mountainview) (2)
- High quality streams in Paradise Township, Pocono Township
- Paradise Creek - all
- McMichael Creek
- Mill Creek - Nine Foot Hole
- Wigwam Run

- Cranberry Run
- Devils Hole
- Cranberry Creek (Barrett to Paradise Twp)
- Cranberry Creek - Pocono Twp
- Tank Creek - three springs draining into creek
- Sand Spring
- Lake Swiftwater - above and below
- Lake Crawford
- Deep Lake
- Crescent Lake
- Goose Pond
- East Stroudsburg Reservoir
- Stroudsburg water supply

Also mentioned were scenic waterfalls:

- Sylvan Cascade Falls - Butz Run
- Cranberry Falls - Cranberry Creek (Pocono Twp)
- Paradise Falls
- Indian Ladder Falls - Barrett Twp
- Buck Hill Falls

Preservation of the rural character of the watershed, including scenic vistas:

- Northeast part of Brodhead watershed - unfragmented forest
- Forested lands
- Pocono Manor Lands
- Villages - Cresco, Mountainhome, Canadensis
- Mt. Pocono Knob (2)
- Birchwood area
- Scenic viewsheds
- Big Pocono - maintain panoramic views (3)
- Brodhead Creek - Canadensis to Analomink - vistas
- Sunset Hill - views from

Preservation of recreation and park facilities:

- Big Rock (swimming hole below Stokes Mill Road)
- Pinebrook Park
- Brodhead Greenway
- Big Pocono - trails
- Recreational asset (entire watershed)
- Red Rock - natural waterslide

Historic significance:

- Henryville House
- Delaware Water Gap historic railroad station
- Captain Utt's Grave
- Learn Road cemetery (Native American graves)

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- Sullivans Trail
- Pocono Manor Inn
- Glenwood Hall
- Analomink Area

Preservation of unique natural resources:

- Cranberry Bog (4 mentions)
- Unusual wildlife species
- Fishing clubs' protected lands / streams

## ***Stream Walk Assessment***

A Stream Walk Assessment of the Pocono and Buck Hill Creeks was conducted to provide a benchmark study to help assess the overall health of the watershed and to identify potential management strategies. A description of the stream walk process can be found in *Appendix B, Stream Walk Assessment*.

The stream walk assessment of the Pocono Creek identified three major problems. There were numerous areas of streambank erosion, poor habitat, and inadequate riparian buffers undoubtedly causing accelerated stormwater runoff. Several streambank areas were eroded severely enough to warrant immediate attention. Areas of poor habitat were primarily excessively wide and shallow with poor diversity of flow, substrate and depth. In one location, the streambed was discolored by a point source discharge. Several culverts and drains were located that apparently transport runoff directly to the stream.

Although these problems were distributed throughout the length of the Pocono Creek surveyed, they increased in frequency in a downstream direction. The lower several miles of the stream displayed the most unstable streambanks and more numerous areas of poor habitat. Segments of the Pocono Creek channel have been relocated and meanders cut off for highway construction, a few areas have been channelized, and dumped rip-rap and gabions have been used to stabilize stream banks in a few areas.

To provide a contrast to the Pocono Creek, an assessment by volunteers was also conducted for a more pristine area of the watershed, the Buck Hill Creek, designated as Exceptional Value (EV) under DEP water-quality regulations. Results of the Buck Hill Creek stream walk assessment contrasted dramatically with the Pocono Creek results. Natural vegetation (with a few small areas of invasive species) extended for a much greater width along most of the Buck Hill Creek corridor. Stream banks were quite stable, and habitat was excellent to good. The only area of bank erosion needing immediate attention was along a lower portion of the Griscom Run tributary, which flows through an open portion of the golf course.

## ***Citizen Surveys***

### **EXPO Survey**

In March 2000, BWA conducted a watershed survey of attendees at the business EXPO event conducted by the Pocono Mountains Chamber of Commerce. One hundred and twenty-six surveys were completed. Over ninety percent of respondents indicated that protecting the streams and lakes of the watershed is “important” or “very important”. Runoff from parking lots, roads, highways, and construction sites was cited most often as polluting the watershed. Other concerns were litter & illegal dumping, sediment from eroding streambanks, discharges from industry, failing septic systems, and discharges from sewage treatment plants.

When asked how important certain watershed protection actions would be in the next ten years, respondents said repairing malfunctioning septic systems is important, protection of environmentally sensitive areas is a priority, and preserving vegetation along streams is needed. Other actions that respondents supported include: requiring new development to minimize runoff, improving degraded streams, and educating landowners to protect water quality. For a complete tabulation of the EXPO Survey, see *Appendix A, Public Involvement*.

### **Survey of Riparian Landowners**

A survey of riparian landowners along the Brodhead, Pocono, Marshalls, McMichael, Paradise, and Pocono Creeks was conducted in May 2000. The top concerns of these watershed residents was that over the years, they have perceived less water flowing in the streams and more trash in the water. Eroding stream banks were also noted as one of the top concerns. Nearly eighty percent of respondents cited runoff from roads and highways as a contributor to water pollution in the watershed. Respondents also cited litter and illegal dumping, runoff from construction sites, failing septic systems, parking lot runoff, and eroding stream banks as contributing to water degradation.

The majority of those who responded to the survey felt that protection of environmentally sensitive areas was a priority. Many also felt that preserving vegetation along streams was important, and greater awareness of streams was needed. Many wanted to encourage municipalities to work together on planning and zoning and to require new development to minimize polluted runoff. Other supported actions included repairing malfunctioning septic systems and improving degraded streams. For a complete tabulation of the Landowner Survey, see *Appendix A, Public Involvement*.

## ***Categorizing Issues & Developing Goals***

After collecting information through public meetings, the streamwalk assessments, and citizen surveys, including the EXPO Survey and Riparian Landowner Survey, watershed-related issues were categorized into five major issue categories:

- *Water Quality and Quantity* – Priority issues in this category include dirtier stream water, increased flooding, sewage treatment plant discharges, polluted stormwater runoff, hazardous materials shipments, trash & littering, pollution of groundwater, lower stream levels, eroding stream banks, development on wetlands, and lack of groundwater recharge.
- *Watershed Awareness* – Priority issues in this category include the need for environmental education about watershed issues and protection strategies and greater public involvement.
- *Policy, Planning & Regulation* – Priority issues in this category include unplanned growth, preservation of open space, municipal regulations and actions not protective enough of streams, state agencies not doing enough to regulate sewage treatment

plant discharges, enforcement of existing laws, lack of regional conservation planning, and insufficient public access to streams.

- *Fish and Wildlife Habitat* – Priority issues in this category include loss of biodiversity, preservation of animal habitat, invasive species, fewer fish, fisheries management, forest management, and game management.
- *Historic & Cultural Resources* – Priority issues in this category include the need to preserve historic resources throughout the watershed.

Goal statements were then developed for each issue category:

***Water Quality and Quantity*** – Maintain and improve water quality throughout the watershed and insure that an adequate quantity of surface water and groundwater is maintained.

***Watershed Awareness*** – Achieve greater environmental education for all age groups to address water quality, planning & regulations, and habitat.

***Policy, Planning & Regulation*** – Encourage the development of local, state, and federal planning and regulations to collectively facilitate stated watershed management goals.

***Fish and Wildlife Habitat*** – Manage natural habitat to promote biodiversity and to maintain, protect, and enhance natural systems.

***Historic & Cultural Resources*** – Ensure that the historic resources of the Brodhead watershed are preserved and interpreted as educational examples of the area's heritage.

Action items, or potential management options, were then developed by the steering committee and municipal representatives based on the goals previously identified. These action items are discussed in full in *Section 3, An Action Plan for the Brodhead Watershed*.

# An Action Plan for the Brodhead Watershed

This chapter includes a vision and broad goals for the Brodhead watershed as well as specific recommended actions and management options to achieve those goals. The goals and actions were developed through a significant public involvement effort.

## *Vision*

The following represents how citizens in the watershed will view the landscape in the watershed within the next 20 years. It reflects input from the public derived in preparation of the plan and what could happen if the watershed conservation plan is effectively implemented:

*Residents and visitors to the Brodhead watershed care about clean water. The pure streams and safe drinking water the watershed enjoys are viewed as precious assets and all are aware of how important it is to continually maintain and protect this resource. Planning at all levels of government continues to point to the importance of maintaining and enhancing this resource as a critical goal for supporting the quality of life within the watershed. Due to this acute awareness, actions are taken that assure that the streams in the watershed will remain healthy for future generations. Both individual actions and municipal policy decisions are made with the knowledge of how these actions affect the health of the watershed and with the understanding that we are all stewards of the natural and cultural resources that affect the health of the watershed. As a result of this understanding and many appropriate follow-up actions future generations are assured of a watershed that continues to sustain its human and natural residents.*

*Water in the watershed is not only clean and plentiful but many of the streams continue to support pristine trout fisheries. The stream corridors also provide an appropriate sense of place as greenway buffers have been maintained and enhanced in a continuous network or green infrastructure that supports other important ecological and cultural functions. In addition to trout habitat, a rich diversity of land and aquatic species are supported. Also residents and visitors alike are connected to much of this network by a series of trails that provide access to nature, interpret the rich history, and provide alternative routes of transportation.*

## ***Goal Statements***

The following goal statements describe the broad, general goals the plan is striving for in each issue category. The recommended actions listed below were developed with the intention of achieving these goals:

***Water Quality and Quantity*** – Maintain and improve water quality throughout the watershed and insure that an adequate quantity of surface water and groundwater is maintained.

***Watershed Awareness*** – Achieve greater environmental education for all age groups to address water quality, planning & regulations, and habitat.

***Policy Planning & Regulation*** – Encourage the development of local, state, and federal planning and regulations to collectively facilitate stated watershed management goals.

***Fish and Wildlife Habitat*** – Manage natural habitat to promote biodiversity and to maintain, protect, and enhance natural systems.

***Historic & Cultural Resources*** – Ensure that the historic resources of the Brodhead watershed are preserved and interpreted as educational examples of the area's heritage.

## ***Recommended Actions***

Within each issue category, several recommended actions have been identified through the public involvement process. These actions attempt to solve the problems and/or enhance the opportunities associated with that issue category. Potential lead agencies are identified for each action. These actions are summarized in the Management Options Tables below.

## ***Setting Timeframes and Priorities***

Each recommended action is associated with a timeframe, identifying the suggested implementation time necessary for completion of that action.

Timeframes are as follows:

- **Short** = One to three years;
- **Medium** = Three to five years; and
- **Long** = Five to ten years.

This plan recognizes that there will be limited financial and human resources available to execute the many recommended actions listed below. Some change in the timeframe for action implementation is expected, as well as the group(s) responsible for carrying out the recommended actions.

Priorities were assigned according to a review of the draft action items by steering committee members and municipal leaders. For a summary of these responses, see *Appendix C, Summary of Responses / Comments to Draft List of Potential Actions*.

Because headwater streams collectively represent a majority of the drainage network of any watershed, and because headwater streams are exceptionally vulnerable to watershed development, projects in headwaters areas should be given priority whenever possible. In addition, repairing a problem low in a watershed without addressing problems upstream will often lead to revisiting the repaired site sometime in the future.

### ***Incorporating Related Planning Efforts***

The *Monroe County Comprehensive Plan (Monroe 2020)* provides a countywide policy document to help steer growth and development in a positive economic fashion while maintaining, preserving, and enhancing a high environmental quality. The Comprehensive Plan, part of the three-year Monroe 2020 planning effort, was adopted in July of 1999 by the county commissioners. The *Monroe County Comprehensive Plan* is incorporated by reference in this watershed conservation plan and should be considered an integral part of the plan.

The *Monroe County Water Supply and Model Wellhead Protection Study* is incorporated by reference in the Comprehensive Plan and should also be considered an integral part of this plan. This plan recognizes that a primary recommendation of the *Monroe County Water Supply and Model Wellhead Protection Study* is to provide sewer systems as a primary means for handling wastewater. However, this plan strongly encourages alternatives to stream discharge whenever environmentally and economically feasible.

This plan also supports the goals and recommendations as put forth in the *Monroe County Open Space Plan* and ongoing *Multi-Municipal Open Space Plans*. A planning effort recommended by the Comprehensive Plan, the Open Space Plan was adopted in June of 1999 by the county commissioners.

Also incorporated by reference in this watershed conservation plan are the two *Act 167 Stormwater Management Plans* – for the Brodhead and McMichael Creek watersheds, along with their model stormwater management ordinances. An update of the Act 167 Stormwater Management Plan for the Brodhead and McMichael Creeks is currently underway. Initially, Act 167 Plans were developed for the Brodhead Creek (1991) and the McMichael Creek (1988) separately. Since the plans and issues to be addressed are similar, the update currently underway is for the combined area of the Brodhead and

McMichael watersheds. Addressing stormwater runoff will help to reduce flooding, protect the quality of surface water, and address groundwater recharge. *Phase I, Scope of Study*, was completed in October 2000. *Phase II* of the update will set forth management recommendations.

This plan also supports the goals and recommendations as put forth in the ***Pocono Creek Pilot Project***. *Phase I* of the project, ***Goal-Based Watershed Management***, has been completed; *Phase II* has been initiated. The *Pocono Creek Pilot Project* is an important planning effort done at the subwatershed scale. *Phase I* of the study identified water resource goals, water resource targets, twelve watershed management areas and performed detailed studies that examined water quality, stream flow, stream channel stability, and macroinvertebrates. *Phase II* of the study will focus on an analysis of alternative watershed management scenarios and the selection of a preferred management plan.

The *Pocono Creek Pilot Project* provides an important benchmark for future subwatershed planning efforts in the Brodhead watershed.

Abstracts of these plans and others relevant to the planning process are included in this plan as *Appendix F, Prior Studies*. A review of these studies was conducted to identify issues, concerns and constraints and potential management options for the Brodhead Watershed Conservation Plan. These findings have been incorporated throughout.

## ***Management Options Tables***

The following management options tables include action items developed during the public involvement process for each of the identified goals. Potential lead agencies are identified for each action and a time frame for completion is included.

## ***Water Quality and Quantity***

***Goal: Maintain and improve water quality throughout the watershed and insure that an adequate quantity of surface water and groundwater is maintained.***

The Brodhead watershed, for the most part, boasts extremely high quality waters and streams that flow freely throughout the year. The watershed has not suffered many of the impacts of more highly developed areas where streams are unsafe for swimming, devoid of fish, and dry in summer months. However, some streams in the Brodhead watershed show signs of impact from encroaching development and other sources. As with any urbanizing area, the Brodhead watershed faces the threat of real impacts on the watershed. Studies have shown that as impervious cover (parking lots, roads and rooftops) increases, water quality and quantity declines. The Brodhead watershed in the lower reaches around Stroudsburg and East Stroudsburg is reaching the level of impervious cover at which the ability of the stream system to absorb urban impacts will be lost. Thus, it is even more important that upstream areas make every effort to minimize impacts of impervious surfaces on water resources.

In addition, many of the watershed streams receive effluent from point sources such as sewage treatment and industrial waste treatment plants. And development in rural areas depends on on-lot sewage systems for waste treatment and disposal. In either case, malfunctions, poor design, or lack of maintenance can cause these systems to fail and severely impact streams and groundwater.

To date, little use has been made in the Brodhead watershed of alternatives, such as land application, to stream discharge from sewage treatment plants. However, federal and state law requires that such alternatives be investigated and used when "environmentally sound and cost effective when compared with the cost of the proposed discharge."

In areas without central sewage collection and treatment systems, treatment and disposal of wastewater needs to be done in a manner that is compatible with conservation design such as that promoted and developed by Randall Arendt through the Natural Lands Trust and the Pennsylvania Department of Conservation and Natural Resources and endorsed by the American Planning Association and the American Society of Landscape Architects. Flexibility inherent in the design of conservation subdivisions makes them superior to conventional layouts in their ability to provide for adequate sewage treatment and disposal. Greater opportunities to implement environmentally sensitive sewage treatment systems are also offered in this approach. These "alternative technologies" are superior to conventional systems in many ways since they produce limited amounts of sludge by-products and they help replenish local aquifers. Recent Monroe County plans and planning efforts have endorsed and supported this approach.

The recommended actions and management options included in the table below are geared toward minimizing the impacts of urbanization on water resources.

## WATER QUALITY AND QUANTITY

**GOAL: Maintain and improve water quality throughout the watershed and insure that an adequate quantity of surface water and groundwater is maintained.**

Action	Responsible Parties	Priority	Timeframe/ Record of Action
1. Encourage riparian landowners to create and maintain forested stream buffers.	Municipalities, with Brodhead Watershed Association Monroe Co. Planning Commission Monroe Co. Conservation District	Most Important	Short 1-3 Years & Ongoing
2. Strengthen land use ordinances to better protect floodplains.	Municipalities, with Monroe Co. Planning Commission Monroe Co. Conservation District	Most Important	Short <sup>2</sup> 1-3 Years
3. Strengthen land use ordinances to better protect groundwater recharge areas. <ul style="list-style-type: none"> <li>▪ Locate, delineate, and map significant recharge zones throughout the watershed.</li> </ul>	Municipalities Scientific community Monroe Co. Planning Commission Monroe Co. Conservation District	Most Important	Medium <sup>3</sup> 3-5 Years
4. Strengthen land use ordinances to minimize effects of impervious surfaces.	Municipalities, with Scientific community Monroe Co. Planning Commission Monroe Co. Conservation District	Most Important	Medium 3-5 Years
5. Encourage DEP to take prompt action on known sewage treatment plant violations.	Municipalities Brodhead Watershed Association Trout Unlimited	Most Important	Short 1-3 Years
6. Develop sewage management programs to better manage on-lot septic systems.	Municipalities, with PA Dept. of Environmental Protection	Most Important	Short 1-3 Years
7. Develop programs to protect existing and potential future sources of drinking water.	Water suppliers Municipalities	Most Important	Ongoing
8. Use open space funds and other monies to protect critical riparian areas.	County and Regional Open Space Committees	Most Important	Short 1-3 Years

<sup>2</sup> The Monroe County Conservation District has conducted a review of ordinances relative to floodplain protection.

<sup>3</sup> The Monroe County Planning Commission is overseeing the preparation of “Growing Greener” audits for all municipalities in the watershed.

9. Adopt ordinances consistent with the updated Brodhead / McMichael Stormwater Management Plan.	Municipalities	Very Important	Medium 3-5 Years
10. Organize partnerships to restore degraded streambanks and stream crossings.	Brodhead Watershed Association Municipalities Private landowners PennDOT	Very Important	Short 1-3 Years
11. Encourage alternatives (such as land application) to stream discharges from sewage treatment plants where feasible.	Municipalities PA Dept. of Environmental Protection	Very Important	Short 1-3 Years & Ongoing
12. Decrease non-point source pollution from runoff.	Municipalities Brodhead Watershed Association Monroe Co. Conservation District PennDOT	Very Important	Short 1-3 Years
13. Assure that the DRBC standard of “no measurable change” at the Brodhead Boundary Control Point is met in the future.	Delaware River Basin Commission	Very Important	Medium 3-5 Years
14. Protect headwaters areas.	Municipalities Monroe Co. Planning Commission Monroe Co. Conservation District PennDOT Pennsylvania Game Commission Brodhead Watershed Association	Very Important	Ongoing
15. Implement management strategies identified in the Pocono Creek Pilot Project Goal-Based Watershed Management Plan.	Monroe Co. Conservation District Delaware River Basin Commission Municipalities Monroe Co. Planning Commission Brodhead Watershed Association	Very Important	Short 1-3 Years & Ongoing
16. Correct existing stormwater problems identified in the updated Brodhead / McMichael Stormwater Management Plan.	Monroe Co. Conservation District Municipalities Monroe Co. Planning Commission Brodhead Watershed Association	Very Important	Short 1-3 Years & Ongoing
17. Identify environmentally sound lands to be used for land disposal of treated wastewater and acquire where economically feasible.	Sewage treatment plant permittees Monroe Co. Planning Commission Monroe Co. Conservation District Municipalities	Important	Short 1-3 Years
18. Coordinate existing water monitoring efforts: <ul style="list-style-type: none"> <li>▪ Hire paid monitoring coordinator.</li> <li>▪ Review current monitoring plans.</li> <li>▪ Maintain gauging stations.</li> </ul>	Monroe Co. Conservation District	Important	Ongoing
19. Improve environmental conditions at landfills.	Monroe Co. Conservation District PA Dept. of Environmental Protection Municipalities	Important	Ongoing

## ***Watershed Awareness***

***Goal: Achieve greater environmental education for all age groups to address water quality, planning & regulations, and habitat.***

Public understanding of how individual actions impact the watershed and drinking water supply is key. We must also inform the public about ways they can play a part in protecting and improving their environment. Perhaps the most important message to impart is that we all live in a watershed.

“Ownership” of the watershed and all its needs and assets will go a long way toward assuring that water resources are protected for future generations.

<b>WATERSHED AWARENESS</b>			
<i><b>GOAL: Achieve greater environmental education for all age groups to address water quality, planning &amp; regulations, and habitat.</b></i>			
<b>Action</b>	<b>Responsible Parties</b>	<b>Priority</b>	<b>Timeframe/ Record of Action</b>
1. Organize watershed awareness raising activities, especially activities that involve children.	Brodhead Watershed Association, with Trout Unlimited Monroe Co. Conservation District Pocono Mountains Vacation Bureau Chamber of Commerce School districts Stroudsburg Municipal Authority and other water suppliers	Most Important	Short 1-3 Years & Ongoing
2. Develop educational programs about protecting sources of drinking water in the Brodhead watershed.	Water suppliers Brodhead Watershed Association	Most Important	Ongoing
3. Develop education programs to encourage landowners and citizens to plant native species, plant or maintain riparian buffers and improve stream habitat.	Monroe Co. Conservation District Monroe Co. Cooperative Extension Brodhead Watershed Association Non-profit organizations	Most Important	Short 1-3 Years & Ongoing
4. Publish information about watershed issues on a regular basis in the media (including newspapers, radio, television.)	Brodhead Watershed Association, with Trout Unlimited Scientific community Concerned citizens	Very Important	Short 1-3 Years & Ongoing
5. Make presentations on the Brodhead Watershed Conservation Plan at municipal meetings to seek endorsement of the Plan and integration of Plan actions into municipal goals.	Brodhead Watershed Association Monroe Co. Conservation District Stroudsburg Municipal Authority	Very Important	Short 1-3 Years
6. Create a speakers bureau to inform local organizations about watershed issues.	Brodhead Watershed Association	Very Important	Short 1-3 Years
7. Educate interested landowners about placing conservation easements on open land through donation or purchase.	Brodhead Watershed Association Pocono Heritage Land Trust The Nature Conservancy Other land trusts	Very Important	Ongoing
8. Hire full-time staff person to oversee and/or help implement the recommendations of this plan.	Brodhead Watershed Association	Very Important	Ongoing
9. Create a video or CD-ROM about the Brodhead watershed.	Brodhead Watershed Association Chamber of Commerce Pocono Mountains Vacation Bureau Channel 13 and others	Important	Short 1-3 Years

<p>10. Create a "community conservation corps" to encourage riparian neighbors to work together.</p>	<p>Concerned Citizens Monroe Co. Conservation District Audubon Society Garden clubs</p>	<p>Important</p>	<p>Medium 3-5 Years</p>
<p>11. Establish an ongoing county-wide forum for watershed stakeholders to share information about watershed issues and actions.</p>	<p>Monroe Co. Conservation District (watershed specialist) Brodhead Watershed Association Monroe Co. Planning Commission</p>	<p>Important</p>	<p>Short 1-3 Years</p>
<p>12. Encourage landowners to conserve privately owned woodlots.</p> <ul style="list-style-type: none"> <li>▪ Use sustainable forestry practices</li> </ul>	<p>DCNR Brodhead Watershed Association Monroe Co. Conservation District Concerned citizens Monroe Co. Cooperative Extension</p>	<p>Important</p>	<p>Ongoing</p>

## ***Policy, Planning and Regulation***

***Goal: Encourage the development of local, state, and federal planning and regulations to collectively facilitate stated watershed management goals.***

Important as the individual is to protecting water resources, the job cannot be done without commitment from government agencies. And the most important level of government is the local municipalities. Municipalities control land use, which directly impacts both the quantity and quality of water resources.

Municipalities can also take the lead in land acquisition to protect riparian areas and critical wildlife habitats and in developing science-based plans for assuring that supplies of water are adequate for all users, including in-stream uses.

Municipalities cannot do the job alone, however. County, state, regional and federal agencies have resources, both financial and technical, to assist municipalities in making wise decisions. The Pennsylvania Department of Environmental Protection plays a major role in water resources protection in their permitting authority for discharges to and withdrawals from surface and groundwater. The Delaware River Basin Commission has additional permitting authority through Special Protection Waters Regulation, which are intended to assure that streams entering the Delaware River above the Delaware Water Gap do not degrade the river water quality.

Some municipalities are getting help with addressing environmental issues by establishing Environmental Advisory Councils. Municipalities are authorized by state law to appoint EAC's to assist and advise as needed. Like the Municipal Open Space Committees, which are advising local officials on priorities for open space and recreation, Environmental Advisory Councils can advise on a variety of environmental issues, apply for grants, or administer projects. Municipalities in other fast-growing areas are making use of EAC's; Brodhead watershed municipalities might find them useful as well.

**POLICY, PLANNING AND REGULATION**

**GOAL: Encourage the development of local, state, and federal planning and regulations to collectively facilitate stated watershed management goals.**

Action	Responsible Parties	Priority	Timeframe/ Record of Action
1. Promote and develop greenways to link important natural, recreational and wildlife habitat areas in cooperation with willing landowners.	Municipalities, with Monroe Co. Planning Commission Non-profit organizations	Most Important	Short 1-3 Years & Ongoing
2. Pursue funding to prepare subwatershed assessments <sup>4</sup> (similar to the Pocono Creek Pilot Study) for each of the remaining subwatersheds within the Brodhead watershed.	Brodhead Watershed Association Municipalities Monroe Co. Planning Commission Monroe Co. Conservation District	Very Important	Short 1-3 Years
3. Conduct detailed analyses of impervious coverage for each subwatershed of the Brodhead watershed.	Delaware River Basin Commission	Very Important	Medium 3-5 Years
4. Perform a build-out analysis for each subwatershed area of the Brodhead watershed.	Monroe Co. Planning Commission	Very Important	Medium 3-5 Years
5. Promote conservation of important habitat areas through conservation-based ordinances and codes (also known as <i>Growing Greener</i> approaches.)	Municipalities, with Scientific community Monroe Co. Planning Commission Monroe Co. Conservation District	Very Important	Ongoing
6. Review proposed land development plans for impact on outstanding and unique features.	Municipalities, with Monroe Co. Planning Commission Monroe Co. Conservation District	Very Important	Ongoing

<sup>4</sup> Including a study of fluvial geomorphology using Rosgen methodology.

<p>7. Develop a water budget for each subwatershed to assure that surface and groundwater withdrawals do not exceed levels necessary to maintain adequate stream base flow.</p>	<p>Scientific community                  Delaware River Basin Commission                  Private geologists                  USGS                  Monroe Co. Planning Commission                  Monroe Co. Conservation District                  Brodhead Watershed Association                  Municipalities</p>	<p>Very Important</p>	<p>Medium                  3-5 Years</p>
<p>8. Require sewage treatment plant permittees and/or operators to maintain in-stream habitat below sewage treatment plants.</p> <ul style="list-style-type: none"> <li>▪ Encourage the use of bio-monitoring<sup>5</sup> techniques.</li> </ul>	<p>Pennsylvania Department of Environmental Protection</p>	<p>Important</p>	<p>Short                  1-3 Years</p>
<p>9. Establish Environmental Advisory Councils.</p>	<p>Municipalities                  PA Environmental Council</p>	<p>Important</p>	<p>Medium                  3-5 Years</p>
<p>10. Develop ordinances to maintain a minimum percentage of forest cover.</p>	<p>Municipalities                  Monroe Co. Conservation District</p>	<p>Important</p>	<p>Medium                  3-5 Years</p>

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<sup>5</sup> Macroinvertebrate analysis. Cost effective EPA and DEP rapid bio-assessment protocols have been developed.

### ***Fish and Wildlife Habitat***

***Goal: Manage natural habitat to promote biodiversity and to maintain, protect, and enhance natural systems.***

The Brodhead has long been famous for its fine trout fishing. The watershed also includes much public and private land that provides excellent wildlife habitat and popular hunting grounds. Fishing, hunting, hiking, bird watching and other recreational opportunities here contribute significant sums to the local economy. Good management of the natural resources of the watershed will assure that these opportunities continue for residents and visitors.

<b>FISH AND WILDLIFE HABITAT</b>			
<b><i>GOAL: Manage natural habitat to promote biodiversity and to maintain, protect, and enhance natural systems.</i></b>			
<b>Action</b>	<b>Responsible Parties</b>	<b>Priority</b>	<b>Timeframe/ Record of Action</b>
1. Use incentive-based approaches to protect, restore, and conserve important fish and wildlife habitat and direct development away from important habitat areas.	Municipalities Monroe Co. Planning Commission Monroe Co. Conservation District U.S. Fish & Wildlife Service Fishing and hunting clubs	Most Important	Short 1-3 Years & Ongoing
2. Increase public access to fishing waters.	County and regional open space committees	Most Important	Short 1-3 Years
3. Restore in-stream habitat in areas degraded by flooding, channelization, loss of riparian buffer, and increased runoff.	Trout Unlimited Brodhead Watershed Association Fishing clubs Municipalities PennDOT Army Corps of Engineers U.S. Fish & Wildlife Service	Most Important	Short 1-3 Years & Ongoing
4. Develop more effective deer, geese, and other nuisance wildlife management programs.	PA Game Commission DCNR Ducks Unlimited Fishing and hunting clubs	Very Important	Short 1-3 Years

<p>5. Implement programs to control/manage invasive and exotic species.</p>	<p>Monroe Co. Cooperative Extension The Nature Conservancy Delaware River Invasive Plant Partnership (DRIPP) Volunteers</p>	<p>Very Important</p>	<p>Short 1-3 Years</p>
<p>6. Conduct inventories of terrestrial wildlife and their habitats, including birds, reptiles and amphibians.</p> <ul style="list-style-type: none"> <li>▪ Conduct standard census work during breeding and non-breeding seasons.</li> <li>▪ Hold a “bioblitz” throughout the watershed.</li> <li>▪ Determine if areas in the watershed qualify as Important Bird Areas<sup>6</sup>.</li> <li>▪ Continue with research on saw-whet owls and breeding birds.</li> </ul>	<p>Scientific community</p>	<p>Very Important</p>	<p>Medium 3-5 Years</p>
<p>7. Conduct fisheries inventories in high priority stream areas<sup>7</sup> and review fish stocking programs.</p>	<p>PA Fish Commission</p>	<p>Important</p>	<p>Medium 3-5 Years</p>
<p>8. Create riparian parks, using Army Corps of Engineers habitat restoration program.</p> <ul style="list-style-type: none"> <li>▪ Restore the bend in the creek below Analomink.</li> </ul>	<p>Army Corps of Engineers PennDOT Municipalities Monroe Co. Conservation District</p>	<p>Important</p>	<p>Medium 3-5 Years</p>

<sup>6</sup> Sites that provide essential habitat for one or more species of bird. The Important Bird Area (IBA) program, a global effort to identify the areas most important for maintaining bird populations, is administered by the National Audubon Society.

<sup>7</sup> Per a Sept. 12, 2001 memorandum with Don Baylor of Aquatic Resources Consulting, these include: Bulger’s Run, Scot Run, Cranberry Run, Reeder’s Run, Pocono Creek – Bartonsville area, Lake Creek, Kettle Creek, Spring Run, Leavitt Branch, Griscom Run – upper, Goose Pond Run, Cranberry Creek, Butz Run, Cranberry Run, Michael Creek, Middle Branch, Mill Creek – lower, and Marshall’s Creek (other than area of Bridle & Ironcolor Shiners).

## ***Historic & Cultural Resources***

***Goal: Ensure that the historic resources of the Brodhead watershed are preserved and interpreted as educational examples of the area's heritage.***

The Brodhead watershed contains many significant historic structures and landscapes dating from the days of the early settlers to the more recent early development of the tourism industry. Remnants of mills and other early industries, such as tanneries and icehouses, dot the landscape along with early boarding houses and hunting lodges. A few structures have been placed on the National Register of Historic Places, but many more are eligible.

Historic preservation has not been an important concern in much of the watershed, but in several areas local historical societies are beginning to take up the cause of preserving local heritage. Their efforts should be encouraged and supported. In many cases, little remains of area heritage except the memory of older residents; preservation of these memories is essential. Public information about local history, such as markers at historic sites, will help interpret the area to both residents and visitors.

**HISTORIC & CULTURAL RESOURCES**

***GOAL: Ensure that the historic resources of the Brodhead watershed are preserved and interpreted as educational examples of the area's heritage.***

<b>Action</b>	<b>Responsible Parties</b>	<b>Priority</b>	<b>Timeframe/ Record of Action</b>
1. Develop ordinances to encourage creative reuse of historic structures consistent with maintaining the historic character of the building.	Municipalities, with Monroe Co. Planning Commission	Very Important	Short 1-3 Years
2. Complete applications for historic structures eligible to be added to the National Register of Historic Places.	Monroe Co. Historical Association Property owners	Very Important	Short 1-3 Years
3. Amend municipal ordinances to require a permit for demolition of historic structures.	Municipalities	Very Important	Medium 3-5 Years
4. Implement or encourage projects which interpret historic resources.	Local Historical Societies Brodhead Watershed Association Monroe Co. Conservation District Monroe Co. Historical Association Pocono Mountains Vacation Bureau	Very Important	Ongoing
5. Identify and develop a plan to protect important historic structures and areas in the watershed.	Brodhead Watershed Association Monroe Co. Historical Association Local historical societies	Very Important	Short 1-3 Years
6. Develop a plan for interpreting historic and cultural resources in the watershed.	Monroe Co. Historical Association Monroe Co. Planning Commission	Important	Short 1-3 Years
7. Incorporate clear, reasonable design review standards for renovations to historic structures into municipal codes.	Municipalities	Important	Medium 3-5 Years
8. Acquire, restore, or interpret significant historical landscapes, structures, and features in the watershed where feasible.	Municipalities Non-profit groups County agencies	Important	Short 1-3 Years
9. Determine the feasibility of restoration of the historic Henryville House and/or acquiring the site to develop a facility for interpretive use.	Local Historical Societies Brodhead Watershed Association Monroe Co. Historical Association Municipalities	Important	Short 1-3 Years
10. Consider acquiring the 24-acre property containing Marshalls Falls and nearby Titania House as a local park/open space.	Municipalities	Important	Short 1-3 Years
11. Maintain the historic Double Arch Stone Bridge as necessary to preserve original features.	Municipalities Non-profit groups County agencies	Important	Medium 3-5 Years & Ongoing

12. Restore the Creekside Park at the Delaware Water Gap Train Station for historical interpretation and tourism.	Lackawanna Chapter of the Railway and Locomotive Historical Society Municipalities	Important	Medium 3-5 Years
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### ***Funding Sources***

Funding opportunities for many of the action items listed in the Management Options Table can be found through numerous government funding programs as well as through private organizations. A table listing approximately 40 of the government programs that offer funding opportunities can be found in *Appendix D, Rivers, Trails and Greenway Funding Options*.

### ***Composite Mapping for Recommended Actions***

Composite mapping was prepared to help translate the management options to their spatial component. This mapping is meant to be neither definitive nor complete but rather a starting point for identifying “where” in the watershed problems, issues or concerns are located.

The following maps show potential project locations for the resource categories *Water Quality and Quantity, Fish and Wildlife Habitat, and Historic & Cultural Resources*.

# **Description of the Brodhead Watershed**

## ***Physical Setting of the Brodhead Watershed***

The plan area encompasses the Brodhead Creek watershed from the creek's confluence with the Delaware River to its headwater sources in northern Monroe County and Greene Township, Pike County, including its major tributaries: Marshall's Creek, Paradise Creek, Pocono Creek, and McMichael Creek. The Brodhead watershed covers about 285 square miles, extending from Barrett Township and Mount Pocono in the north to Brodheadsville in the west to the Delaware River. The watershed is nearly as wide from east to west as it is long from north to south. The highest elevations (approx. 2,000 feet above mean sea level) are found in the northern and northwestern part of the watershed. Streams flow generally southeastward from the plateau to the relatively low-lying southeastern portion of the watershed. The Brodhead Creek feeds directly into the Delaware River at approximately 300 feet above sea level about two miles north of the Delaware Water Gap.

The watershed consists mostly of forested and recreation land in its headwater areas and around most of its tributaries, with urbanization increasing downstream. The Boroughs of Stroudsburg and East Stroudsburg, with a combined population of 60,000, are located at the base of the main stem, approximately three miles upstream of the Brodhead's confluence with the Delaware River. The Brodhead Creek provides potable drinking water to over 20,000 people in the Stroudsburg area.

## ***Political Boundaries***

The Brodhead watershed is located almost entirely within Monroe County, northeastern Pennsylvania, with a small portion of its northern reaches spilling over into Pike County. In the watershed there are eighteen (18) municipal political subdivisions. The Brodhead watershed touches on all or part of the townships and boroughs listed below:

### **Monroe County**

Townships: Coolbaugh, Barrett, Paradise, Price, Middle Smithfield, Tobyhanna, Pocono, Stroud, Smithfield, Tunkhannock, Jackson, Hamilton, Chestnuthill, and Ross.

Boroughs: Stroudsburg, East Stroudsburg, and Mount Pocono.

### **Pike County**

Townships: Greene.

Boroughs: none.

## ***Topography / Geology***

***Topography.*** The Brodhead watershed lies within two of the major physiographic provinces of Pennsylvania. These physiographic provinces are characterized by their own unique landscape and a distinctive geologic character. The northern half of the watershed falls within the **Appalachian Plateaus Province**, a broad area of hilly to low mountainous terrain that extends north and east into New York State and west across the northern tier counties of Pennsylvania. Topography is characterized by high, flat plateaus with elevations between 900-1,800 feet. The southern portion of the watershed falls within the **Valley and Ridge Province**, characterized by long, parallel, sharp-crested mountain ridges separated by long, narrow valleys. Elevations range from 1,600 feet along ridgetops to 500 feet in the valley bottoms.

Each physiographic province is further divided into sections. The northwestern part of the watershed falls within the *Pocono Plateau Section* of the Appalachian Plateaus Province while the northeastern portion of the watershed lies within the *Glaciated Low Plateaus Section* of the same. The southern part of the watershed lies within the *Appalachian Mountain Section* of the Valley and Ridge Province.

***Pocono Plateau Section.*** The Pocono Plateau is located in the extreme southeastern corner of the Appalachian Plateaus Province and is known as the “Pocono Mountains.” The plateau’s scenic eastern rim towers about 1,000 feet above the surrounding countryside. Rocks of the plateau have a low dip to the east, resulting in a gently sloping rock structure in the plateau. Topographic relief is low, rarely exceeding 100 feet. The entire section has been glaciated, with swamps and peat bogs frequent.

***Glaciated Low Plateaus Section.*** The northeastern part of the watershed lies within the Glaciated Low Plateaus Section, a glaciated plateau of moderate relief, characterized by smooth, rolling hills and a large number of glacial lakes and swamps.

***Appalachian Mountain Section.*** The southernmost portion of the watershed falls within the Appalachian Mountain Section, characterized by long, parallel, sharp-crested ridges separated by long, narrow valleys. Rapidly-weathering rocks underlie the valleys, while more resistant quartzite and sandstone form the higher ridges. The differential weathering characteristics and upright folds have produced the long valleys and ridges unique to this section.

**Geology.** The plateau section of the basin is underlain by nearly flat-lying sandstone units containing subordinate amounts of siltstone and shale. The valley and ridge section of the basin is underlain by primarily shale, siltstone, and minor carbonate units. Fifteen thousand years ago, Wisconsinian glaciers covered the entire basin. Nearly all areas, with the exception of hilltops, are now covered with unconsolidated sediments deposited or reshaped during deglaciation. Ground moraine till, up to several meters thick, covers most of the plateau section. The valley and ridge section is generally covered by thicker glacial deposits. They are typically meltwater-derived and include ice contact, outwash, and lacustrine deposits. Rock fragments in the glacial sediments are generally similar to the composition of the underlying bedrock and are thus assumed to be locally derived. Colluvium – soil and rocks deposited at the base of steep inclines – decreases the topographic slope at the base of most hills throughout the basin. Alluvium (sediment deposited by flowing water) consisting of sand, gravel, and cobbles from eroded till deposits is common to many of the streams. Several streams (Brodhead, Appenzell, and McMichael) have losing reaches immediately downstream of the point where they exit the bedrock uplands into thick permeable outwash deposits.

The watershed is mainly underlain by sedimentary rocks of the Devonian (360 to 408 million years ago) and Silurian (408 to 436 million years ago) ages. The Devonian Period is sometimes called the “Age of Fishes” because fish became abundant and diverse during this time. The first amphibians also appeared during this time. The first jawed fishes and vascular plants appeared during the Silurian Period.

The rocks in the Appalachian Mountains Section (southern part) have been intensely deformed by folding and faulting, resulting in dramatic topography. Rocks in the northern part of the watershed are gently folded and not as deformed as those in the southern portion.

***Summary of bedrock geologic units underlying the watershed.***

Undifferentiated Silurian-Devonian aged rocks are found in a band across the southern part of the watershed. Devonian aged rocks are located through most of the watershed with the youngest rocks found in the northernmost part of the watershed:

- *Marcellus Formation* – Grayish-black, fine grained carbonaceous fissile shale and silty shale. Underlies valleys and is often overlain by thick, unconsolidated deposits.
- *Mahantago Formation* – Medium to dark grey fine-grained shale and siltstone.
- *Trimmers Rock Formation* – Gray to olive gray, fine to medium grained massive siltstone and minor shales characterized by graded bedding and marine fossils.
- *Catskill Formation* – A succession of grayish-red, fine to medium grained siltstone, shale and sandstone, usually encountered in fining upward cycles. The Catskill Formation is divided up into members: *Towamensing Member*, *Walcksville Member*, *Beaverdam Run Member*, *Long Run Member*, and *Packerton Member*.

## ***Socio-Economic Setting***

### **Population and Employment**

The population of Monroe County, the county in which the predominant area of the watershed is located, has nearly doubled since 1980 and is projected to grow by 60 percent by 2020. Managing the impact of this growth in a way that conserves and protects natural and cultural resources while also encouraging the development of environmentally friendly businesses to provide close-to-home employment is at the root of the many recent planning efforts in the County. The following summaries the current population and employment situation:

#### **Population**

Monroe County's population boom began in the 1960s with the opening of Interstate 80. The trend continued during the '70s and '80s, and by the 1990 census, almost 96,000 people lived in the County. The 2000 census confirmed that the growth of the County continues – nearly 140,000 people live in the County today. The combination of further metropolitan in-migration and natural increase as county residents form new households and have children will result in continued growth over the next few decades and beyond. The projected population for the County in the year 2020 is 177,000 to 221,000.

Viewed together with average household size, this population estimate serves as a gauge for future housing demand. In 1990, average household size in Monroe County was 2.69 persons per house. Trends analyzed by the U.S Bureau of the Census show decreasing household size nationally and in Monroe County as well. Monroe County's demographic profile is approaching that of a typical suburban jurisdiction and its average household size is moving towards 2.5. The County is likely to see as many as 30,000 new dwelling units between 1998 and 2020 if the total population projected to 2020 lives in smaller household groupings as expected.

#### **Employment**

Many of Monroe County's jobs are held by people who commute in from other areas. For example, the Tobyhanna Army Depot is the County's largest employer, but fewer than 600 of its 3,600 employees live in the County. The majority of these commute from the Scranton/Wilkes-Barre area. Some workers also commute to Monroe County from Northampton and Carbon Counties to the south.

Likewise, many of Monroe County's residents commute to jobs outside of the county – many of these to the New York-New Jersey metropolitan areas, and some to the Allentown-Bethlehem-Easton area. The *Monroe County Comprehensive Plan* estimated that in 1998, an estimated 9,000 workers – or close to 18 percent of Monroe County's estimated 50,900 residents age 16 and older who are employed – commute out of Monroe County to work.

Not unusually, the County's labor force and its job base are not precisely aligned with each other. This trend is occurring in communities nationwide.

The *Monroe County Comprehensive Plan* projected the number of jobs in Monroe County in the year 2000 to be somewhere between 49,250 and 57,750, an average annual growth rate of about 1.6-1.9 percent. In the decade following the year 2000, Monroe County's rate of employment growth is expected to level off as at annual average of around 1.6 percent, consistent with rates expected in the nearby counties of New Jersey.

The following table illustrates Monroe County's population growth between 1990 and 2000.

**Population Change 1990-2000**

<b>County or Municipality</b>	<b>2000 Population</b>	<b>1990 Population</b>	<b>Population Change</b>	<b>Percent Change</b>
<b>Pennsylvania</b>	<b>12 281 054</b>	<b>11 881 643</b>	<b>399 411</b>	<b>3.4</b>
<b>Monroe County</b>	<b>138 687</b>	<b>95 709</b>	<b>42 978</b>	<b>44.9</b>
Barrett Township	3 880	3 216	664	20.6
Chestnuthill Township	14 418	8 798	5 620	63.9
Coolbaugh Township	15 205	6 756	8 449	125.1
Delaware Water Gap Borough	744	733	11	1.5
East Stroudsburg Borough	9 888	8 781	1 107	12.6
Eldred Township	2 665	2 202	463	21.0
Hamilton Township	8 235	6 681	1 554	23.3
Jackson Township	5 979	3 757	2 222	59.1
Middle Smithfield Township	11 495	6 382	5 113	80.1
Mount Pocono Borough	2 742	1 795	947	52.8
Paradise Township	2 671	2 251	420	18.7
Pocono Township	9 607	7 529	2 078	27.6
Polk Township	6 533	4 517	2 016	44.6
Price Township	2 649	1 633	1 016	62.2
Ross Township	5 435	3 696	1 739	47.1
Smithfield Township	5 672	4 692	980	20.9
Stroud Township	13 978	10 600	3 378	31.9
Stroudsburg Borough	5 756	5 312	444	8.4
Tobyhanna Township	6 152	4 318	1 834	42.5
Tunkhannock Township	4 983	2 060	2 923	141.9

Source: U.S. Census Bureau

Prepared by: Pennsylvania State Data Center

## ***Land Cover***

Dominant land covers in the watershed are forest (84%), pasture or hay (7%), and residential or commercial (5%). Eighty-four (84) percent of the watershed is covered by deciduous, mixed, and evergreen forests. Low intensity residential development covers approximately 3.5 percent of the land, while high intensity residential and commercial areas cover approximately 1 percent of the land in Stroudsburg, East Stroudsburg, and Mount Pocono. Examination of land cover within 100 meters on either side of the stream network shows that the area along streams is dominated by a transitional habitat, at 55.5 percent. Transitional habitat is defined as areas dynamically changing from one land cover to another, often because of land use activities. Examples of transitional habitat include forestlands cleared for timber.<sup>8</sup>

LAND COVER TYPE	AREA (HECTARES)	PERCENT
Deciduous Forest	49,528	66.84
Mixed Forest	7,682	10.37
Evergreen Forest	4,989	6.73
Pasture/Hay	4,703	6.35
Low Intensity Residential	2,555	3.45
Woody Wetlands	1,889	2.55
Open Water	1,122	1.51
High Intensity (Commercial/Industrial/Transportation)	562	0.76
Row Crops	548	0.74
Other Grasses (parks, lawns, golf courses)	199	0.27
High Intensity Residential	185	0.25
Transitional	83	0.11
Emergent Herbaceous Wetlands	42	0.06
Quarries, Strip Mines, Gravel Pits	10	0.01

## ***Land Use / Zoning and Land Use Controls***

Land use in the watershed is primarily residential, especially in Chestnuthill and Pocono Townships. Large undeveloped areas can be found throughout the watershed. Urbanized areas are found mostly in the southern part of the watershed, in Stroudsburg and East Stroudsburg Boroughs and Smithfield and Stroud Townships. Commercial land uses are

<sup>8</sup> 1988-1993 LANDSAT mapping, *Basin and Drainage System Characteristics, Brodhead Creek Watershed, Pennsylvania*, NIER, 1999.

mainly concentrated along major arterial and collector highways such as Routes 611, 209, 191, and 447.

Of the eighteen municipalities the watershed falls within, only two do not have zoning. These are Ross Township, in southwestern Monroe County, and Greene Township, Pike County, at the extreme northern end of the watershed.

Follow-up actions to Monroe 2020, the County's Comprehensive Plan, adopted in June of 1999, and the Monroe County Open Space Plan, adopted in June 2001, resulted in all twenty municipalities preparing joint municipal open space plans. Six joint municipal areas emerged for these follow-up planning efforts. All six joint municipal regions have some portion of their study area in the Brodhead watershed. To date, Pike County has no similar program that affects Greene Township.

Also as a result of these county plans, all twenty municipalities have "*Growing Greener*" audits either completed, in progress, or to be scheduled.<sup>9</sup> These audits provide recommendations for updating local plans and ordinances through the use of the *Growing Greener* techniques, including the model ordinance language for conservation subdivisions. Revisions to local ordinances based on these audits are required in order to implement the goals and recommendations of the County Comprehensive Plan, the County Open Space Plan, and the recommendations contained in this watershed conservation plan.

Another audit of municipal codes was conducted by the Monroe County Conservation District. This review focused on municipal floodplain regulations and points to weaknesses in the existing codes and makes recommendations for correcting the same.

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<sup>9</sup> *Growing Greener* audits consist of a review of the municipality's local plans and ordinances relative to land conservation goals. The *Growing Greener* program was developed by the Natural Lands Trust and the Pennsylvania Department of Conservation and Natural Resources.

## ***Transportation***

The major traffic routes in the Brodhead watershed include:

- Interstate Routes 80 and 380;
- US Routes 209 and Business 209; and
- PA Routes 611, 715, 33,191, 390, and 447.

Interstate Route 80 runs east-west through the center of the watershed. There is also one active rail line, which snakes diagonally through the watershed from Mount Pocono Township to East Stroudsburg Borough. (See *Watershed Base Map*).

## ***Scenic Geologic Features***

Outstanding Scenic Geological Features of Pennsylvania are documented in a report by the same name authored by the State Geologist Arthur A. Socolow (Environmental Geology Report 7, Parts 1 & 2, 1979). In the preface, Mr. Socolow notes, "*Scenery has been recognized as a natural resource since 1864, when the first state park, Yosemite Valley, California, was established ... Today, society recognizes these geologic features as a valuable environmental resource ... Because of their outstanding geologic significance, the geologic features described here become outdoor classrooms, places where you can study the earth's surface in an almost natural condition, relatively undisturbed by human activities.*" The following describes sites that occur in the Brodhead watershed:

*Indian Ladder Falls.* Privately owned by Skytop Lodges, Inc., permission to enter must be obtained to view these falls. Located 4.2 miles north of the village of Canadensis, these falls drop over gray and red sandstones, siltstones, and claystones at the escarpment of the Pocono Plateau.

*Buck Hill Falls.* Located one half mile north of Buck Hill Falls Village, these falls drop over sandstones and siltstones and are considered one of the most beautiful falls in the state.

*Devils Hole.* Located along Devils Hole Creek on State Game Lands No. 221, about two miles north of mount Pocono, the Devils Hole is a steep walled, shady ravine sculpted by glacial scour at the foot of the Pocono Plateau escarpment. The escarpment here rises a dramatic 500 - 600 feet above the surrounding land to the southeast.

*Mount Pocono Overlook (Pocono Knob).* Located along Knob Road in Mount Pocono, this overlook affords magnificent views of the rim of the Pocono Plateau, east into the Glaciated Low Plateaus section, and of the Delaware Water Gap in the distance.

*Big Pocono Overlook.* Located on top of Camelback Mountain within Big Pocono State Park, Big Pocono Overlook is the highest point in the Brodhead watershed at 2,133 feet.

On a clear day, the Catskill Mountains of New York can be seen. Camelback Mountain marks the edge of the Pocono Plateau in Monroe County.

*Tannersville Cranberry Bog.* Located parallel to Cherry Lane Road east of PA Route 611 near Tannersville, this is the best developed, southernmost low altitude boreal bog along the eastern seaboard.

*Centerfield Coral Reef.* Located on private property four miles north of Stroudsburg, this is one of the best sites in the state for collecting specimens of fossil horn corals. Fossils found here include coelenterates, bryozoans, brachiopods, and one genus of trilobite.

*Marshalls Falls.* These falls are found on Marshalls Creek, about one mile from the village of Marshalls Creek on private property. Remotely secluded in a hemlock grove, the falls plunge 35 feet into a deep pool. Siltstone cliff contains fossils.

*Buttermilk Falls.* Found several miles south of Marshalls Falls, these falls have a gradual drop of about 30 feet over limestone.

*Twin Falls.* Also found on Marshalls Creek, these falls are located upstream of Buttermilk Falls.

*Clarke Falls.* Located on the Brodhead Creek, just north of Analomink.

*Indian Chair.* Located northeast of the village of Minisink Hills, the dark-gray chert (flint) exposed here was used by the Lenni-Lenape tribe for making weapons and tools. Many important archaeological discoveries have been made here. Nearby is found the old tribal village of Minisink. Indian Chair is named for the rock outcrop near the crest of the hill which resembles a large chair.

*Kellersville Esker.* Located about 3.5 miles north of Saylorsburg, this is an outstanding example of an esker, delta, and lake plain. An esker is a long, narrow ridge of coarse gravel deposited by a stream flowing in or under a retreating glacial ice sheet. Very coarse gravel is exposed in the esker, while sand and gravel is quarried from the delta.

Some additional sites, identified through the public involvement process, include:

*The Kettles.* Located on an unnamed tributary to Kettle Creek, the Kettles are deep, circular depressions in bedrock created by the melting of large blocks of stagnant ice left behind by the glaciers.

*Lake Mineola.* Located just north of Route 209 in Brodheadsville, Lake Mineola marsh, in the McMichael watershed, contains the endangered northeastern bulrush. An adjacent property, including a pond which influences the water level in the marsh, has been purchased by the Nature Conservancy to protect the marsh habitat. Plans for the property include some recreational development and protection of the bulrush habitat.

# **Water Resources**

A watershed ultimately connects the communities within it through their common dependence on water resources. Our flowing creeks and streams are perhaps the best barometer of how well we accept stewardship of the land on which we live. Watersheds are important in every community because they embody our sense of place in the landscape, and their waters are important in our daily life. Watersheds are the geographic addresses for our communities.

In addition to being an important source of recreation and wildlife habitat, the Brodhead watershed provides the drinking water supply for area residents and visitors. The boroughs of Stroudsburg and East Stroudsburg and surrounding areas are served by public water systems which draw on the Brodhead and Sambo Creeks and nearby wells. The water resources of the Brodhead watershed include the Brodhead Creek and its tributaries, and the connected but unseen water in aquifers below the surface of the land.

## ***Subwatersheds***

The Brodhead watershed drains an area of about 285 square miles, almost half of Monroe County, emptying into the Delaware River just north of where the Delaware River flows through the dramatic cut in Kittatinny Mountain known as the Delaware Water Gap. The Brodhead watershed can be divided into six major subwatersheds:

- Upper Brodhead Subwatershed;
- Lower Brodhead Subwatershed;
- Marshalls Creek Subwatershed;
- Paradise Creek Subwatershed;
- Pocono Creek Subwatershed; and
- McMichael Creek Subwatershed.

## **Upper Brodhead Subwatershed**

The Upper Brodhead subwatershed includes the headwater tributaries, as well as eight miles of the main stem of the Brodhead Creek above its confluence with Paradise Creek. The Upper Brodhead subwatershed drains an area of 65.9 square miles, including parts of Coolbaugh, Barrett, Price, and Middle Smithfield townships. A small portion of the upper headwaters extends into Greene Township, Pike County. The Upper Brodhead Creek is paralleled by Route 447. Most of the headwater streams of the Brodhead Creek are found in Barrett and Price townships. These include Buck Hill Creek, Middle Branch, Leavitt Branch, Goose Pond Run, Spruce Cabin Run, Stony Run and Poplar Run.

The headwater tributaries of the Brodhead Creek sustain a 900-foot vertical drop, resulting in waterfalls found on Stony Run, Goose Pond Run, Spruce Cabin Run, two on Buck Hill Creek, Spruce Mountain Run, Rattlesnake Creek, and Leavitt Branch (Indian Ladder Falls). Alpine Mountain ski area is located along the Brodhead Creek, upstream of the confluence with Paradise Creek. Skytop Lodge is located on the highest elevation of the Brodhead watershed, on the Pocono escarpment.

The headwater streams of the Upper Brodhead were named for their location, appearance or function. Some, like Red Run, emerge from acidic bogs on the edge of the Pocono Plateau and are named for their colored acidic water. Others, like Clear Run, are spring fed and named for their crystal clear appearance. Flowing through the rock outcrops of Cresco Heights, Rattlesnake Creek was named for the reptiles found in these parts.

In the century past, the streams provided power for the tanneries, which brought prosperity to the region. Mill Creek, which flows through Mountainhome, was one of the more heavily used creeks. Later, visitors experienced the joys of fishing the small runs and brooks. Canadensis, the village where the streams converge to form the Brodhead, has often felt the power of all that water. Spring floods regularly affect the surrounding homes; most devastating was the flood of 1955 when bridges and dams up and down the creeks washed out and isolated many areas.

The large tracts of undeveloped land in state gamelands or owned by private individuals, hunting clubs and the older resorts of Skytop and Buck Hill serve as buffer areas protecting these streams.

Two sewage treatment plants discharge to the streams, one serving the community of Buck Hill Falls and one the Skytop Lodge and community. Of concern are areas with a high water table, where conventional septic systems are likely to malfunction. Fortunately, population growth in the headwaters areas has been relatively slow, so streams have not been significantly impacted.

Exceptional Value streams in the Upper Brodhead subwatershed include Buck Hill Creek, Rattlesnake Creek, Mill Creek, Spruce Cabin Run, Stony Run, Mud Run, Deep Hollow, and Poplar Run.

**Named Streams:**

Brodhead Creek

- Pine Mountain Run
- Poplar Run
- Stony Run
  - Mud Run
- Lucky Run
- Mill Creek
  - Rattlesnake Creek
    - Beaver Brook
  - Schafer Swamp Run
- Spruce Cabin Run
- Goose Pond Run

- Andy Sommer Run
- Horse Meadow Run
- Bon Hill Run
- Buck Hill Creek
  - Griscom Creek
  - Clear Run
    - Red Run
  - Gilpin Run
- Leavitt Branch
- Middle Branch
  - Dry Run
  - Laurel Run
  - Spruce Mountain Run

**Municipalities:**

- Barrett Township
- Price Township
- Coolbaugh Township
- Middle Smithfield Township
- Greene Township, Pike County

**Named Lakes, Ponds, and Impoundments<sup>10</sup>:**

- Mountain Lake (on Leavitt Branch)
- Lake Jamie (on Leavitt Branch)
- Lake in the Clouds (on Leavitt Branch)
- Skytop Upper Lake (on Leavitt Branch)
- Skytop Lower Lake (on Leavitt Branch)
- Leavitt Branch Dry Dam<sup>11</sup> (on Leavitt Branch)
- Goose Pond, *natural* (on Goose Pond Run)
- Ransberry Pond (on Goose Pond Run)
- Annunziata (on Goose Pond Run)
- Goose Pond Run Dry Dam<sup>12</sup> (on Goose Pond Run)
- Vanderwheel Dam (on Goose Pond Run)
- Canadensis Hotel Dam (on Goose Pond Run)
- Longacre Pond (on Middle Branch)
- Gravel Pond (on Laurel Run)
- Kresge Dam (on Rattlesnake/Mill Creek)
- Mill Creek Dam (on Rattlesnake/Mill Creek)
- Onawa Lake (on Rattlesnake/Mill Creek)
- Geissinger Dam (on Rattlesnake/Mill Creek)
- Pace Pond (on Griscom Creek)
- Spruce Cabin Pond, *natural* (on Spruce Cabin Run)
- Reinhart Lake (on Spruce Cabin Run)
- Sommers Dam (on Spruce Cabin Run)
- Browns Lake (on Stony Run)
- Dormoy Lake (on Stony Run)
- Snow Hill Dam (on Stony Run)
- Hiawatha Lake (on Pine Mountain Run)
- Manzanedo Lake (on Pine Mountain Run)

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<sup>10</sup> All lakes and ponds are manmade impoundments, with dam, unless otherwise noted.

<sup>11</sup> Two dry dams were built for flood control following the 1955 flood.

<sup>12</sup> Ibid.

## **Lower Brodhead Subwatershed**

The Lower Brodhead subwatershed includes the Brodhead Creek and its tributaries below the Brodhead's confluence with Paradise Creek, at Routes 191 and 447. The Lower Brodhead flows for 6.5 miles through Price and Stroud Townships, then forms the boundary between Stroudsburg and East Stroudsburg Boroughs for another 5.5 miles before joining the Delaware River, draining a total of 28.2 square miles. After the flood of 1955, the Brodhead was channelized from below Analomink thru the boroughs of Stroudsburg and East Stroudsburg and levees were built through the boroughs. Intense commercial and residential development occurs along and near the stream in the mid and southerly sections of the subwatershed. Major tributaries include Sambo Creek, Cranberry Run, and Michael Creek.

The Lower Brodhead and the Sambo Creek are important sources of drinking water for the boroughs of Stroudsburg and East Stroudsburg. The reservoir for East Stroudsburg's drinking water supply is found on the Sambo Creek. The Stroudsburg Municipal Authority draws fifty percent of its water from the Brodhead Creek and has permits to withdraw 5.38 million gallons per day (mg/d) from the Brodhead Creek and nearby wells. In 1999, the average daily use was approximately 1.9 mg/d or about 35 percent of its total permitted capacity. Of the permitted 5.38 mg/d, approximately 2.5 mg/d is withdrawn directly from the Brodhead Creek and approximately 2.88 mg/d is drawn from the nearby wells. On an annual basis, approximately 8-12 million gallons are exported from the watershed to be used for bottled water.

The East Stroudsburg borough, Rock Tenn, Inc, and Manwalamink (Shawnee) sewage treatment plants discharge to the Brodhead. Blue Mountain Lake Development and Smithfield township sewage treatment plants discharge in the Sambo subwatershed. Penn Estates Development discharges to Cranberry Run, which enters the Brodhead near Pinebrook Camp, and Bible Fellowship Camp sewage treatment plant discharges to the Brodhead in this section.

### **Named Streams:**

Brodhead Creek

- Sambo Creek
  - Little Sambo Creek
- Cranberry Run
- Michael Creek
- Marshalls Creek

### **Municipalities:**

- East Stroudsburg Borough
- Stroudsburg Borough
- Stroud Township
- Smithfield Township
- Middle Smithfield Township

### **Named Lakes, Ponds, and Impoundments:**

- Hallwood Lake (on Long Run)

- Woodland Lake (on Michael Creek)
- Analomink Lake (on trib to Brodhead Creek)
- Pocohontas Dam (on trib to Brodhead Creek)
- Blue Mountain Lake (on trib to Brodhead Creek)
- Pinebrook Lake (on trib to Brodhead Creek)
- Spring Lake (on trib to Brodhead Creek)
- Gregory Pond (on Zacharias Run)
- East Stroudsburg Upper Reservoir (on Sambo Creek)
- East Stroudsburg Middle Reservoir (on Sambo Creek)
- East Stroudsburg Lower Reservoir (on Sambo Creek)
- Eagle Lake (on unnamed trib to Sambo Creek)
- Mountain Vista Campgrounds Lake (on unnamed trib to Sambo Creek)
- Lake Valhalla (on Little Sambo Creek)
- Zacharius Pond (in East Stroudsburg)

## **Marshalls Creek Subwatershed**

Marshalls Creek flows for 10.5 miles through Middle Smithfield and Smithfield Townships before joining the Lower Brodhead Creek, just above where the Brodhead meets the Delaware. Only two major tributaries flow into the Marshalls Creek: Bear Swamp Run and Pond Creek, both second-order streams. The headwaters of Marshalls Creek flows in an easterly direction from the edge of the Pocono escarpment, like other headwaters tributaries of the Brodhead watershed. Pond Creek flows from two spring fed lakes, Echo Lake and Coolbaugh Lake, which give the stream its name. Pond Creek parallels Route 209 from the stream's beginning to the village of Marshalls Creek, where it joins the stream of that name. Marshalls Creek then parallel's Route 209, a major commercial artery and thoroughfare. The Marshalls Creek subwatershed drains an area of 26.8 square miles.

Marshalls Creek and its tributaries are distinguished by harboring rare fishes. Two species of shiner that have been found in Marshalls Creek have a proposed endangered status.<sup>13</sup> The bridle shiner (*Notropis bifrenatus*) has a current status as a candidate species. The ironcolor shiner (*Notropis chaleybaeus*) was thought to be extirpated.

Collectively, endangered, threatened, and candidate species (ETC species) are vulnerable species and account for approximately 30 percent of Pennsylvania's native fish diversity. These fishes represent an important component of Pennsylvania's fish diversity and as such, deserve protection afforded under Section 2305 of the Fish and Boat Commission's code. Geographic representations of ETC species' distributions may provide a foundation for developing preventative (proactive) management strategies and aid conservation biologists to curb biodiversity loss. Existing populations need to be monitored. The ironcolor shiner population is one of only two known in Pennsylvania. The bridle shiner is sympatric with the ironcolor shiner in Marshalls Creek and appears in good numbers.

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<sup>13</sup> *Application of Geographical Information System Technology to Fish Conservation in Pennsylvania, Phase I*, June 1998, revised October 1998

**Named Streams:**

Marshalls Creek

- Pond Run
- Bear Swamp Run

**Municipalities:**

- Smithfield Township
- Middle Smithfield Township

**Named Lakes, Ponds, and Impoundments:**

- Lake Monroe (on Bear Swamp Run)
- Belon Lodge Dam (on Marshalls Creek)
- Meadow Lake (on Clark Run)
- Longshore Dam (on Clark Run)
- Pocono Highlands Lake (on Clark Run)
- White Heron Lake (on Newton Creek)
- Echo Lake, *natural* (on Pond Creek)
- Coolbaugh Lake, *natural* (on Pond Creek)
- Davidson Dam (on Pond Creek)
- Williams Pond (on Pond Creek)
- Rakes Dam (on Pond Creek)
- Pardee Place Dam (on Pond Creek)
- Marshall Lake (on Pond Creek)
- Deer Lake (on Pond Creek)

## **Paradise Creek Subwatershed**

Paradise Creek drains the Pocono Plateau in its headwaters in Mount Pocono Borough, and Barrett, Coolbaugh and Tobyhanna Townships, flowing for nine miles in a southeasterly direction through Paradise Township before joining the Brodhead Creek. The Paradise Creek subwatershed drains a surface area of approximately 44.5 square miles. The Paradise Creek is paralleled for much of its length by PA Route 191. This highway is largely undeveloped, primarily due to the land being owned by fishing clubs. Major tributaries include Devils Hole Creek, Cranberry Creek, Butz Run, Swiftwater Creek and Forest Hills Run.

Seven sewage treatment plants discharge into the Paradise watershed: Paradise Stream Resort and Monsignor McHugh High School discharge to the Paradise, Mt. Pocono Municipal Authority and Mt. Airy Resort discharge to Forest Hills Run and Pocono Manor Inn, Pocono Mountain School District, Swiftwater Campus, and Aventis-Pasteur, Inc. discharge into the Swiftwater.

Paradise Creek boasts a healthy population of native and stocked trout. The good water quality can be attributed primarily to the high gradient of the streams in the watershed. The streams in the Paradise Creek subwatershed drop 800 feet in 8 miles. As the water bubbles over rocks and down slopes, it absorbs oxygen from the air and moves nutrients through rapidly so they are not absorbed. In addition, the high water table contributes

groundwater flows into streams. Devils Hole Creek, a headwaters tributary of the Paradise, is designated Exceptional Value.

The Paradise, along with the Brodhead, is credited as the birthplace of American trout fishing tradition. Paradise Valley is home to the first licensed trout hatchery in Pennsylvania. (Paradise Brook Trout Hatchery.) Teddy Roosevelt, Annie Oakley, and Calvin Coolidge fished the Paradise.

**Named Streams:**

Paradise Creek

- Butz Run
- Cranberry Creek
- Forest Hills Run
  - Swiftwater Creek
    - Indian Run
- Devil's Hole Creek
  - Tank Creek
  - Yankee Run

**Municipalities:**

- Paradise Township
- Mt. Pocono Borough
- Pocono Township
- Coolbaugh Township
- Barrett Township
- Tobyhanna Township

**Named Lakes, Ponds, and Impoundments:**

- Crawford Lake (on Paradise Creek)
- Pocono Gardens Pond (on Paradise Creek)
- Greevy Dam (on Paradise Creek)
- Paul Dam (2) (on Paradise Creek)
- Sabatino Dam (on Devils Hole Creek)
- Harriton Dam, Paradise Stream Pond (on Devils Hole Creek)
- Mt. Airy Lake (on Forest Hills Run)
- Fairview Lake (on Forest Hills Run)
- Swiftwater Lake (on Swiftwater Creek)
- Lake Minausin (on Swiftwater Creek)
- Pocono Manor Dam (on Swiftwater Creek)
- Whitestone Dam (on Swiftwater Creek)
- Wetbrook Dam/Weiler Pond (on Cranberry Creek)
- Daigle Dam (on Cranberry Creek)
- Alpine Lake (on Butz Run)
- Freeland Pond (on Butz Run)
- Lake Tanelo (on Butz Run)
- Meisertown Dam (on Butz Run)
- Tanners Henry Lake (on Butz Run)

## **Pocono Creek Subwatershed**

The Pocono Creek drains the Pocono Plateau in its headwaters in Tobyhanna and Tunkhannock Townships and flows for 16 miles in a southeastern direction through Pocono, Jackson, Hamilton and Stroud Townships where it converges with the McMichael Creek in Stroudsburg. The Pocono watershed drains a surface area of approximately 48 square miles and contains 14 sub-basins within its boundaries. The Pocono Creek is paralleled by Interstate-80 and the county's primary commercial artery, Route 611, which was built in the floodplain. Intense commercial development occurs along and near the stream in the mid and southerly sections of the watershed.

The Pocono Plateau escarpment forms the watershed's most prominent topographic feature, Big Pocono Mountain, which forms the western watershed boundary. The watershed includes the Tannersville Cranberry (peat) Bog, which is believed to have formed during a glacial retreat. The Cranberry Bog is the southernmost alpine boreal bog in the United States and is found in the east-central portion of the watershed. A large portion of the bog is protected through ownership and management by the Nature Conservancy. The Bog forms the eastern edge of the watershed.

The major tributaries running south into the Pocono Creek are Dry Sawmill Run, Sand Spring Run, Wolf Swamp Run in the north and Scot Run, Transue Run, Bisbing Run, Bulger's Run, and Cranberry Creek in the mid-section. Those running north into the Pocono Creek's mid-section are Colmoor Creek and Reeder's Run. Wigwam Run, Flagler Run, Big Meadow and Little Pocono are within the lower third of the watershed. Sand Spring Run and Wolf Swamp Run are designated Exceptional Value.

A number of sewage treatment plants discharge into the Pocono and its tributaries, including: Caesars Brookdale, discharges to Brookdale Lake; Crossings Outlet Mall, Camelback Ski Resort, Big Pocono Utilities, and Pocono Auto-Truck Stop discharge to the Pocono; PennDot rest-stop on Rte 80, Fountain Court and Fountain Court West discharge to tributaries; Barton Court Trailer Park and Monroe County Vo-Tech School discharge to Laurel Lake Run; Birchwood Resort discharges to the Cranberry Bog.

Evidence indicates that the Pocono Creek watershed is a high-quality resource on the edge of decline, and that same evidence may reveal the thresholds at which impairment occurs. Many negative impacts have been observed in localized areas. The natural resilience of the watershed is currently taxed by development, transportation, and maintenance practices. Storm water runoff from parking lots and roads causes habitat damage and numerous localized stream modifications such as roads, bridges, culverts, channelized areas, floodplain development, and riparian vegetation removal degrade the watershed's streams as well.<sup>14</sup>

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<sup>14</sup> *Pocono Creek Pilot Study, Phase I*, Monroe County Conservation District, 2001

Big Pocono Mountain (Camelback) forms the watershed divide between the McMichael and the Pocono watersheds. Camelback ski area, on the north face of the mountain, drains to the Pocono Creek.

**Named Streams:**

Pocono Creek

- Little Pocono Creek
- Big Meadow Run
- Flagler Run
- Wigwam Run
- Rocky Run
- Reeders Run
- Coolmoor Creek
- Cranberry Creek
- Bulgers Run
- Scot Run
  - Transue Run
- Wolf Swamp Run
  - Sand Spring Run
  - Dry Sawmill Run

**Municipalities:**

- Pocono Township
- Jackson Township
- Stroud Township
- Stroudsburg Borough
- Tobyhanna Township
- Tunkhannock Township

**Named Lakes, Ponds, and Impoundments:**

- Wolf Swamp Run Dam (on Wolf Swamp Run)
- Pine Tree Lake (on Dry Sawmill Run)
- Emerald Lakes/Youngs Pond (on Dry Sawmill Run)
- Crescent Lake (on Dry Sawmill Run)
- Mountaintop Lake (on Dry Sawmill Run)
- Wilson Dam (on Dry Sawmill Run)
- Deer Pond (on Dry Sawmill Run)
- Little Deer Pond (on Dry Sawmill Run)
- Deep Lake (on Sand Spring Run)
- Lindemere Dam (on Pocono Creek)
- Barneys Pond (on Pocono Creek)
- Camelback Reservoir (on Pocono Creek)
- Shaeff & Peters Dam (on Pocono Creek)
- Brookdale Lake (on Scot Run)
- Leisure Lake (on Scot Run)
- Massad Camp Dam (on Scot Run)
- Noah's Ark Dam (on Scot Run)
- Hemlock Lake (on Cranberry Creek)
- Hunter Lake (on Rocky Run)
- Lenape Lake (on Rocky Run)
- Wigwam Lake (on Wigwam Run)

- Flagler Dam (on Flagler Run)
- Lower Dam (on Flagler Run)
- Laurel Lake (on Laurel Run)
- Twin Hills Dam (on Little Pocono Creek)

## **McMichael Creek Subwatershed**

The McMichael Creek forms at the confluence of three headwater tributaries: Hypsy, Bowers, and Fall Creeks, which arise from wetlands and springs on the Pocono Plateau in Tunkhannock and Jackson Townships. The headwaters area of these creeks is relatively steep terrain forested primarily with second-growth hardwoods and a streamside canopy of rhododendron.

The McMichael Creek flows in a southerly, then northeasterly direction before converging with the Brodhead Creek in Stroudsburg. The McMichael Creek flows approximately 19 miles with a vertical drop of 1700 feet and drains an area of 69.5 square miles. Headwaters streams begin at elevations ranging from 2100 feet at the top of Big Pocono Mountain to 1800 feet at Hypsy gap; the McMichael Creek enters the Brodhead at an elevation of about 400 feet. The main channel separates at two locations: one mile below the town of McMichaels and again one mile above Brodheadsville, forming two distinct “splits” which rejoin downstream.

A significant portion of the McMichael Creek subwatershed is designated Exceptional Value, including Fall Creek, Bowers Creek, Hypsy Creek, and the upper part of the McMichael Creek.

The Stroudsburg Borough sewage treatment plant discharges to the McMichael Creek, near its confluence with the Brodhead. Plants at Snydersville Diner, King Arthur Restaurant and Monroe County Jail/Pleasant Valley Manor discharge to the McMichael or tributaries in the Snydersville area.

Lake Creek flows from Saylor's Lake, joining the McMichael near Sciota. Formerly known as Lake Poponoming, Saylor's Lake is the most southern moraine lake in the State. “It lies absolutely on the top of the moraine, and its surroundings are especially interesting from the fact that large boulders have been found on its shores which originally came from a point not nearer than the Adirondack region, 250 miles away, and which must have been transported by the slow moving ice masses of the ice age.” (Report of the State Commissioner of Fisheries, 1896, p. 234) The lake is fed by strong bubbling springs in the bottom of the lake.

The Northern Bullrush, a globally rare plant, is found at Lake Mineola in the McMichael watershed.

The Kettles, located on an unnamed tributary to Kettle Creek, are deep, circular depressions in bedrock created by the melting of large blocks of stagnant ice left behind by the glaciers.

Big Pocono Mountain (Camelback) forms the northeastern boundary of the McMichael watershed.

**Named Streams:**

McMichael Creek

- Appenzell Creek
  - Kettle Creek
  - Sand Spring Run
- Lake Creek
  - Spring Run
- Fall Creek
- Hypsy Creek
- Bowers Creek
- Pocono Creek

**Municipalities:**

- Jackson Township
- Hamilton Township
- Chestnuthill Township
- Stroud Township
- Stroudsburg Borough
- Ross Township
- Tunkhannock Township

**Named Lakes, Ponds, and Impoundments:**

- Lake Akiba (on Sand Spring Creek)
- Mountain Springs Lake (on Appenzell Creek)
- Trout Lake (on Appenzell Creek)
- Grubers Lake (on Appenzell Creek)
- Sheridan Dam (on Kettle Creek)
- Saylor's Lake, *natural* (on Lake Creek)
- Lake Watawah (on Lake Creek)
- Lenape Lake (on Spring Run)
- Lake Mineola, *natural* (on trib to McMichael)

## ***Watershed Management Units***

At the heart of watershed planning and management is the concept of watershed management units. This watershed conservation plan is meant to set up additional planning efforts at a more manageable scale, to keep the focus of the plan clear. Overall the plan represents a long-term process and continuous management commitment. There are many different watershed management units, including river basins, watersheds, subwatersheds, and catchments. A watershed can be defined as the land area that contributes runoff to a particular point along a waterway. In our case, the Brodhead watershed is all the land that drains to the point where the Brodhead meets the Delaware River. A typical watershed can cover tens to hundreds of square miles, and extend over several political boundaries or jurisdictions. The largest management unit is the basin. The Brodhead Creek flows to the Delaware River basin.

Watersheds are broken down into smaller geographic units called subwatersheds. Subwatersheds typically have a drainage area of 2 to 15 square miles, or larger, and include the land area draining to the confluence of two second-order streams or to the limits of a third order stream. This plan has identified six major subwatersheds from between 40 to 70 square miles each that form the Brodhead watershed based on the Brodhead Creek's major tributaries: Pocono Creek, Paradise Creek, McMichael Creek, Marshalls Creek, Upper Brodhead Creek, and Lower Brodhead Creek.

Management at the subwatershed level refers to assessment-level studies and specific projects within the smaller subwatershed units, while management at the watershed level refers to broader management issues across an entire watershed. The management units of watershed and subwatershed are most practical for local plans such as this one. Every watershed is composed of many individual subwatersheds, each having its own unique water resource objectives.

The recommendations of this plan focus on the broader issues across the entire watershed. However, the plan recognizes the importance of focusing on the subwatershed unit for several reasons:

- The influence of impervious cover on water quality, hydrology, and biodiversity is most evident at the subwatershed level, where the influences of individual development projects are easily recognizable.
- Because subwatershed management areas are limited to a smaller area, fewer pollutant sources are present to confuse management decisions.
- Subwatersheds are small enough to be within just a few political jurisdictions where it is easier to establish a clear regulatory authority and incorporate the smaller number of stakeholders into the management process.
- A subwatershed plan can generally be completed within two to three years and still allow ample time for goal development, agency coordination, and stakeholder involvement.

## ***Stream Order***

Stream order is a measure of where in a watershed a stream is and how many tributaries it has. First-order streams have no tributaries. Second-order streams have only first-order streams as tributaries. Third-order streams have only first- and second-order streams as tributaries, and so on.

The Brodhead Creek is a sixth-order stream below its confluence with the McMichael Creek, and a fifth-order stream below its confluence with Paradise Creek. The McMichael Creek is also a fifth-order stream, below its confluence with Appenzell Creek. Third-order streams in the watershed include the Upper Brodhead Creek, the lower portions of Paradise and Pocono Creeks, and the middle section of the McMichael Creek. Marshalls Creek is a third-order stream for most of its length.

Headwater streams are defined as first- and second-order streams. Headwater streams, although the smallest streams, are crucial in watershed management because they dominate the landscape through their sheer number and cumulative length. Although typically short in length, headwater streams actually comprise about 75% of the total stream mileage in the United States.

What happens in the local landscape is directly translated to headwater streams. As urbanization increases, streams handle increasing amounts of runoff, which degrades headwater streams and eventually, major tributaries.

Focusing on the headwater stream level in watershed management is important for several reasons:

- Headwater streams are exceptionally vulnerable to watershed changes;
- Headwater streams are often on the same scale as development projects;
- The public intuitively understands streams and strongly supports their protection;
- Headwater streams are good indicators of watershed quality.

Headwater streams have fewer upstream uses to cause problems and can be a reservoir of biodiversity, if protected. In addition, lower-order streams are narrower and therefore are more likely to have overarching trees, lower temperatures, and better food sources for aquatic invertebrates.

Headwaters areas in the Brodhead watershed are delineated by the presence of first- and second-order streams on the map *Stream Order*.

## ***Stream Designations***

Water quality throughout the Brodhead watershed is generally high. Much of the watershed is classified as a high quality cold water fishery (HQ-CWF) under Pennsylvania's water quality criteria (PA Code Title 25, Chapter 93.) Several sub-basins are classified as Exceptional Value streams. The lower part of the watershed also contains some sub-basins designated as Trout Stocking Fisheries, Cold Water Fisheries, and Migratory Fisheries.

In recognition of the pristine water quality in the headwaters streams of the Brodhead and its major tributaries, several of the streams in Barrett, Price, Coolbaugh, Tunkhannock, Jackson, and Chestnuthill Townships are classified as Exceptional Value. This regulatory definition determines the level of protection provided for the stream when discharge permits are issued by the PA Department of Environmental Protection.

Exceptional Value streams in the Brodhead watershed include:

- Buck Hill Creek
- Rattlesnake Creek
- Mill Creek (headwaters)
- Spruce Cabin Run
- Stony Run
- Poplar Run
- Devils Hole Creek
- Upper McMichael Creek to its headwaters
- Sand Spring Run
- Hypsy Creek
- Bowers Creek
- Fall Creek
- Wolf Swamp Run

Most of the rest of the watershed, including the Brodhead main stem downstream to Stokes Mill Avenue, is designated High Quality Cold Water Fishery, which means the streams are provided less protection in permit reviews but must be maintained at a water quality level sufficient to protect cold water fishes. Sambo Creek is designated a Cold Water Fishery / Migratory Fishery. The Lower Brodhead (from the bridge at Stokes Mill Road to the mouth at the Delaware) and a short section of the lower McMichael Creek are designated Trout Stocking Fisheries.

HQ and EV status signifies that these streams are suitable for Pennsylvania's anti-degradation water quality protection strategies for waters that exceed state standards, and that possess exceptionally high water resource values. The Pennsylvania Fish and Boat Commission (PFBC) classifies the several streams as Class A wild trout streams, finding significant populations of wild brook trout and wild brown trout.

State regulations in Chapter 93 define stream classifications and designated uses and describe how designated uses are used to determine what impact can be allowed from various permitted activities.

- Permitted discharges to Exceptional Value streams cannot change existing water quality.
- Permitted discharges to High Quality streams must maintain existing water quality except when social or economic justification for lowering water quality can be demonstrated.
- Permitted discharges to all other streams must protect existing uses (designations).

### **Stream Classifications and Designated Uses<sup>15</sup>**

**EV = Exceptional Value Waters.** Special Protection. A surface water which is of exceptional ecological significance, such as thermal springs or wetlands which are exceptional value wetlands under Chapter 105,17(1); or a surface water that has excellent water quality, meeting the tests for High Quality Waters, and also meets other requirements such as: is located in a National wildlife refuge or a State game propagation and protection area; or is located in a designated State park natural area or State forest natural area, National natural landmark, Federal or State wild river, Federal wilderness area or National recreational area; or is an outstanding National, State, regional or local resource water; or is a surface water of exceptional recreational significance; or meets a biological test set forth in DEP regulations at Chapter 93.4b(a)(2) or is designated by the Fish Commission as a "Wilderness Trout Stream."

**HQ = High Quality Waters.** Special Protection. A surface water having quality which exceeds levels necessary to support designated uses as shown by meeting chemical or biological standards set forth in DEP regulations at Chapter 93.4b (a).

**CWF = Cold Water Fishery.** Maintenance and/or propagation of fish species including the family Salmonidae and additional flora and fauna which are indigenous to a cold water habitat.

**TSF = Trout Stocking Fishery.** Maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.

**MF = Migratory Fishery.** Passage, maintenance and propagation of anadromous and catadromous fishes and other fishes which ascend to flowing waters to complete their life cycle.

**Class A Wild Trout Water.** A surface water classified by the Fish and Boat Commission based on species specific biomass standards, which supports a population of naturally produced trout of sufficient size and abundance to support a long term and rewarding sport fishery.

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<sup>15</sup> Chapter 93, Title 25, Pennsylvania Code of Regulations.

## ***Wetlands***

Wetlands are the transitional areas between clearly defined aquatic environments and clearly defined terrestrial environments. These areas are inundated by water at or near the surface of the land or are covered by shallow water. Wetlands can be scientifically delineated by the presence of hydric soils, hydrophytic plants, and water.

Wetlands serve many valuable functions. They provide quality wildlife habitat, filter runoff before it enters streams, and provide natural catchment basins for stormwater runoff. The natural filtration processes of wetlands have inspired communities and conservation districts to design and construct wetlands for the purposes of stormwater and sewage treatment.

Wetlands have important value in reducing water turbidity and improving water quality. They provide recreational opportunities for fishermen, hikers, hunters, and wildlife watchers. Wetlands also provide extremely important wildlife habitat. They provide water, food, and shelter for a multitude of creatures, ranging from the smallest amoeba to fish, reptiles, amphibians, furbearers, and waterfowl.

The biggest threat to wetlands today is development. Statewide statistics show that between 1956 and 1979 there was a 6 percent loss of wetlands. Forty-six percent of the loss was due to pond and lake construction, 37 percent to development, and 17 percent to agriculture. More recently, the Monroe County Conservation District has issued 142 permits for minor road crossings in wetlands in the last 10 years.

According to the U.S. Fish and Wildlife study, *Wetlands Trends for Selected Areas of the Northeast Glaciated Region of Pennsylvania (1981-82 to 1987-88)*, “the overall trend for the study area’s<sup>16</sup> wetlands was losses of vegetated wetlands and gains in non-vegetated wetlands (mostly ponds)... As development increases, the quality of wetlands can be expected to deteriorate due to increased sedimentation, groundwater withdrawals, increased water pollution, agricultural runoff, and other factors, unless adequate safeguards are taken to protect not only the existence of wetlands, but their quality.”

Woody wetlands cover about 2.55 percent of the watershed, or 1,889 hectares. Emergent herbaceous wetlands cover about 0.06 percent of the watershed, or 42 hectares.

The *Tannersville Cranberry Bog* is an outstanding feature of the watershed and is designated a National Natural Landmark. Located east of PA Route 611 near Tannersville, the Cranberry Bog is the best-developed, southernmost low altitude boreal bog along the eastern seaboard. The Cranberry Bog is owned by The Nature Conservancy.

Various programs, such as the Conservation Reserve Program run by the U.S. Department of Agriculture or Ducks Unlimited’s PA Habitat Stewardship Program, offer

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<sup>16</sup> Study area of Towanda, Montrose, and Tunkhannock.

incentives to farmers and others to protect existing wetlands. Additionally, funds are available to farmers to fence off wet areas, allowing the area to revert to its natural state. Along with incentives, present regulations require anyone filling a wetland to mitigate the action by restoring or constructing replacement wetlands.

## ***Floodplains***

Early settlers in the Brodhead watershed established communities along the rivers, as these were the most opportune locations for transportation, trade, and natural resources. Unfortunately, many of these towns were established in floodplains, leaving some residences and businesses prone to frequent flooding. Flooding in the watershed typically occurs in the early spring as melting snow and rainstorms combine to raise river levels. Levees have been constructed by the Army Corps of Engineers along the Brodhead Creek where it forms the border between Stroudsburg and East Stroudsburg Boroughs and along the McMichael Creek through the borough of Stroudsburg.

The Monroe County Conservation District, through a contract with the Pennsylvania Department of Community and Economic Development, has completed a detailed evaluation of the Floodplain Management practices for the 20 municipalities that comprise Monroe County. All 17 municipalities in the Brodhead watershed are enrolled in the National Flood Insurance program. As such, they are required to regulate activities within the flood hazard areas of the municipality as delineated by the Flood Insurance rate map and the Flood Insurance Study.

Although there are minimum floodplain management standards established by the Federal Emergency Management Agency and the PA Dept. of Community and Economic development, the municipalities are not restricted to providing the minimum protection. In fact, they are encouraged by FEMA and DCED to adopt more restrictive measures.

A matrix has been developed showing the level of floodplain resource management by municipality. Seven municipalities have adopted floodplain regulations that meet the minimum standards. Six have some degree of added resource protection and of them; two have indicated a willingness to study the possibility of adopting even more protective measures. The remaining four municipalities have enacted regulations that either prohibit any new development in the floodplain or that permit only those activities that will not adversely alter the hydrologic functions of the floodplain.

There are varying degrees of protection allotted to floodplains throughout the watershed. This has led to the disjunct management of floodplain corridors from a watershed protection perspective. Given the present atmosphere of inter-municipal cooperation, the time is right to consider the conservation of floodplain resources on a watershed basis.

Floodplain Ordinance Provision Matrix					
Municipality	Enrolled in NFIP	Minimum Regulatory Provisions	Some Restrictive Regulatory Provisions	More Restrictive Regulatory Provisions	Considering More Restrictive Regulatory Provisions
Barrett Twp.	X		X		
Chestnuthill Twp.	X			X	
Coolbaugh Twp.	X	X			
East Stroudsburg Bor.	X	X			
Hamilton Twp.	X	X			
Jackson Twp.	X	X			
Mid. Smithfield Twp.	X		X		
Mount Pocono Bor.	X			X	
Paradise Twp.	X	X			X
Pocono Twp.	X		X		
Price Twp.	X	X			
Ross Twp.	X			X	
Smithfield Twp.	X		X		
Stroud Twp.	X		X		X
Stroudsburg Bor.	X		X		
Tobyhanna Twp.	X			X	
Tunkhannock Twp.	X	X			
Greene Twp., Pike Co.	X				

## ***Storm Water***

The Act 167 Stormwater Management Plan Update, for the Brodhead and McMichael Creek watershed, is currently underway. Initially, Act 167 Plans were developed for the Brodhead Creek (1991) and the McMichael Creek (1988) separately. Since the plans and new issues to be addressed are similar, the update currently underway is for the combined area of the Brodhead and McMichael watersheds. Addressing stormwater runoff will help to reduce flooding, protect the quality of surface water, and address groundwater recharge.

A municipal questionnaire sent out as part of the Act 167 Update showed several occurrences of small stream flooding and stream bank erosion through the watershed during major storm events, resulting in both public and private property damages. These problems were found to be more pronounced in the more populated areas, most likely due to encroachments onto floodplain areas and undersized culverts or bridges. During winter months, frozen ground coupled with high snowfall and rapid melting can also lead to flooding. Shallow bedrock can also contribute to rapid runoff.

An additional concern of stormwater runoff relates to water quality. The conversion of farmland, forests, wetlands, and meadows to rooftops, roads, parking lots, and lawns creates a layer of impervious cover in the landscape. Water from storm events and melting snow runs rapidly off these surfaces, carrying pollutants to streams and aquifers, instead of slowly percolating into the soil. Research has shown that the amount of impervious cover in a subwatershed can be used to project the current and future quality of streams. In many regions of the country, as little as ten percent watershed impervious cover has been linked to stream degradation, with the degradation becoming more severe as impervious cover increases.

In residential areas, streams are contaminated by residential nutrient runoff from excessive applications of fertilizers, animal waste or malfunctioning septic systems; soil erosion, and streambank erosion. Bacteria, nutrients, sediments and erosion have been identified as water quality problems in the watershed, as a result of agricultural non-point source pollution and sediment from stream bank erosion. Habitat loss and eutrophication are other problems associated with stormwater runoff.

## ***Water Quality***

Although water quality is generally high throughout the watershed, human activities appear to be measurably contributing nutrients and increasing conductivity and hardness in surface waters in parts of the watershed. A slight but significant increase in nutrient concentrations in the main channel over the past two decades is not surprising given the rapid increase in population. Population has nearly doubled since 1980 in Monroe County, and is expected to grow by 60 percent by 2020.

Extensive water quality data has been collected in the watershed by a variety of groups including the Monroe County Planning Commission, the Brodhead Watershed Association, townships and fishing clubs, as well as by the Department of Environmental Protection. The results of County monitoring efforts are documented in the annual *Monroe County Water Quality Study*. Monroe County's annual water quality monitoring efforts began in 1985. For an abstract of one of these reports, as well as other reports incorporated into this plan by reference, see *Appendix F, Prior Studies*.

However, with the exception of the current assessment of the Pocono Creek watershed by the Delaware River Basin Commission and others, no thorough analysis of the available data has been completed. Assessments similar to the Pocono study of the other sub-watersheds in the Brodhead watershed would provide a valuable analysis of current conditions and trends.

Threats to the quality of water in the Brodhead watershed may be either "man-made" or naturally occurring. Threats to drinking water sources in the Brodhead watershed can be considered as Groundwater Threats or Surface Water Threats; since the two are inseparably linked in the hydrologic cycle, a problem with one will inevitably mean a problem with the other.

## **Groundwater Threats**

**Man Made Threats.** Many human activities can negatively affect groundwater quality as well as quantity. For many years it was generally believed that the filtering capabilities of the soil protected groundwater from contamination by human activities on the surface.

But with the discovery in the 1970's of human-made organic chemicals in groundwater, people began to realize how extensively our activities can affect groundwater. In fact, in a nationwide study commissioned by the U.S. Environmental Protection Agency, 65% of the private wells tested failed to meet at least one drinking water standard.

Those activities that can have a negative impact on groundwater can be categorized in four groups: waste disposal, resource extraction, agricultural practices, and urbanization.

***Waste Disposal.*** The best-known source of groundwater contamination is waste disposal sites (landfills), both municipal and industrial, that were in existence before new regulations went into effect in 1988.

Septic systems are another potential source of groundwater contamination. If septic systems are improperly installed or maintained, bacteria, viruses, nitrate, phosphorus, chlorides, and the organic solvents that are found in many household cleaners as well as products sold to "clean" septic systems can all make their way into groundwater. As a result of poor construction or maintenance of their septic systems, rural homeowners are frequently the cause of contamination of their own wells. Improper management of land application of wastewater may also be a threat.

**Resource Extraction.** As mines intersect aquifers and collect water, they interfere with groundwater storage and can lead to lowered water levels in wells. In the Brodhead Watershed, stone quarries can have a negative impact on both groundwater and surface water sources.

**Agriculture.** Common agricultural practices such as fertilizing and applying pesticides are coming under increased scrutiny because groundwater samples have revealed nitrates and, in some cases, pesticides. The most prevalent problem is high levels of nitrate from over application of manure and fertilizer. Nitrate is especially harmful to babies, interfering with the blood's ability to transport oxygen, which causes the baby to suffocate ("blue baby" disease).

**Urbanization.** Many human activities and land use practices, which proliferate with urbanization, can negatively affect groundwater. Even cemeteries, for example, can contaminate groundwater.

One effect of urbanization is recharge diversion. Soils that have been covered with impervious surfaces – roofs, parking lots, or streets – obviously cannot absorb precipitation. Nor can soils that have been compacted by heavy machinery. As a result, much of the water from rain and snowmelt goes directly into streams and is never available to recharge groundwater.

Large concentrations of people can also lead to over pumping of aquifers. This can result in significant aquifer drawdown, which in turn reduces the quantity of stream flow. Stream water quality then suffers due to higher concentrations of sewage treatment plant effluent. Intensive pumping in coastal areas can cause salt water to be drawn into aquifers and wells. Polluted stream water can also be drawn into drinking water wells.

With increased population comes industrialization and an increase in the amount and variety of industrial activities, many of which can potentially contaminate groundwater. Leaking storage tanks at both industrial sites and gas stations have contaminated groundwater in many instances.

Individual homeowners also impact groundwater through a number of activities. These include improper disposal of used oil and over application of fertilizer and pesticides on lawns and gardens. Homeowners use four to eight times the amount of fertilizer and pesticides per acre than farms. Golf courses are another potential source of groundwater contamination from overuse of fertilizer and pesticides.

**Natural Contamination.** The natural constituents of water that may affect its suitability for drinking and other purposes most commonly found in groundwater are dissolved solids, calcium carbonate, and iron. Concentrations of chlorides and nitrates can also restrict use of water. These constituents enter water by leaching from rocks as water moves through them. Hardness is a property of water, usually measured by the concentration of calcium carbonate, which increases the amount of soap needed to produce lather.

Radon, a naturally occurring radioactive gas formed from decaying uranium or radium deposits, is a natural contaminant of increasing concern. Where radon is present in bedrock it can dissolve in groundwater and become a health hazard either when consumed or when the gas escapes into the air during showering, cooking, and laundering.

Hydrogen sulfide is an infrequent natural contaminant of groundwater caused by water storage in certain types of shale rock. It imparts a characteristic rotten egg odor to the water, but is not seen as a health threat at the levels at which it makes water unpalatable.

Corrosive groundwater is common. Corrosivity involves many factors including high acidity and low concentrations of calcium carbonate. In a recent Penn State survey of groundwater in private wells, 60 percent had corrosive water. Corrosive water dissolves lead and copper from pipes and plumbing fixtures thus causing a health risk.

## **Surface Water Threats**

Because surface water (rivers, streams, ponds, lakes, reservoirs and springs) are by their nature more "visible," most people have more experience with this water source. Surface waters are often used for recreation, providing us with opportunities for swimming, boating, fishing, and camping. Most of us have pleasant memories and experiences related to these water habitats and view them as a wonder of nature, representing crisp, clear, clean water.

However, surface waters are even more at risk of contamination than groundwater, especially in the Brodhead watershed. This is due to the fact that the watershed is both a recreational area and a high growth area. This increases the human activity within the watershed and, thus, increases the chances of pollution. Surface waters can be contaminated by pollution from non-point sources or point sources – usually permitted discharges from sewage treatment or industrial waste treatment plants.

**Point Sources.** Point sources of pollution are those sites, such as industries or sewage treatment plants, that discharge wastewater directly into a body of water. The entry point of the discharge is at one or more discrete locations in the stream and therefore its effects can be readily measured and regulated. The primary regulatory mechanism of point sources is the National Pollutant Discharge and Elimination System (NPDES), a permitting system set up by the Clean Water Act and enforced by the EPA and DEP. Most often these are permits for industrial waste, sewerage wastewater or a stormwater discharge. The permitting process attempts to minimize the impact of human activity on the surface water sources. In the Brodhead watershed, a total of 39 facilities have NPDES permits.

In the Brodhead watershed there are numerous discharge permits and discharge points, ranging from systems discharging 1,000 gallons per day up to 2.25 million gallons per day in size. While point source sites do not contribute the volume of discharge to surface water sources that non-point source sites do, they must be maintained and operated

properly or they can have an immediate negative impact on the receiving water body. The following is a key to explain the permit type in the chart of NPDES permittees:

STP/P = Sewage treatment plant, public STP/NP = Sewage treatment plant, non-public IW = Industrial waste S-I = Stormwater industrial IND = Individual
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MUNICIPALITY	PERMIT #	PERMITTEE / SITE NAME	TYPE	DISCHARGE POINT	WATERSHED	MGD
E. Stroudsburg	PA0020168	East Stroudsburg Boro	STP/P	Brodhead	Lower Brodhead	2.25
Smithfield Twp	PA0060143	Manwalamink Sewer	STP/NP	Brodhead	Lower Brodhead	0.245
Smithfield Twp	PA0012963	Rock Tenn Co	IW	Brodhead	Lower Brodhead	0.326
Stroud Twp.	PA0035033	Bible Fellowship Church	STP/NP	Brodhead	Lower Brodhead	0.021
Stroud Twp.	PA0060992	Stroudsburg Municipal Authority	IW	Brodhead	Lower Brodhead	0.0125
Stroud Twp.	PA0060283	Penn Estates Utilities	STP/NP	Cranberry Run	Lower Brodhead	0.1
Smithfield Twp	PA0061361	Smithfield Twp Sewer Authority	STP/P	Little Sambo	Lower Brodhead	
E. Stroudsburg	PA0034517	East Stroudsburg/ Water Filtration Plant	IW	Sambo	Lower Brodhead	0.03
Stroud Twp.	PA0062464	Blue Mt. Lake Development	STP/NP	Sambo	Lower Brodhead	
E. Stroudsburg	PA0012394	Patterson-Kelley	IW	UNT Brodhead	Lower Brodhead	0.016
E. Stroudsburg	PA0013269	McGraw Edison	IW	UNT Brodhead	Lower Brodhead	0.06
Hamilton Twp.	PA0029220	Snydersville Diner	STP/NP	Kettle	McMichael	0.0125
Hamilton Twp	PA0063649	Howard Newhard/King Arthur Restaurant	STP/NP	McMichael	McMichael	
Hamilton Twp.	PA0060704	Monroe Co/Jail &Pleasant Valley Manor	STP/NP	McMichael	McMichael	0.038
Stroudsburg	PA0029289	Stroudsburg Boro	STP/P	McMichael	McMichael	2.5
Paradise Twp.	PA0061808	Royle George	IND	(land)	Paradise	
Mt. Pocono Boro	PA0044997	Mt Pocono Municipal Authority	STP/P	Forest Hills Run	Paradise	0.6
Paradise Twp.	PA0060054	Mt Airy Lodge	STP/NP	Forest Hills Run	Paradise	0.22
Paradise Twp.	PA0061115	Caesars Paradise Stream	STP/NP	Paradise	Paradise	
Paradise Twp.	PA0040444	Pocono Mt. School Dist.	STP/NP	Swiftwater	Paradise	0.0286
Pocono Twp.	PA0029149	Ireland Hotels/ Pocono Manor	STP/NP	Swiftwater	Paradise	0.14
Pocono Twp.	PA0060071	Aventis-Pasteur	IW	Swiftwater	Paradise	0.053
Barrett Twp.	PAS222202	Bestway Lumber Treatment Center	S-I	Cranberry Creek	Paradise	
Barrett Twp.	PA0029190	Monsignor McHugh High School	STP/NP	UNT Paradise Creek	Paradise	0.022
Pocono Twp.	PA0061921	Caesars Brookdale	STP/NP	Brookdale Lake	Pocono	
Pocono Twp.	PA0063024	Jeff Snyder Fountain Court	STP/NP	Cranberry	Pocono	0.005
Pocono Twp.	PA0034631	GP Mgmt/Birchwood (Onetime Inc.)	STP/NP	Cranberry Bog	Pocono	0.03
Pocono Twp.	PA0035335	Papillion Contracting/Barton Court	STP/NP	Laurel Lake Run	Pocono	0.0117
Stroud Twp.	PA0061093	Monroe Co. Vo-Tech	STP/NP	Laurel Lake Run	Pocono	0.015
Hamilton Twp.	PA0013676	Pocono Auto-Truck Stop (Oil Separator)	IW	UNT Pocono	Pocono	
Pocono Twp.	PA0061026	Big Pocono Utilities	STP/NP	Pocono	Pocono	0.0369
Pocono Twp.	PA0060569	Camelback Ski Resort	STP/NP	Pocono	Pocono	0.4
Pocono Twp.	PA0062979	Gem Corp. & Insalaco /Crossings)	STP/NP	Pocono	Pocono	0.024
Pocono Twp.	PA0041076	PA DCNR	STP/NP	UNT Scot Run	Pocono	0.005
Pocono Twp.	PA0063673	Jeff Snyder Fountain West	STP/NP	UNT Pocono	Pocono	0.0095
Pocono Twp.	PA0061051	Summit Resort (Farda)	STP/NP		Pocono	0.2
Stroud Twp.	PA0060631	Stroud Twp / Pocono Auto-Truck Stop)	STP/NP	UNT Pocono	Pocono	0.014
Pocono Twp.	PA0032859	Penn DOT Reststop 41	STP/NP	UNT Pocono	Pocono	0.00921
Pocono Twp.	PA0063584	Progressive Labels - PENDING	STP/NP	Scot Run	Pocono	0.00075
Barrett Twp.	PA0029483	Buck Hill Falls Co.	STP/NP	Buck Hill Creek	Upper Brodhead	0.2
Barrett Twp.	PA0029874	Skytop Lodge	STP/NP	Leavitt Branch	Upper Brodhead	0.075

**Non-Point Sources.** Non-point source pollution threats are those threats to surface water sources that cannot be traced to one particular discharge location. Run-off from farms, golf courses, street and highway systems, parking lots, recreational fields, leaking storage tanks or septic systems, railroad or vehicle accidents (i.e., chemical and fuel spills), are all considered "non-point source pollution." Atmospheric deposition is also a significant non-point source of pollution. Airborne pollutants, from sources such as automobiles and coal fired power plants, fall to the ground through rain, snow, or fog, entering surface water.

Combined, these potential sources of pollution in the Brodhead watershed area pose the greatest threat to the water quality. These threats run the full course of human activity from industrial and manufacturing centers, to the tourist industry, agriculture, residential homes and recreational uses.

Nutrients and pesticides from golf courses, agricultural uses and residential homes threaten the receiving waters. Chemicals and waste products from industrial and commercial facilities, if not properly treated and disposed of, threaten surface waters; air pollution from automobiles and combustion can find its way into the hydrologic cycle; auto and truck accidents can introduce chemicals or fuels into a water source, and run-off from parking lots and streets and other roadways contains oil and grease, nutrients, sediment and road chemicals.

A contaminated aquifer can influence a surface water source when it discharges into a surface water source (e.g. when groundwater, contaminated by malfunctioning septic systems, parking lot runoff, or overuse of fertilizers or pesticides, enters a stream).

## ***Water Supply***

### **Private Drinking Water Systems**

Everyone who lives, works, or visits the Brodhead watershed depends on the watershed for their drinking water supply. Water supplies can be either a private water system (an individual homeowner's well) or a public system.

A common source of drinking water in the Brodhead watershed is the private well. Fifty percent of homeowners and small businesses in the Brodhead watershed depend on private wells for their drinking water supplies. Most wells are used for residential purposes, although small commercial entities also utilize wells for their drinking water source.

Unlike Public Water Systems, private systems are neither monitored nor regulated by the Department of Environmental Protection (DEP). The private individual (residential or small commercial operation) is responsible for both the quality and quantity of their private water systems.

Private drinking water systems (wells) can vary in depth from less than 100' to over 700' deep. These wells face the same threats to their water sources (groundwater) as Public Water Systems, yet without the monitoring requirements of the Public Water Systems. Private systems depend on pumps, storage tanks and electrical service and, most importantly, the care of the homeowner, in order to operate.

Whether affected by a drought, water contamination or a mechanical/electrical malfunction, private drinking water system owners, for the most part, are "on their own" and are responsible for the operation and maintenance of these systems.

## **Public Drinking Water Systems**

Public Water Systems are licensed and regulated by the Pennsylvania Department of Environmental Protection (DEP). A Public Water System is defined as one which provides water to the public for human consumption. The term includes collection, treatment, and storage and distribution facilities used in connection with the system. The term also includes a system which provides water for bottling or bulk hauling for human consumption.

Within this definition, the Department of Environmental Protection regulates three different categories of Public Water Systems as follows:

- **Community water system** - a water system which serves at least 15 service connections, is used by year-round residents, or regularly serves at least 25 year-round residents.
- **Non-transient non-community water system** - a water system that regularly serves at least 25 of the same persons over 6 months per year; examples are a factory or a school.
- **Transient non-community water system** - a water system which serves a facility, such as a restaurant, where 25 or more different people may drink the water each day.

All of these types of systems are represented in the Brodhead watershed. From a school or large commercial building, to strip malls, doctor's office complex, a municipal authority, or municipal water department, all depend on the watershed for their water source.

Water systems may use "surface water" sources (streams, creeks, springs, lakes or reservoirs) and/or they may use "groundwater" sources (wells). Regardless of their size or the complexity of their treatment facilities, all are regulated by and report to DEP. Of course, these Public Water Systems are at risk from the various threats common to all water users in the Brodhead watershed, whether they utilize groundwater sources or surface water sources.

**Community Water Systems in the Brodhead watershed include:**

- Stroudsburg Municipal Authority
- East Stroudsburg Borough Water Department
- Pennsylvania American Water Company (Mt. Pocono, Pine Hill, Summit Pointe, Pocono Country Place, Pocono Farms East)
- National Utilities, Inc. (Mountainhome Division and Hamilton Division)
- Pocono/Jackson Joint Water Authority
- Buck Hill Water Company
- Skytop Lodge
- Pocono Manor
- Village at Camelback

**Stroudsburg Municipal Authority**

The Stroudsburg Municipal Authority (SMA) is the largest Public Water System in Monroe County, serving over 20,000 people in the Borough of Stroudsburg, Stroud Township and Smithfield Township. The Authority is located in Stroud Township, on the west side of the Brodhead Creek. Its annual operating budget is approximately \$2.2 million, with an annual capital improvement program of \$200,000 - \$300,000. In the 1990's, the Stroudsburg Municipal Authority spent over \$13.5 million to upgrade and extend its water distribution system, develop new sources of water (wells #1 and 2) and modernize its Water Treatment Plant into a "state-of-the-art" facility.

The Authority is permitted to withdraw 5.38 million gallons per day (mgd) from its wells and the Brodhead Creek. Wells #1 and 2 can produce up to 1,000 gallons per minute (gpm) each for a total capacity of 2.88 mgd. The wells are located approximately ¼ of a mile north of the Water Treatment Plant, on the west side of the Brodhead Creek. The Water Treatment Plant can generate 2.5 mgd with its source being the Brodhead Creek. In 1999, the average daily use was approximately 1.9 mgd or about 35% of its total permitted capacity.

The SMA has developed a Watershed and Wellhead Protection Program of its own within the larger Brodhead watershed area. The Authority continually monitors its sources and its finished water supplies for both quality and quantity. Its annual Water Quality Report (Consumer Confidence Report) is distributed to its customers on a yearly basis.

**Borough of East Stroudsburg Water Department**

East Stroudsburg Borough operates its water system, the only government operated system in the Brodhead watershed. The system is supplied primarily from a reservoir on the headwaters of Sambo Creek. Approximately 900,000 to 1,000,000 gallons per day are drawn from that reservoir. In addition, two supplemental wells are available from the campus of East Stroudsburg University, drawn when needed. A well located in Dansbury Park provides the balance of the 1.2 million gallons per day used by the 3,650 customers of the system; a fourth well, also located at Dansbury Park, is now coming on line. The two largest customers of the system are East Stroudsburg University and Pocono Medical Center. Capacity available in the East Stroudsburg system is 2.2 million gallons per day.

**Pennsylvania American Water Company**

Pennsylvania American Water Company (PAWC), an investor owned public water system, operates several water supply systems in the Mt. Pocono area: Pocono Country Place, Pocono Farms East, Summit Pointe, Pine Hill and Mt. Pocono Borough (formerly served by Fairview Water Company). Each of these is located partly or wholly in the Brodhead watershed. All systems are interconnected, so if a problem develops in one area, water can be provided from one of the other systems.

Pocono Country Place and Pocono Farms East are served by four wells which, combined, produce 614,000 gallons per day for residential and commercial use. The wells range from 175' to 700' deep. Water is provided to more than 3,000 customers in developments along Route 196, including Pocono Country Place, Pocono Farms East, Carriage Estates, and Whispering Glen.

Mt. Pocono Borough (portions of), including Summit Pointe development and the Pocono Mountain Industrial Park, are served by one well and a treatment station located in the Industrial Park which produces an average of 198,150 gallons per day for 558 residential, commercial and industrial customers. The well is 438' deep.

A third well in the PAWC system, located along Route 611 at the Coolbaugh Township Municipal Building property, delivers 500 gallons per minute (720,000 gallons per day) and serves the Tobyhanna village area and northern portion of the service area.

Several self-supplied developments in the Borough operate their own public water systems, independent of PAWC. These include: Limekiln Manor, Oakview Terrace Condo Association and Snow Shoe Condominium Association.

It is noted that Summit Pointe, Pine Hill, the Pocono Mountain Industrial Park, and Mt. Pocono Borough have sewer service provided by the Mt. Pocono Municipal Authority, which operates a sewage treatment plant located on and discharging to Forest Hills Run, a tributary of Paradise Creek. All water supplied to these areas (except for a few private wells) comes from the Tobyhanna watershed.

**National Utilities Company**

National Utilities Company, an investor owned public utility with offices in Scranton, Pennsylvania, operates two water systems in the Brodhead watershed, the Mountainhome Division and the Hamilton Division. The Mountainhome Division operates two wells located at the old reservoir site and supplies water to 547 customers. The Hamilton Division draws water from two wells, one located on Anchorage Road and one on Lily Road, and supplies 500 customers in the Saylorburg area.

**Pocono-Jackson Water Authority**

Pocono-Jackson Water Authority was formed to provide water to homeowners in Jackson Township when their private wells were contaminated by the Butz Landfill, a Superfund

site. The Authority provides water to 47 customers from 3 wells located at the base of Big Pocono Mountain in Jackson Township.

### **Resort Communities and Private Developments**

Many residential communities and resort communities are served by public water systems operated by the resort, a homeowners association or a private investor. Some of these are:

- Buck Hill Water Company - Service is provided to 279 customers; water sources are Buck Hill Creek, Big Spring and Well #2.
- Skytop Lodge - Water supply is 4 wells; service is provided to 45 customers.
- Pocono Manor Inn - Water supply is two springs; service is provided to 45 customers.
- Village at Camelback - Operates as three separate service areas:
  - Reservoir #1 provides water for Townhomes #1 through # 104
  - Reservoir #2 provides water for Townhomes #105 through # 260
  - Reservoir #3 provides water for Townhomes #261 through # 310
  - Water is drawn from four wells which are all interconnected.
- Penn Estates Utilities, Inc (owned by Utilities, Inc. Northbrook, Illinois) provides water from 6 wells to 1275 customers in Penn Estates. The system has capacity available for an additional 500 homes. Current water usage is 120 million gallons per year. (32,875 gallons per day).

### ***Wellhead Protection Areas***

Because it is out of sight, groundwater is often out of mind. For many of us, we only take notice of well water if it looks, smells, or tastes funny. But groundwater can be contaminated well before any obvious signs appear. Yet it can be difficult to clearly track a groundwater pollutant to its source, especially considering the many layers of soil and rock that water seeps through to reach an aquifer. Cleaning up a contaminated well is very difficult and costly, and it may not return to potable for a relatively long time. Thus it is important to create a “safe zone” around a wellhead by protecting the surrounding land from any potentially harmful activities.

DEP’s Wellhead Protection Program is predicated on the principle that it is cheaper to protect drinking water sources than to clean up after contamination occurs.

The following pollution vulnerability map illustrates the relative vulnerability of water supplies to pollution from surface or near-surface releases of contaminants. Natural protection of bedrock aquifers is provided by soil and sediment cover. Highly permeable soils (hydrologic soil groups A & B) provide little protection while less permeable soils (hydrologic soil groups C & D) provide progressively greater levels of protection. Alluvial deposits of sand and gravel serve as shallow water table aquifers in Monroe County. These deposits are highly permeable and regardless of soil cover and are highly vulnerable to pollution.

# Land & Biological Resources

The Brodhead watershed consists primarily of small communities, rural areas, farmland, and forests, with pockets of urbanization found mostly in the southern part of the watershed, in Stroudsburg and East Stroudsburg Boroughs and Smithfield and Stroud Townships. The dominant land cover in the watershed is forest, at 84 percent. Deciduous forest is the most common type, at 67 percent, or 122,384 acres. Mixed forest covers over 10 percent of the watershed, or 18,982 acres. Evergreen forest covers nearly 7 percent of the watershed, or about 12,355 acres. Residential use accounts for 3.7 percent of the land use in the watershed, or 6,771 acres.

## *Soil Characteristics*

### **Soils Types**

Like geology, soils play an important role in determining stream chemistry, and are also important for development and land planning purposes. Properties such as thickness, texture, and moisture capacity make some soil associations better suited to certain uses, such as agriculture or development, than others. The Brodhead Creek and its tributaries flow through eight major soil associations. These include the Lackawanna-Wellsboro-Oquaga, Wurtsboro-Swartswood-Volusia, Clymer-Buchanan, Wellsboro-Morris-Lackawanna, Lordstown-Oquaga, Mardin-Bath-Volusia, Benson-Rock outcrop, and the Wyoming-Chenango-Pope.

The northwest portion of the watershed consists almost entirely of deep soils formed in glacial till, such as the Lackawanna-Wellsboro-Oquaga, Wurtsboro-Swartswood-Volusia, Clymer-Buchanan, and Wellsboro-Morris-Lackawanna Associations. It also contains pockets of moderately deep soils formed in glacial till: the Lordstown-Oquaga Association. An area extending from Stroudsburg west to the Brodheadsville area also consists of moderately deep soils formed in glacial till; the Mardin-Bath-Volusia Association.

Across the southern boundary of the watershed lies the steep, shallow, well-drained soils and areas of rock outcrop underlain by shale, slate, sandstone and quartzite of the Benson-Rock outcrop. Lastly, in a dendritic pattern throughout the watershed, mostly following the low-lying stream corridors, is the Wyoming-Chenango-Pope Association.

### **Limitations**

***Lackawanna-Wellsboro-Oquaga Association*** – This soil association is the most common association in the watershed and is found in the central to northwest part of the watershed. The soils are mainly level to sloping, but some moderately steep slope soils are found on knolls and in stream valleys. Lackawanna soils are well drained but have a slowly permeable fragipan. (A fragipan is a brittle subsurface layer that appears cemented and restricts roots.) Wellsboro soils are moderately well drained and have a

seasonal high water table during wet periods. Oquaga soils are moderately deep and well drained. Except where cleared, these soils are too stony for cultivation and are better suited to woodland, wildlife habitat, and recreation. The major limitations in addition to stoniness are the slow permeability, the seasonal high water table, and the moderate depth to bedrock.

***Wurtsboro-Swartswood-Volusia Association*** – This soil association is also found throughout the northwest portion of the watershed, and is similar to the Lackawanna-Wellsboro-Oquagua Association. Wurtsboro soils are moderately well drained and have a seasonal high water table during wet periods. Swartswood soils are well drained but have a slowly permeable fragipan. Volusia soils are somewhat poorly drained and have a seasonal high water table during wet periods. The major limitations in addition to stoniness are the slow permeability and the seasonal high water table.

***Clymer-Buchanan Association*** – This soil association is found in a limited area to the west of Pocono Creek, south of Tannersville. Clymer soils are well drained, while Buchanan soils are moderately well drained or somewhat poorly drained and have a seasonal high water table during wet periods. The major limitations in addition to stoniness are the seasonal high water table in the Buchanan soils.

***Wellsboro-Morris-Lackawanna Association*** – This soil association is also found in a limited area, straddling the border of Pocono and Stroud Townships. Wellsboro soils are moderately well drained and have a seasonal high water table. Morris soils are somewhat poorly drained and have a seasonal high water table during wet periods. Lackawanna soils are well drained and have a slowly permeable fragipan. The major limitations in addition to stoniness are the slow permeability and the seasonal high water table.

***Lordstown-Oquaga Association*** – This soil association is found throughout the upper watershed on ridges and uplands of the plateau. The soils are mainly sloping to very steep, but some soils on the ridgetops are nearly level. Lordstown soils are yellowish brown, are moderately deep to bedrock, and are well drained. Oquaga soils are reddish brown, are moderately deep to bedrock, and are also well drained. These soils have low to moderate available water capacity and crop yields decrease during dry periods. The major limitations in addition to stoniness are the moderate depth to bedrock and the slope.

***Mardin-Bath-Volusia Association*** – This soil association extends in a broad swath from Stroudsburg east to near Brodheadsville. Mardin soils are moderately well drained and have a seasonal high water table. Bath soils are well drained but have a slowly permeable fragipan. Volusia soils are somewhat poorly drained and have a seasonal high water table. The major limitations in addition to stoniness are the slow permeability and the seasonal high water table.

***Benson-Rock outcrop Association*** – This soil unit extends along the southern edge of the watershed; its steep slopes form the watershed boundary to the south. It consists of moderately steep to very steep bedrock ridges. The soils are mainly steep and hilly, but

some rolling and nearly level soils can be found on ridgetops. Benson soils are shallow and well drained. This association is poorly suited to most crops grown in the region because of surface stones, rock ledges, and shallow depth to bedrock. Slope is also a major limitation.

**Wyoming-Chenango-Pope Association** – This soil association can be found along valley bottoms in the watershed. All of these soils are deep and well drained. Most of this unit has been cleared and is used for agriculture. The major limitations for these soils are the rapid permeability and flooding.

Of particular concern for this watershed plan is the fact that most of the watershed has severe limitations for conventional, in-ground septic tank absorption fields. (See the map of *Septic Tank Absorption Limitations*<sup>17</sup>.) Only a small percentage of the soils in the watershed are classified as having moderate or slight limitations for septic tank absorption capacities. Thus, many homes in the rural areas of the watershed use alternative systems such as sand mounds for wastewater treatment. Given these limitations and the widespread use of sand mound systems throughout the watershed, it is critical that these systems are monitored and maintained in proper working order. To that end, the Action Plan recommends that municipalities establish sewage management programs to assure that on-lot systems are properly monitored and maintained.

This plan also encourages the exploration of other alternative systems for wastewater treatment which would offer improvements over the prevalent methodology. One such alternative system is land application of treated sewage and industrial wastewater. The map of *Soil Suitability for Land Application of Treated Wastewater*<sup>18</sup> shows where in the watershed soils that are suitable for land application are located. Suitable soils were chosen according to their ranking in a table of suitable soils found in the *Manual for Land Application of Treated Sewage and Industrial Wastewater*, PA DEP, 1981. Soils are represented on the map in three categories:

- “Most Suitable” soils are those with a maximum application rate of 1.5”-2.0” per week. These soils are well drained (wooded or open). Their irrigation season is approximately March to December.
- “Suitable” soils are those with a maximum application rate of 1”-1.5” per week. These soils are shallow well drained to moderately well drained (wooded or open). Their irrigation season is approximately March to December.
- “Less Suitable” soils are those with a maximum application rate of 0.5” per week. They are somewhat poorly drained and have an irrigation season of approximately May to September.

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<sup>17</sup> Map was produced using readily available information for Monroe County. Additional information is required to complete this map for the portion of the watershed falling within Greene Township, Pike County.

<sup>18</sup> Ibid.

“Not Suitable” soils are those that are poorly drained or slopes in excess of 15 percent.

Little use has been made of these systems in the Brodhead watershed to date. However, one notable example of a spray irrigation system in the watershed is that operated by Spruce Lake Retreat, in Barrett Township, at the headwaters of the Brodhead Creek.

This spray irrigation wastewater system sprays into three forested zones comprising a total of five acres. The permitted volume for 2001 was 494,000 gallons per month for the months of March through November. However, the actual volume sprayed during the 2001 nine-month permitted period was 228,000 gallons per month, on average.

Another system, located on the watershed boundary, is operated by Pleasant Valley School District at their Middle School in Brodheadsville.

An interesting nearby project is that of the Pike County Business Center, located in Blooming Grove Township, a 615-acre business park with a projected sewage flow of 10,000 gallons per day. Sewage will be collected from each site, treated, and returned to be recycled as flush water for toilets and urinals. The remaining 20% will be discharged to a spray irrigation field.

## ***Land Ownership***

About 16,100 acres of land, or 8.7% of the Brodhead watershed, are publicly owned, including state lands, county lands, and municipal lands. Private protected lands, including private conservation lands, homeowners' association lands, and purchased agricultural easements, total about 3,375 acres, or about 1.8% of the watershed. Quasi-protected lands, or lands indicating a conservation interest, include agricultural security areas and Pennsylvania Act 319 lands. These lands total about 99,300 acres, or 54% of the watershed.

### **State Lands**

There are about 15,000 acres of state-owned land in the watershed, including state forests, gamelands, and Big Pocono State Park.

- *Delaware State Forest* – 8,638 acres of this 80,000-acre state forest are in Monroe County; about 6,630 acres fall within the Brodhead watershed.
- *State Gamelands* – About 6,000 acres of land in the Brodhead Watershed is owned by the Pennsylvania Game Commission. State Gamelands # 38 and State Game Lands #182 are both found in Pocono Township.
- *Big Pocono State Park/Camelback Mountain* – This park consists of 1,306 acres of rugged terrain on the summit and the ski slopes of Camelback Mountain.

### **County Lands**

There are about 400 acres of county-owned land in the watershed.

- *Kettle Creek Wildlife Sanctuary* - Owned by Monroe County and located in Hamilton and Jackson townships, this 120-acre site contains the offices of the Monroe County Conservation District and the District's Environmental Education Center and grounds dedicated to environmental study and the enjoyment of nature.
- *Meesing Nature Center* – This 130-acre site is located in Middle Smithfield Township. The Meesing Nature Center is in the Delaware State Forest on ground owned by PA DCNR and leased by Monroe County. The Monroe County Conservation District operates a maple sugar demonstration site there.
- *Monroe County Park* - The County Recreation and Park Commission headquarters is located in Snydersville. The site features an administration building and an 11-acre park with ballfields, trail and restroom. It is the county's only active recreation site.
- *Burnley Workshop* - The Burnley Workshop leases land from Monroe County. The Workshop allows Monroe County to use the land for athletic fields.
- *J.A. Karmilowicz, Inc. Tract* – Monroe County recently purchased this 100-acre tract with open space bond monies for permanent preservation and as a crucial connection for the planned Brodhead greenway and development of the Godfrey Ridge trail. The tract, which is adjacent to

the Brodhead Creek in Stroud and Smithfield Townships, will protect nearly a mile of riparian woodland.

### **Municipal Lands**

There are about 700 acres of municipal-owned protected lands and parkland in the watershed.

- High Acres – Barrett Twp, 21.68 acres
- Chestnuthill Township Park – Chestnuthill Twp, 37 acres
- Dansbury Park – East Stroudsburg Borough, 15.7 acres
- Zacharius Pond – East Stroudsburg Borough, 25.1 acres
- Gregory’s Pond – East Stroudsburg Borough, 10 acres
- Miller Park – East Stroudsburg Borough, 2 acres
- Schimpf – Hamilton Twp, 21 acres
- FSR Homestead – Hamilton Twp, 5 acres
- Open Space – Hamilton Twp, 2 acres
- Jackson Memorial – Jackson Twp, 4.9 acres
- Resica – Middle Smithfield, 37 acres
- Unnamed – Middle Smithfield, 17 acres
- Open Space Natural Area – Middle Smithfield, 5 acres
- Mt. Pocono Borough Park – Mt. Pocono Borough, 2 acres
- Deerfield Oak Street Park – Mt Pocono Borough, 15 acres
- Paradise Twp Park – Paradise Twp, 10 acres
- Mountain View Park – Pocono Twp, 81 acres
- Saylorburg Playground – Ross Twp, 14.09 acres
- Waterfront Park – Smithfield Twp, 53.3 acres
- Minisink – Smithfield Twp, 25 acres
- Little League Field – Smithfield, 11 acres
- Big Pines – Stroud Twp, 25 acres
- Jay Albertson – Stroud Twp, 5.37 acres
- Katz Park at Wedgewood Lake – Stroud Twp, 7.2 acres
- Kovarick Lands – Stroud Twp, 13 acres
- Michael Moore – Stroud Twp, 0.51 acres
- Daily Property – Stroud Twp, 1.91 acres
- Laurel Street Pond – Stroud Twp, 1.58 acres
- McMichael Creek Conservation Lands – Stroud Twp, 107 acres
- Yetter – Stroud Twp, 15 acres
- Carl Dennis – Stroud Twp, 31.19 acres
- Pinebrook – Stroud Twp, 60 acres
- Third Street Park – Stroudsburg Borough, 3 acres
- McMichaels/Rotary – Stroudsburg Borough, 5 acres
- Glen Park – Stroudsburg Borough, 10 acres
- Stroudsburg Park – Stroudsburg Borough, 5 acres

### **Other Protected and Quasi-Protected Lands**

Other protected lands in the watershed include private conservation lands – including those protected by conservation easement, homeowners’ association lands, and purchased

agricultural easements. Quasi-protected lands include agricultural security areas, Pennsylvania Act 319 lands, and hunting & fishing club lands.

- Private conservation lands are those protected by private land trusts and conservancies, such as the Nature Conservancy and the Pocono Heritage Land Trust. Private conservation lands total about 2,400 acres in the watershed. These include the Tannersville Cranberry Bog, owned by the Nature Conservancy. Lands protected by easement include those along Buck Hill Creek, including Jenkins Woods.
- Homeowners association lands (HOA) protect about 515 acres of land in the watershed through their commons. Homeowners associations in the county range from small developments of 25 houses to large communities such as Penn Estates. Public access is often restricted from these lands.
- Purchased Agricultural Easements permanently protect about 460 acres of agricultural land in the watershed.
- Agricultural Security Areas are not protected but are areas deemed suitable for protection by purchased agricultural easements. There are about 3,800 acres of Agricultural Security Areas in the watershed.
- Pennsylvania Act 319 lands are those protected under the “Clean and Green” program, which provides property tax breaks to owners. These lands are *not* permanently protected – a landowner can simply pay the back-taxes in order to develop the site (examples of this have already occurred in Monroe County). Act 319 lands in the watershed total approximately 95,500 acres and include both agricultural and forested lands.
- Hunting and fishing club lands include those owned by the Pohoqualine Fishing Club, Henryville Conservation Club, Brodhead Forest & Stream, Brodhead Hunting & Fishing, Parkside, and others. While the nature of their ownership provides a measure of protection, these lands are not permanently protected.

## ***Critical Land Areas***

### **Natural Areas Inventory Sites**

Important natural features of the Brodhead watershed were first identified in 1991 with the completion of the *Monroe County Natural Areas Inventory*. This inventory was the result of a combined effort between the Department of Community Affairs, The Nature Conservancy, and Monroe County. An update of this report was conducted in 1999 in conjunction with the development of the Monroe County Open Space Plan, adopted in June 2001.

The emphasis of the *Monroe County Natural Areas Inventory* is upon locations for species listed as rare, threatened, or endangered in Pennsylvania and exemplary natural communities. A few of these species are listed by The Nature Conservancy as globally imperiled Exemplary Natural Communities. NAI sites are shown on the map of *Critical Land Areas*.

### **Natural Treasures Registry Sites**

The Monroe County Open Space “Natural Treasures Registry” (NTR) project was initiated during preparation of the County Open Space Plan to allow County citizens and other interested individuals to suggest or identify areas of special interest or unique natural features that could be considered for eventual protection. Using a *Natural Treasures Registry* referral form, individuals and organizations were asked to identify and register “lost” natural areas that may not be included in existing County or state natural areas inventories. This effort is ongoing.

Nominated sites include many scenic and cultural sites, as well as habitat sites. Included in the habitat sites initially nominated were vernal pools, headwaters areas, wetlands, swamps, and riparian areas. Sites nominated for their cultural or scenic quality included views of woodlands, farms, and waterfalls.

This community-generated natural treasures information will help identify and protect significant and important sites of local interest and is meant to be an ongoing process. It also should be noted that some of the nominations received identified resources which might be better viewed as relating to the County’s cultural heritage, such as small eighteenth century cemeteries and important scenic sites. Natural Treasures Registry sites of the watershed are shown on the map of *Critical Land Areas*.

### **Important Bird Areas**

IBA is a bird habitat conservation project administered by the National Audubon Society. The IBA program is a global effort to identify the areas that are most important for maintaining bird populations, and focus conservation efforts at protecting these sites. IBA is cited by DCNR as important to consider during the development of a Pennsylvania Watershed Conservation Plan.

Audubon Pennsylvania’s Important Bird Areas Program was the first to develop a state IBA program in the United States. Based on strict scientific criteria, a group of scientific

advisors (known as the Ornithological Technical Committee) selected 73 Important Bird Areas encompassing over one million acres of public and private lands. These sites include migratory staging areas, winter feeding and roost areas, and prime breeding areas for songbirds, wading birds and other species. They also include critical habitats, such as spruce-fir bogs, tidal saltmarsh, bottomland hardwood swamps, and open grasslands. IBA sites in Pennsylvania are selected by the technical committee on an ongoing basis.

Important Bird Areas are sites that provide essential habitat for one or more species of bird. IBAs include sites for breeding, wintering, and/or migrating birds. IBAs may be a few acres or thousands of acres, but usually they are discrete sites that stand out from the surrounding landscape. IBAs may include public or private lands, or both, and they may be protected or unprotected.

To qualify as an IBA, sites must satisfy at least one of the following criteria. The site must support:

- Species of conservation concern (e.g. threatened and endangered species);
- Restricted-ranges species (species vulnerable because they are not widely distributed);
- Species that are vulnerable because their populations are concentrated in one general habitat type or biome; or
- Species, or groups of similar species (such as waterfowl or shorebirds), that are vulnerable because they occur at high densities due to their congregatory behavior.

There are three Important Bird Areas in Monroe County, including Pocono Lake Preserve (# 63 in Pennsylvania IBA book) and Long Pond Preserve (# 64). In addition, the entire Kittatinny Ridge (#51) is considered an Important Bird Area, encompassing 280 square miles of forested ridge. This ridge forms the southern boundary of Monroe County, and falls just outside the Brodhead watershed. The Kittatinny Ridge is the premier raptor migration corridor in the northeastern United States.

## ***Biological Resources***

The biologic quality of Monroe County and the Brodhead watershed is recognized not only by the county itself, but also by the Commonwealth of Pennsylvania, the U.S. Environmental Protection Agency, and the Nature Conservancy. In a preliminary evaluation, the U.S Environmental Protection Agency has identified Monroe County as an area of high biodiversity within the Middle Atlantic Region of the United States. Biodiversity is defined by the EPA as “the variety and variability among living organisms and the ecological complexes in which they occur”.

### **Wildlife**

#### **Terrestrial Wildlife**

The landscape of the Brodhead watershed, with its forests and numerous streams, ponds, and bogs, provides valuable habitat for wildlife. The most well-known mammal species are game animals, including black bear and white tailed deer. Squirrel, raccoon, woodchuck, skunk, and opossum are found in the more developed areas of the watershed. Common furbearers include mink, muskrat, beaver, and otter, all of which are associated with and depend upon clean water. A 1995 study of Monroe County found a total of 231 species in the county: 40 species of herpetofauna, 147 species of birds, and 44 species of mammals. However, by some estimates, the watershed may support as many as 56 species of mammals. The following is a list of mammals known to inhabit the watershed, their occurrence (common or uncommon) and their habitats:

- Black Bear – Wetland areas and upland areas
- White-Tailed Deer – Common throughout, found in both remote and populated areas
- Coyote – Throughout, more common in upper watershed
- Red Fox – Lower areas of watershed
- Gray Fox – Found in upper, more wooded areas
- Bobcat – Upper watershed, found in more remote areas
- Beaver – Small feeder streams and lakes in upper watershed
- Otter – Along streams through much of watershed, very mobile
- Mink – Common along waterways
- Fisher (recently reintroduced in north-central Pennsylvania)
- Raccoon – Common along waterways
- Weasel, striped skunk, opossum – Common throughout in a variety of habitats, including the Short-tailed weasel (rare).
- Muskrat – Common in smaller streams and wetlands
- Woodchuck – Common in lower watershed in open areas
- Squirrels & Chipmunks – Common, found in forested areas throughout. These include: Gary squirrel (common), Red squirrel (common), Chipmunk (common), and Northern flying squirrel (rare).
- Cottontail Rabbit – Open areas in lower watershed

- Snowshoe Hare – Uncommon, found in upper watershed mostly associated with wetland areas
- New England cottontail (rare)
- Porcupine – Becoming more common in upper watershed areas that are predominantly forested
- Mice, Voles, Shrews, Moles – Common throughout watershed in preferred habitat for each species. These include: Woodland jumping mouse (rare), Meadow jumping mouse, White-foot mouse (common), Deer mouse (common), House mouse, Star-nose mole, Hairy-tailed mole, Short-tailed shrew, Masked shrew, Water shrew, Red-backed vole, Meadow vole, Rock vole (rare), Pine vole (woodland vole), Norway rat, and Eastern woodrat.
- Bats include the Little brown bat and the Big brown bat.

### **Reptiles and Amphibians**

A wide variety of amphibians and reptiles inhabit the woods, meadows, wetlands, and waters of the Brodhead watershed. Amphibians evolved from fishes about 350 million years ago to become earth's first terrestrial vertebrates and are still dependent upon clean water in one important way – for reproduction. Jelly-like eggs are laid in water, hatch into gilled larvae or tadpoles, and later metamorphose into air-breathing amphibians. These adults are still dependent upon water for their survival – they need to maintain moist skins even in their terrestrial lives. Amphibians are often dependent upon “vernal pools” for their reproduction. Formed by spring runoff in wooded depressions, these pools lack predatory fish and turtles and provide a safe area for breeding before drying up in mid-summer. The following is a list of amphibians known to inhabit the watershed, their occurrence (common or uncommon) and their habitats:

- Fowler's Toad – Uncommon, found in sandy areas near the Delaware River
- American Toad – Common throughout, found in variety of habitats
- Gray Treefrog – Common in woodlands throughout, especially near wetlands
- Spring Peeper – Common near most aquatic habitats
- Pickerel Frog – Common throughout in variety of habitats
- Wood Frog – Common in woodlands throughout
- Bullfrog – Common throughout in many aquatic habitats
- Green Frog – Common throughout in many aquatic habitats
- Slimy Salamander – Common in woodlands throughout
- Four-Toed Salamander – Uncommon, found in woodlands especially near sphagnum wetlands
- Northern Spring Salamander – Uncommon, found in springs & small streams
- Northern Red Salamander – Uncommon, found in woodlands near springs and small streams
- Long-Tailed Salamander – Uncommon, found in woodland seeps

- Northern Two-Lined Salamander – Common, found in small streams and seeps throughout
- Marbled Salamander – Uncommon, localized in woodlands
- Jefferson Salamander – Uncommon, localized in woodlands
- Spotted Salamander – Common in woodlands throughout
- Red-Spotted Newt – Common in standing water habitats (adults) & woodlands (immature stage) throughout
- Northern Dusky Salamander – Common in small streams, brooks, and seeps
- Mountain Dusky Salamander – Uncommon, found in woodlands near small streams
- Red-Backed Salamander – Common in woodlands throughout

Reptiles evolved about 300 million years ago from amphibians. They are completely terrestrial in their breeding and inhabit both terrestrial and aquatic habitats. The following is a list of reptiles known to inhabit the watershed, their occurrence (common or uncommon) and their habitats:

- Northern Water Snake – Common in variety of water habitats
- Northern Brown Snake – Uncommon and localized in a variety of habitats
- Northern Red-Bellied Snake – Common in wooded areas of upper watershed
- Eastern Ribbon Snake – Uncommon, found in or near a variety of aquatic habitats
- Eastern Garter Snake – Common throughout in a variety of habitats
- Eastern Hognose Snake – Uncommon, found in dry, sandy soil habitats
- Northern Ringneck Snake – Common in rocky, upland areas
- Eastern Worm Snake – Uncommon, found in woodlands, sandy bottomlands
- Northern Black Racer – Common in many upland habitats
- Eastern Smooth Green Snake – Common, but localized in grassy, weedy habitats of upper watershed
- Black Rat Snake – Common in rocky habitats, especially in lower watershed
- Eastern Milk Snake – Common in variety of habitats throughout
- Northern Copperhead – Uncommon, found in rocky upland areas
- Timber Rattlesnake – Uncommon, found in rocky woodlands of upper watershed
- Snapping Turtle – Common throughout in a variety of aquatic habitats
- Spotted Turtle – Uncommon, found in marshes, swamps, and small streams
- Wood Turtle – Uncommon, found in woodlands near water
- Box Turtle – Uncommon, found in upland habitats
- Painted Turtle – Common in a variety of aquatic habitats
- Bog Turtle – Uncommon; occurs on PNDI species listing.

The biggest problem facing reptiles and amphibians in the watershed is loss of habitat. Countless acres of wetlands and woodlands have been replaced by housing developments, lawns, shopping malls, and parking lots. A large number of amphibians and reptiles are also killed by cars as they cross roads.

### **Aquatic Wildlife**

The Brodhead watershed supports coldwater fishes throughout its entire length. Most of the headwater streams and small tributaries are the remaining refuges of the brook trout, the salmonid native to the drainage. Brook trout once thrived in much of the drainage but have been relegated to the headwater areas due to environmental degradation and competition with exotic species. Introduced brown trout have become naturalized through much of the watershed. In a few limited areas of the Swiftwater and upper McMichael Creeks, there is some natural reproduction of introduced rainbow trout. Some headwater streams have fish populations limited to trout alone or trout and sculpins. Fish diversity increases in a downstream progression to include dace, darters, fallfish, suckers, American eels, and other species including the endangered bridled and ironcolor shiners in the Marshalls Creek. From the vicinity of Stroudsburg to its confluence with the Delaware River, the Brodhead includes some cool and warmwater species, along with the typical trout stream species. Rock bass, smallmouth bass, and bluegills inhabit the lower reaches. Migratory species include the American eels mentioned previously, along with the occasional American shad or striped bass from the Delaware. Sea Lampreys spawn in the lower Brodhead and Marshalls Creeks. The entire Brodhead drainage is an important recreational fishery heavily utilized in private and public areas by anglers fishing for wild and stocked trout and for other species in the lower drainage.

The Brodhead drainage also hosts very diverse aquatic invertebrate populations. There are numerous taxa of mayflies, stoneflies, and caddisflies, along with true flies, aquatic beetles and their larvae, and hellgramites. In addition to the aquatic insects, there are crustaceans - crayfish, sowbugs, and shrimp. Freshwater clams, snails, and worms are included in the invertebrate populations. As in any complex drainage, there is a great deal of longitudinal succession of invertebrate species in the Brodhead. In most of the headwater tributaries, species predominate that are limited to pristine conditions because of low pollution tolerance. Intolerant species continue to predominate through most of the drainage with the exception of certain degraded areas.

### ***Birds of the Brodhead Watershed***

The Brodhead watershed is home to a rich and varied avifauna. The dramatic rise in elevation from the watershed's confluence with the Delaware River to the top of the Pocono Plateau where the headwater streams rise is the reason for the diversity in habitats that support such diverse bird life.

The altitude and latitude of the Pocono Plateau create climatic conditions that support several boreal species. Northern birds finding the southern limits of their breeding range include the Magnolia and Blackburnian warblers, Red-breasted Nuthatch and the Golden-crowned Kinglet. The cliffs on the southern face of Spruce Mountain are home to the only nesting pair of Common Ravens in the entire region. The watershed's swift flowing

streams are home to the Louisiana Waterthrush, one of the species on the National Audubon Society's "Watch List" for Pennsylvania. Several other species on the "Watch List" found in the watershed include the Wood Thrush, Black-throated Blue, Cerulean, Worm-eating Warbler, and Prairie Warbler. The Golden-winged warbler is the subject of a national effort by the Cornell Laboratory of Ornithology to study its decline as well as being on the "Watch List." This bird can be found nesting at the Meesing Nature Center as well as the Tannersville Cranberry Bog. At the lowest elevations of the watershed at least one southern species finds the northern limits of its range, the Yellow-throated Warbler. In between are a dazzling array of neotropical migrants and residents alike.

Bald Eagles and Osprey have made an incredible recovery in northeastern Pennsylvania and are often seen in the Brodhead watershed. Although not yet listed as breeders in the watershed it is just a matter of time before the nest of one or both of these species is found. Red-tailed hawks are the most common diurnal raptor in the watershed but Broad-winged, Red-shouldered, Sharp-shinned and Cooper's hawks are all recognized as breeders in the region. The most common of the nocturnal raptors is the Barred Owl, which is associated with swamps and bottomland forests. In the dryer forests and in more developed areas the Great-horned Owl and Screech Owl are found. There is some evidence that the smallest of our nocturnal raptors, the Northern Saw-whet Owl, uses the valleys of the Brodhead Watershed as migration corridors. In an effort to learn more about this secretive bird, the Pocono Avian Research Center conducted a mist netting effort on the property of Skytop Lodge in the fall of 2000. Even though there had been no previous records of these diminutive owls on the 5,000-acre property, PARC banded sixty owls in late October and early November, with a high of thirty individual birds banded on the night of October 22. The nocturnal bird of concern now is the Whip-poor-will, which seems to be disappearing from the forests of the watershed and the entire region at an alarming rate.

Christmas Bird Counts conducted by the Pocono Audubon Society have discovered some interesting wintering birds in the watershed including Yellow-rumped Warbler, Bluebird, Northern Shrike and, depending on conditions, several species of northern finches. During these years the watershed supports wintering populations of grosbeaks, siskins, redpolls and crossbills. In all seasons it is possible to see chickadees, titmice, cardinals and blue jays. The heavily forested nature of the watershed makes it prime habitat for woodpeckers and several of the more rare species are found here including the Red-bellied woodpecker, the Pileated woodpecker and the Yellow-bellied Sapsucker.

Game bird populations are very high. The Ruffed Grouse can be heard drumming throughout the watershed in the spring. Woodcock fill the late winter twilight with their incredible courtship flights but neither of these birds can compare in stature with the wild turkey that is undergoing a population explosion. These large birds are taking advantage of banner crops of nuts provided by the beech and hickory trees over the last few years.

There is a growing problem in the watershed with non-migratory Canada Geese. Over the last ten years they have become more hated than Starlings. Starlings and House Sparrows are not the problem in the Brodhead watershed that they are in more urban and agrarian

communities but they are still causing problems for other cavity nesting birds. The Brown-headed Cowbird is found in the watershed but the severity of its impact on the overall bird populations in the watershed is not yet known.

Due to its clean flowing streams and intact habitats, the Brodhead watershed is home to one of the richest avifauna in the state. Besides the natural threats to the watershed's birds there is the growing problem of habitat manipulation as either fragmentation or outright loss. Continued research by the Audubon Society and Pocono Avian Research Center will be invaluable resources in recording the changing dynamics of avian populations in the watershed and monitoring the effectiveness of resource management on a habitat scale.

### ***PNDI Species***

The Pennsylvania Natural Diversity Inventory (PNDI) database was established in 1982 as a joint effort of the Pennsylvania Science Office of the Nature Conservancy, the Pennsylvania Department of Environmental Resources (now the Department of Conservation and Natural Resources), and the Western Pennsylvania Conservancy. Since its development, the PNDI database has become Pennsylvania's chief storehouse of information on outstanding natural habitat types (natural communities). Its focus is on species rarity and areas of highest natural integrity in order to protect the full range of biological diversity in Monroe County.

The Pennsylvania Natural Diversity Inventory has identified many species of special concern that exist within the Brodhead watershed. These are:

- Roadside skipper (*amblyscirtes vialis*)
- Bog rosemary (*andromeda polifolia*)
- Dusted skipper (*atrytonopsis hianna*)
- Brown sedge (*carex buxbaumii*)
- Collin's sedge (*carex collinsii*)
- Cloud Sedge (*carex haydensii*)
- Slender sedge (*carex lasiocarpa*)
- Mud sedge (*carex limosa*)
- A sedge (*carex tetanica*)
- Bog turtle (*Clemmys Muhlenbergii*)
- Timber rattlesnake (*Crotalus horridus*)
- Elegant skimmer (*dorocordulia lepidia*)
- Small waterwort (*elatine minima*)
- Boreal bluet (*enallagma boreale*)
- Persius duskywing (*erynnis persius persius*)
- Bobcat (*felis rufus*)
- Small floating manna grass (*glyceria borealis*)
- Barrens buckmoth (*hemileuca maia*)

- Cobweb skipper (*Hesperia metea*)
- Henry's elfin (*incisalia henrici*)
- Frosted elfin (*incisalia irus*)
- Common juniper (*juniperus communis*)
- American brook lamprey (*lampetra appendix*)
- Bog copper (*lycaena epixanthe*)
- Appalachian sandwort (*minuartia glabra*)
- Northern Myotis (*myotis septentrionalis*)
- Bridle Shiner (*notropis bifrenatus*)
- Ironcolor shiner (*notropis chalybaeus*)
- White fringed orchid (*platanthera blephariglottis*)
- Mulberry wing (*poanes massasoit*)
- Racemed milkwort (*polygala polygama*)
- Bushy knotweed (*polygonum ramosissimum*)
- Three-toothed cinquefoil (*potentilla tridentata*)
- Pink sallow (*psectraglaea carnosa*)
- Tufted buttercup (*ranunculus fascicularis*)
- Smith's bullrush (*schoenoplectus smithii*)
- Torrey's bullrush (*schoenoplectus torreyi*)
- Northeastern bullrush (*scirpus ancistrochaetus*)
- Bur-reed (*sparganium angustifolium*)
- White twisted-stalk (*streptopus amplexifolius*)
- Allegheny cave amphipod (*stygobromus allegheniensis*)
- Spreading globe flower (*trollius laxis*)
- Eastern mudminnow (*umbra pygmaea*)

For a complete list of PNDI species in the Brodhead watershed and their state and federal status, see *Appendix E, List of PNDI species and Ecological Communities*.

### **Important Habitats**

The emphasis of both the Pennsylvania Natural Diversity Inventory (PNDI) database and the *Monroe County Natural Areas Inventory* is upon locations for outstanding natural habitat types and exemplary natural communities. Many nominated Natural Treasures Registry sites also represent important habitat areas. NAI sites, Natural Treasures Registry Sites, and wetlands are shown on the map of *Critical Land Areas*.

The Pennsylvania Natural Diversity Inventory has identified several natural community types and geologic features that exist within the Brodhead watershed. These are:

- Acidic broadleaf swamp
- Acidic shrub swamp
- Boreal conifer swamp
- Broadleaf-conifer swamp
- Erosional remnants

- Invertebrate fossil animals
- Mesic central forest
- Northern conifer forest
- Northern conifer swamp
- Glacial bog
- Ridgetop dwarf-tree forest

For a complete list of PNDI natural community types in the Brodhead watershed and their state and federal status, see *Appendix E, List of PNDI species and Ecological Communities*.

## ***Vegetation***

### **Land Cover Types**

Forest types in the watershed include deciduous forest (67 percent), mixed forest (10 percent), and evergreen forest (7 percent). Mixed forest refers to those areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the tree cover present. All together, eighty-four percent of the watershed is covered by deciduous, mixed, and evergreen forests. Shrubland types in the watershed include deciduous shrubland, evergreen shrubland, and mixed shrubland. About 6 percent of the watershed is covered by pasture or hay. Woody wetlands are more common than emergent herbaceous wetlands, covering about 2.5 percent of the watershed. The following describes some of the major vegetative community types in the watershed.

### **Forest Community Types**

The following summarizes the major forest cover classes in the watershed:

- Northern Hardwood Forest – Common in the upper watershed on the Pocono Plateau, dominated by northern hardwoods such as American beech, red maple, yellow birch, white ash, and eastern hemlock. Common understory trees and shrubs include maple-leaf viburnum, spice bush, mountain laurel, and rhododendron.
- Northern Conifer Forest – Characterized by northern evergreens, predominately the eastern hemlock in the canopy and rhododendron in the understory and shrub layers. Groundcover supports a wide variety of ferns, mosses and liverworts. Commonly found in deep cool ravines on steep slopes, especially north-facing ones.
- Northern Hardwood - Northern Conifer – Mix of hardwoods and conifers with no clear dominance by either.
- Mixed Oak – Common in the lower watershed, supports high diversity. Black, red, and white oak are the dominant species. Associated species include tulip poplar, basswood, American beech, and white ash.
- Shrub/Scrub Oak Barrens – Dominated by scrub oak, pitch pine, and dense heath shrubs. Found scattered on the Pocono Plateau on dry sites exposed to wind and subject to repeated burns by wildfires.

## Wetland/Aquatic Community Types

The following summarizes the major wetland cover classes in the watershed:

- Northern Conifer Swamp – Forested wetland dominated by coniferous species such as white pine and eastern hemlock, influenced primarily by acidic water. Other indicator species include yellow birch, speckled alder, and high bush blueberry
- Boreal Conifer Swamp – Forested wetland dominated by boreal coniferous trees such as black spruce, balsam fir, and tamarack. Often contains small open bog areas.
- Broadleaf-Conifer Swamp – Forested wetland co-dominated by both coniferous and broadleaf trees.
- Hardwood Swamp – Forested wetland dominated by broadleaf deciduous trees such as red maple, black gum, and yellow birch.
- Acidic Shrub Swamp – A shrub-dominated wetland with at least 50 percent shrub cover and less than 20 percent trees. Indicator species include speckled alder, high bush blueberry, and smooth alder.

## Invasive Species

Exotic plants are a serious threat to the watershed. These species grow aggressively, spread, and displace native plants that have more value as forage and habitat for indigenous animal species. In addition, invasive species can disturb or alter natural communities within an ecosystem, often upsetting the natural balances required to keep these systems functioning properly. Endangered, rare, and threatened native species are especially at risk because they occur in small populations, which makes them particularly vulnerable.

Invasive plants are generally undesirable because they are difficult to control. Most invasive plants arrived from other continents and as such are often referred to as “exotic,” “alien,” “introduced,” or “non-native.” Invasive plants are noted for their ability to grow and spread aggressively. They can be trees, shrubs, vines, grasses, or flowers. Invasive plants have the ability to reproduce rapidly by roots, seeds, shoots, or by a combination of all three. They also have the ability to adapt to a diverse range of growing conditions and once established, exploit or colonize these areas. Second to habitat loss from development, invasive plants are the next major factor contributing to the decline of native plants in the watershed.

Recognition of invasive plants, understanding the potential damage they can cause, managed control, and most importantly, avoiding the use of them in plantings, is essential to stopping their spread and protecting native vegetation.

The following species have been documented by DCNR Bureau of Forestry as serious threats in Northeastern Pennsylvania and are present in the Brodhead watershed:

Amur Honeysuckle	<i>Lonicera maackii</i>	Shrub - seeds spread by birds
Autumn Olive	<i>Elaeagnus umbellata</i>	Shrub - seeds spread by birds

Bull Thistle	<i>Cirsium vulgare</i>	Noxious Weed – seed in open fields
Canada Thistle	<i>Cirsium arvense</i>	Noxious Weed – seed in open fields
Garlic Mustard	<i>Alliaria petiolata</i>	Noxious Weed – seed in woodland understory
Jap. Honeysuckle	<i>Lonicera japonica</i>	Vine – seed spread by birds
Multiflora Rose	<i>Rosa multiflora</i>	Shrub – seed spread by birds
Norway Maple	<i>Acer platanoides</i>	Tree – straight species spread by seed
Oriental Bittersweet	<i>Celastrus orbiculatus</i>	Vine – spread by seed
Purple Loosestrife	<i>Lythrum salicaria</i>	Wetland Flower - root or seed in waterways
Reed Grass	<i>Phragmites australis</i>	Wetland grass - forms huge colonies
Tatarian honeysuckle	<i>Lonicera tatarica</i>	Vine- seed spread by birds
Tree of Heaven	<i>Alianthus altissima</i>	Tree – spread by seed
Jap. Knotweed	<i>Polygonum cuspidatum</i>	Noxious Weed - dense stands in wet areas

## ***Hazard Areas***

### **Superfund Sites**

Superfund is a program administered by the EPA to locate, investigate, and clean up the worst hazardous waste sites throughout the United States. Citizen concern about the prevalence of highly contaminated sites – including abandoned warehouses, manufacturing facilities, processing plants, and landfills – prompted Congress in 1980 to establish the Superfund Program to address the health and environmental threats posed by hazardous waste sites. Five Superfund sites are found within the Brodhead watershed. These include:

- Brodhead Creek, located south of the Main Street bridge, Stroudsburg
- Butz Landfill, located on township route 601, Stroudsburg
- Snyder Site, located on Shinehill Road, Scotrun
- Truck Stop Asbestos Site, located on Route 611, Bartonsville
- Village of Reeder's GW, located on Route 715, Jackson Township

An additional two sites are located just outside the watershed boundary. Surface drainage from these sites does not flow to the Brodhead Creek.

- Route 940 Drum Dump, located off route 940, Pocono Summit
- Tobyhanna Army Depot, located in Tobyhanna

**Description of the Brodhead Creek Superfund Site.** From 1981 through 1984, several investigations and emergency response measures were initiated when coal tar was observed seeping into the Brodhead Creek. Measures to mitigate the problem included installation of temporary filter fences and underflow dams to intercept coal tar seepage, installation of a temporary coal tar recovery pit on the bank of the creek, construction of a slurry wall, excavation of a backwater channel area, and installation of recovery wells in the main coal tar pool, with the subsequent recovery of approximately 8,000 gallons of coal tar. The site was placed on the National Priorities List (NPL) in December 1982.

Cleanup information and site status for the sites listed above can be obtained through the EPA's website, by querying Monroe County Superfund sites through the "Envirofacts Warehouse".

**Landfills / Waste Sites**

Landfill sites in the watershed include one located on Dry Sawmill Run, Pocono Township; and one located near Pocono Creek in Stroud Township – both located in the Pocono Creek subwatershed. Also, on the main stem of the Brodhead is a landfill site in East Stroudsburg Borough; this is the current site of the Twin Boroughs Recycling Center. The Stroud Township and East Stroudsburg landfills are routinely monitored. Monitoring has indicated the presence of contaminants at concentrations that were generally low, but in some cases exceeded regulatory limits. These landfills discharge leachate to the Pocono and Brodhead Creeks, respectively.

*Butz Landfill*, a closed landfill and Superfund site, is also located in the Pocono Creek subwatershed, at the base of Camelback Mountain. A closed municipal landfill is located in Barrett Township in the headwaters of Cranberry Creek off of Sand Spring Road.

**Mines / Quarries**

A total of seven major mining operations have been identified within the Brodhead watershed. These include the following:

Upper Brodhead Creek watershed:

- Bill Barry Excavating – Barrett Township, Lower Seese Hill Road

Paradise Creek watershed:

- Bill Barry Excavating – Barrett Township, Cranberry Creek headwaters

*McMichael Creek watershed:*

- Eureka Stone – Snyder'sville, east of Rte 33
- Eureka Stone – Saylorsburg sandpit, west of Rte 33
- Hanson Aggregates – Bossardville
- Pocono Industries (Lesoine's) – Hamilton Township, Rte 209, north of Rte 33

Marshalls Creek watershed:

- Middle Smithfield Materials – west of Rte 209, one mile before Fernwood

In addition, numerous operations hold mining permits for sites under five acres:

Small permits (under five acres):

- Harry Ahnert – Paradise Township, Rte 611 south of Mt. Pocono
- Russell Nauman – Paradise Township, Devils Hole
- Harry Howard – Barrett Township, Cranberry Creek headwaters
- Birchwood/Worthington – Pocono Township

- Floyd DeHaven – Pocono Township
- Russel Dyson – Pocono Township, Rte 314, west of Rte 611
- Sheldon Kopelson – Pocono Township
- Pocono Manor – Pocono Township, north of Brookdale
- Pocono Manor – Tobyhanna Township, east of Rte 380
- Michael Brocko – Hamilton Township, Rte 209
- G&R Materials Recycling – Hamilton Township, Rte 33, north of Snydersville
- Izzy Industries – Hamilton Township, east of Rte 33, Snydersville
- Possinger (3 permits) – Hamilton Township, Snydersville
- Charles Hoffman, McIlhaney – Chestnuthill Township
- Richard Ianuale – Jackson Township, Sciota
- Louis Manzie – Stroud Township, Hamilton Road
- Marion Serfass – Stroud Township, Hamilton Road
- Louis Manzie – Stroud Township, Rte 191, north of Stroudsburg
- Papillon Contracting – Stroud Township Rte 191, north of Stroudsburg
- Penn Hills Enterprises – Stroud Township Rte 191, north of Stroudsburg
- Robert Felins – Stroud Township, Rte 80

### **Hazardous Materials**

Hazardous materials information is contained in the Resource Conservation and Recovery Act Information (RCRAInfo), a national program management and inventory system about hazardous materials handlers. In general all generators, transporters, treaters, storers, and disposers of hazardous materials are required to provide information about their activities to state environmental agencies. These agencies, in turn, pass on the information to regional and national EPA offices. This regulation is governed by the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments of 1984. A hazardous materials query of Monroe County found 184 facilities known to handle hazardous materials. These included industrial facilities, air-conditioning and heating equipment, dry cleaning, upholstery repair shops, paint shops, and automotive services, among others.

### **Underground Storage Tanks (UST) Sites**

According to recent data, there are 97 underground storage tank locations in the Brodhead watershed. Not surprisingly, the majority of these are found in the Stroudsburg/East Stroudsburg Borough area. Many others are found along major road corridors. These underground storage tanks contain leaded and unleaded gasoline, diesel fuel, heating oil, kerosene, BTEX, and other fuel oils. Site locations include automobile gas stations and service centers, convenience stores, car and truck washing stations, apartment buildings, department and chain stores, the Monroe County Courthouse, borough maintenance buildings, resort facilities, and schools.

# Historic & Cultural Resources

The great scenic and environmental value of Monroe County and the Brodhead watershed has not gone unnoticed at the national scale. As early as 1923, Monroe County was recommended as part of a large natural reserve by the landscape architect Warren Manning in his *National Plan for the United States*. Manning anticipated the growth of the industrial east and selected Monroe County as having qualities that should be protected as a focus for outdoor recreation.

## *Historic Resources*

### **Historical Overview**

Named after Daniel Brodhead, who settled on the stream in 1738 at East Stroudsburg (Analomung to the natives), the Brodhead Creek has provided transportation, food, recreation, livelihood and beauty – not to mention water – to humans and other creatures for thousands of years.

Part of a warm and shallow sea more than half a billion years ago, the area we call the Poconos silted in and subsided again and again for millennia. Then folding, uplifting, and fresh-water erosion of the rock softened the hard edges of the Appalachians and cut out wind and water gaps. Glaciers a mile high scoured the earth, loaded with rock and debris – halting here as recently as 15,000 years ago, when modern humans were moving across the land bridge spanning the Bering Sea. Some of the continent's millions of buffalo and elk, mastodon, camels, and other large mammals had made this home.

Where the Brodhead meets the Delaware, hunting and gathering Indians lived as early as 10,000 years ago. Agriculture and more settled villages were common here by the 1500s. For white settlers, the Delaware and other rivers were public roadways: when sent by General Washington to quell the Iroquois in the Wyoming Valley, General Sullivan first had to build a road from Easton – which he did through the Brodhead Watershed by following the creeks and then climbing across the Pocono Plateau.

During the 1700s most of the white population lived in the Delaware River Valley, the Cherry Creek Valley and the Stroudsburg or Pleasant Valley (the Route 209 valley). In the early 1800s, people started to settle the valleys carved by the streams coming from the Pocono Plateau. In these narrow valleys with their rocky hillsides, the growing season was shorter than in the lower elevations. Sheep pasturing was a common use of the land.

Lumbering became a major industry in the Brodhead Creek Valley, using the creek for rafting timber. Creeks and streams powered saw mills, gristmills and tanneries in Barrett, Paradise, Price, Pocono, Smithfield, and Stroud Townships and in Stroudsburg and East Stroudsburg. A woolen mill and even a sanatorium offering a “water cure” used the

water as well. In the broader McMichael and Pocono valleys, creeks were dammed to allow ice harvesting.

Rail service began in 1856, with the completion of the Delaware Lackawanna and Western Railroad. And the railroad, too, followed the waterways: from the southwest bank of the Brodhead to Experiment Mills (now Minisink Hills) in Smithfield Township, where it crossed to the northeast bank of the creek, the railroad followed the Brodhead Creek to the Paradise (or West Branch) as it climbed the Pocono Plateau. In 1882, the New York Susquehanna and Western Railroad through Monroe County used the Brodhead Creek Valley from Delaware Water Gap to Stroudsburg.

The wide flood plain between Analomink and Stroudsburg became the site of railroad yards, a roundhouse and industrial plants. The railroads also encouraged development of the town and, later, the borough of East Stroudsburg.

With the railroads, tourism boomed in the Brodhead Creek Valley. Farms and homes were converted into boarding houses and inns. Artists and actors came to the Paradise branch of the valley. The actor Joseph Jefferson spent time at Paradise Inn and Henryville House and he attracted others. Victorian style hotels built of wood were scattered over the hillsides and along the creeks. The Brodhead and its tributaries were known for their native brook trout. President Cleveland fished in the area, as did Annie Oakley and “Buffalo Bill” Cody. Deer and small game hunting brought people to the area. The Stites Mountain House near the junction of the Brodhead and Paradise creeks was taken over by a fishing club, the Brodhead Forrest & Stream Association. About 1904, the Buck Hill Falls Inn was constructed by the Society of Friends in Barrett Township. Around the hotel developed a summer community of people from Philadelphia. Quakers from Philadelphia also bought the land and built the hotel and surrounding cottages at Pocono Manor around the turn of the century. In the late 1920s, Skytop Lodge and its surrounding community began.

These visitors often “improved” their surroundings by damming the creeks and digging out the swamps to build lakes for fishing, swimming and boating.

Unleashed by twin hurricanes, the Flood of 1955 cost 78 lives and untold loss of property as upstream dams broke, like dominoes, and water poured down the mountains into Stroudsburg and East Stroudsburg. Following the flood, the Army Corps of Engineers bulldozed and diked long runs of the Brodhead, the Pocono Creek, and others in the now-discredited belief that “channelizing” a stream would prevent its overflowing its banks.

Between the 1980s and 2000, with the advent of new highways, population boomed in the area, increasing from under 100,000 to over 140,000. New roads, schools, housing, sewage treatment plants, industry and shopping developments have resulted, in some cases changing the character of entire townships from rural to semi-suburban and affecting the quantity and quality of streams and groundwater.

The history of any area is affected by its geography, wildlife, climate, natural resources – and, often very dramatically, by its human inhabitants. Fast-forward 100 years, and you’ll see that the history of the Brodhead Watershed is being shaped right now, by you.

## Historical Highlights of the Brodhead Watershed

- **The Walking Purchase of 1737 / Marshall’s Creek**

One of the most notorious land scams perpetrated against the Lenni-Lenape, the first residents of the area, was the infamous Walking Purchase of 1737. Two sons of William Penn had acquired a deed signed by their father with the Lenni-Lenape which gave to William Penn and his heirs a generally triangular piece of land in the Pocono Mountains area of eastern Pennsylvania. The boundary was defined as “as far as a man could walk in a day and a half. While this meant a leisurely stroll to the Lenni-Lenape, the Penn brothers recruited the fastest walkers in the area. The Lenni-Lenape anticipated that the day-and-a-half walk through the heavy forest would cover no more than thirty-five miles. The Penn brothers recruited the three fastest men in the area, including the only one who survived the grueling pace, Edward Marshall. The Lenni-Lenape could not keep up with Marshall, who had run some sixty-five miles. When the hoax was over, the Penn brothers had gained for themselves twelve hundred square miles of prime hunting land in northeastern Pennsylvania and the undying hatred of the Lenni-Lenape. In revenge, the Lenni-Lenape killed Marshall’s pregnant wife and, in another raid, his son Peter. Marshall went into hiding on the island in the Delaware that today bears his name. Marshall moved to New Jersey and lived to almost 90 years old. Marshall’s Creek in the eastern Brodhead watershed still bears his name. Other settlements in the Walking Purchase were attacked, especially in Smithfield Township and at Depuis and Brodheads in the Water Gap area.<sup>19</sup>

- **McMichael Creek**

Less is known about John McMichael, for whom the western-most major tributary of the Brodhead watershed is named. In his book titled, *The Unwritten History of Smithfield Township*, Luther Hoffman says of McMichael:

McMichael was an early squatter of a quarrelsome disposition, always in bad repute with both whites and Indians. His shortcomings have all been forgotten and we only remember him from the beautiful creek and village which carries his name.<sup>20</sup>

- **General Sullivan’s March**

In 1779, not long after the Walking Purchase infuriated the resident Indians, General George Washington sent General John Sullivan and his New Hampshire

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<sup>19</sup> *Delaware Diary*, by Frank Dale (Rutgers Univ. Press 1996), page 6-7 (See hand-drawn map of Walking Purchase Territory).

<sup>20</sup> Hoffman at 56.

troops to build a road from Easton to the Wyoming Valley to quell the Indians who were attacking settlers there. Sullivan's March took the men through Wind Gap to Brinker's Mill in what is now Sciota, and then along the Pocono Creek through what is now Tannersville and across the Pocono Plateau to the Wyoming Valley. On May 31, 1779, Sullivan reported to Washington:

“Dear General, I Last Evening returned from the Great Swamp for which place I Set off the Day before. I found the Road Cleared to within twenty three miles of Wyoming & through all the Difficult parts of the Swamp... the Road is now cut the whole Distance & through a Country the most Difficult I Ever Saw - it is not possible for a Country to be Thicker with wood among which the Laurels are so thick that a man cannot get through them but on his hands & Knees. The number of Sloughs and Creeks are almost Incredible...”

- The Birth of American Trout Fishing/Henryville House on Paradise Creek

“The genesis of angling tradition on the Brodheads is found in the little Halfway-House which Arthur Henry built on the freight trace between Easton and Scranton in 1836.”<sup>21</sup> The building, now abandoned and in disrepair, still stands at the intersection of routes 191 and 715 in Henryville.

#### **“They Fished Here?”**

John Wise, long considered the dean of Pennsylvania trout fisherman, was a regular on the Brodhead before 1890. Wise was an engineer whose canny executive skills forged the extensive holdings of the Pennsylvania Power and Light Co.<sup>22</sup> “Wise caught his first trout on Henryville water in 1887, using flies tied by his mentors and leaders made of hairs lovingly gathered from the horse that carried them on the final leg of their eighteen-hour trek from Philadelphia. Wise acquired his extensive trout stream holdings in the Poconos during the First World War, including much of Tunkhannock and Tobyhanna, and the twenty-odd miles of water have spawned a half-grudging, half-admiring limerick among old-time Pocono fisherman:

Of all the old guys,  
That fish with flies,  
Old Johnnie Wise takes the prize;  
And we'll post our bets at ten to seven;  
He'll buy a trout stream  
Up in heaven.”

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<sup>21</sup> *Remembrance of Rivers Past*, Ernest Schweibert, (The Macmillan Company, New York 1972), page 231 (This chapter, titled, *Homage to Henryville*, was reprinted from earlier editions)

<sup>22</sup> Id at 235.

Grover Cleveland and Benjamin Harrison were registered [at Henryville House] simultaneously for an enigmatic week of fishing before their election campaign in 1880.<sup>23</sup> Henry Van Dyke wrote:

Over the hill to Henryville  
'Tis oft' the fisherman's cry,  
For I'll catch a fourteen-incher  
With an artificial fly!<sup>24</sup>

“Buffalo Bill” Cody and Annie Oakley came to Henryville House to fish and demonstrate their marksmanship skills on the rolling lawns.<sup>25</sup>

- **Early Impacts on the Watershed**

Author Ernie Schweibert, thought to be one of the world's top fly-fisherman, noted that as early as the late 1800s, the river experienced an early decline:

The impressive forty-fish baskets of trout, and the almost carnal lumbering that ravaged the conifers for railroad structures and mine timbers – and left great hemlocks rotting in the woods, their acid-rich bark stripped off for the tanneries – has taken their toll. Lumbering and clearing farms had changed the watershed. Its currents had become too warm for its native trout, and the last big stream-spawned brookie recorded in the fishing log at Henryville was a two-pounder taken early in the spring of 1893.<sup>26</sup>

The Brown Trout was introduced from Europe, where it was considered a superior sporting fish, in the 1880's. The Brown Trout is more tolerant of warmer stream temperatures and thrived in the streams of the Brodhead watershed. Fishing remained popular and groups of friends began to purchase farms containing streams, or leasing sections of streams, for their private use. The first club to form in the Brodhead drainage was on the McMichael Creek, the Pohoqualine Club, which was chartered in 1894. Next to form was the Swiftwater Preserve, which dates from 1896. Later clubs include the Parkside Angling Association, Brodhead Hunting and Fishing Association, and the Brodhead Forest and Stream Association, all with property along the Brodhead, and Henryville Conservation Club with land along the Paradise.

Ernest Schweibert, a member of the Henryville Club, bemoans this situation, “The fishing pressure that came with a reputation for greatness eventually caused some regulars to enlarge the private clubs.... The biggest of little rivers was no longer public.”<sup>27</sup> Schweibert adds, “The once great river declined rapidly (with the post war population explosion and resulting fishing pressure) it offered little more than the

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<sup>23</sup> Schweibert at 237.

<sup>24</sup> Id.

<sup>25</sup> Schweibert at 244.

<sup>26</sup> Schweibert at 237.

<sup>27</sup> Schweibert at 252

popular hoax of put-and-take stocking, and there was little or no decent sport on the public pools. The regulars were in mourning.”<sup>28</sup>

The flood of 1955 was devastating to the stream and the fisheries, as described by Jack Welsh of the Brodhead Hunting and Fishing Association.

“The Brodhead before the flood was an ideal trout stream lined with hemlock, rhododendrons and laurel, wonderful undercut banks, many beautiful pockets behind rocks, five great pools and a stream bed ideal for producing food for trout. The flood swept this all away as the stream was literally torn apart. Today we have recovered to a large degree from that devastation, but still remember the great fishing we enjoyed before the flood.”

## **National Registry Sites**

The following is a list of National Registry Sites in the watershed, derived from Monroe County GIS data and arranged by municipality:

**BARRETT:**  
Buck Hill Inn

**EAST STROUDSBURG:**  
Jesse Flory House  
Delaware, Lackawanna & Western RR  
Starbird House  
Brown House  
Burson Farmhouse

**HAMILTON:**  
Kellersville Hotel / Fable Farm  
Millers House  
Shoemaker House  
Kellersville Mill  
George Keller House  
Judge Rhoades House  
Quiet Valley Farms  
Christ Church Parsonage  
Christ Hamilton Church  
Buzzard’s Antiques  
Wheelwright’s House  
Colonel Snyder House

**MIDDLE SMITHFIELD:**  
Middle Smithfield Presbyterian Church

**PARADISE:**  
Paradise Inn

**POCONO:**  
Swiftwater Inn

**SMITHFIELD:**  
Worthington Hall  
Hauserville Chapel  
Sittig House  
Yeisley Log Cabin

**STROUD:**  
Posten-Angle Homestead  
The Brookside  
Spraugeville ME Church  
Glenbrook Country Club

**STROUDSBURG:**  
Dansbury Mission  
A. Mitchell-Palmer House  
Koflach’s Funeral Home  
Fort Penn Site  
Jacob Stroud House  
Fort Hamilton Site  
Monroe County Courthouse  
Monroe County Jail  
Dr. Reeve Jackson’s House

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<sup>28</sup> *Id* at 252

## Historic Areas

The Monroe County Historic Legacy report identifies several historic areas in the Brodhead Watershed. These are located on the map *Historic Resources*. These and other potential historic areas should be evaluated for qualification as possible historic districts or historic landscapes. The National Park Service Bulletin Number #18 provides guidelines and procedures for evaluating and nominating potential historic landscapes to recognize and preserve their historic landscape character.

These historic areas are listed below, by municipality:

### STROUDSBURG:

First Ward  
Lower Main Street  
Main Street (5<sup>th</sup>-10<sup>th</sup> Street)  
Wallace Street & Fulmer Ave.  
Scott Street  
Thomas Street  
Monroe Street  
Sarah Street  
Ann Street

### EAST STROUDSBURG:

Washington Street  
Braeside Ave, Ridgeway Street

### STROUD:

Analomink  
Cherry Valley Road

### HAMILTON:

Foundry Road  
Sciota Village  
Snydersville Village  
Bossardville  
Kellersville Historic District  
Saylorburg Village

### JACKSON:

Appenzell

### POCONO:

Bartonsville  
Tannersville

### CHESTNUTHILL:

Brodheads ville Village  
McMichael's Crossroad Village

### SMITHFIELD:

Minisink Hills

### PARADISE:

Henryville  
Paradise Valley

### BARRETT:

Buck Hill Falls

### TUNKHANNOCK:

Tunk Sawmill Zone

### MT. POCONO:

Mt. Pocono Borough

## Historic Sites, Structures, and Locations in the Brodhead Watershed

Water powered mills dotted the streams in the Brodhead watershed. Saw mills operated as long as the timber lasted to supply the raw material for mine timbers, railroad ties and spragues, used as brakes for coal carts in mines. Gristmills ground the grain produced by local farmers. Tanneries used the bark from hemlock trees to tan skins, both from local hunters and later, pelts imported from South America, which came by rail.

Other industries grew up along streams, dependent in some way on the water that flowed by. In some cases, structures are intact and still in use. In others little remains, but possible projects would be to identify the locations and erect historical markers describing the site and/or to develop interpretive publications, exhibits or maps.

Some sites have been identified, and are described below. Others remain to be researched.

### Paradise Creek:

- A mill last operated by Jacob Kintz is located along Paradise Creek near Rte 191, where Mill (Redrock) Road crosses the Paradise. The mill was built about 1849 by the Edinger family and operated as a gristmill until about 1912. Surviving are the foundation, with a smaller building built on it, and the tail race. Remnants of the millpond are also visible. The mill is privately owned by the Deetz family.
- *Paradise Brook Trout Hatchery*, located in Paradise Valley, is the oldest licensed trout hatchery in the state. Still in active operation, producing trout for stocking and the table, the facility includes buildings dating to the early 1900's.
- The historic *Henryville House*, a boarding house which once housed such famous visiting fisherpersons as Annie Oakley, is privately owned and in badly deteriorating shape. A potential project is to determine feasibility of restoration of the building and/or acquiring the site to develop a facility for interpretative use.
- Historic buildings remain on the *Aventis-Pasteur, Inc.* property along Swiftwater Creek. Originally known as National Lab, this business was started in 1898.
- *Swiftwater Inn*, on Swiftwater Creek, was an early stagecoach stop and a popular overnight stop for visiting fishermen and women. The inn is still in operation.
- In Paradise Township, the following mills were identified in the *County Atlas of Monroe, Pennsylvania*, published by F.W. Beers & Co.: *Saw*

*Mills:* James Henry at Henryville (1833), Charles Henry north of Henryville (1842), E. Slutter in Devil's Hole. *Grist Mills:* James Kintz in Paradise Valley (1849), James Henry at Henryville.

### **Upper Brodhead Creek:**

- *William S. White* operated a tannery on Mill Creek (at the confluence with Rattlesnake and Beaver Brook) and also one in Analomink. Both were water powered, to grind the bark and to roll the skins. White controlled over 10,000 acres from the top of Paradise Valley to Buck Hill area. The Mill Creek tannery operated from 1856-1885, though White sold it in 1861. White was instrumental in the railroad route going to Cresco, and he built a siding from the Cresco station to his tannery in Mountainhome.
- The following mills were identified in Barrett Township in the *County Atlas of Monroe, Pennsylvania*, published by F.W. Beers & Co.: *Saw Mills:* near the residence of G. Washington Ink on Middle Creek, George Price & Sons on Buck Hill Branch, Jacob Price on Brodhead Creek, I. Price on Mill Creek, E.F. Palen in Canadensis, and Shafer & Rinehart in Mountain Home. *Grist Mills:* John Pitt built a gristmill in 1845, later owned by Solomon Edwards. *Tanneries:* Palen & Northrop, Canadensis (1847), White & Barkley, Mountainhome (1856). *Quarries:* Frederick Duebler.
- And in Price Township: *Saw Mills:* John Price, later owned by E.T. Long. Also, one was built by Eleazer Price, later owned by Perry Price. *Water Power:* Near G. Haase residence. *Cold Spring:* One near residence of G. Haase, two near residence of J.C. Houck.

### **Pocono Creek:**

- *The tannery in Tannersville*, built around 1834, was located where the Tannersville Elementary Center now sits along Route 611. The tannery ponds remain on the site, which is owned by Pocono Mountain School District. The tannery owner, Mr. Kistler, lived in Glenwood Hall (built in 1838 and is still standing) next to the tannery.
- The foundation and tailrace of *Jacob Stauffer's* (Brown's) mid-1800's mill on *Bisbing Run*, remain on private property (George Learn and Werkeiser). The timbers from the mill were used to build the house (1936/37) now occupied by the Bankers First Mortgage Company on Route 611 between Tannersville and Bartonsville, next to Pocono Peddler's Village.

- A *Brick Factory* was located along Dry Sawmill Run off Sullivan Trail near the road to Crescent Lake. The factory used clay from the area and operated from the mid-1800s to the early 1900's.
- *Chowder Camp* on Sullivan's march from Easton to Wyoming is recognized by a stone monument off Sullivan Trail before the road to Crescent Lake.
- *The Gantzhorn Water Company*, located south of Route 715 about one-half mile east of Route 611, provided water from springs through a cast iron line to Glenwood Hall and other homes in the area. This was one of the first water companies in the watershed. The springhouses and water line may have been built by Stephen Kistler around 1834, when the tannery was built, and operated until about 1930.
- A mill on the Pocono Creek at Bartonsville at Route 611 and Rimrock Road was dismantled and rebuilt at Millbrook Village, N.J. in the Delaware Water Gap National Recreation Area.
- A mill on Flagler Run gave its name to the "Old Mill" development in Stroud Township.
- *The Tannersville Cranberry Bog*, located at the headwaters of Cranberry Creek, is a National Natural Landmark owned by The Nature Conservancy, with interpretive programs given by the Monroe County Conservation District.
- Lost to history is *Learned's Tavern*, a stop on Revolutionary War General John Sullivan's march from Easton to Wyoming to quell warring Indian tribes. The boarding house burned in 2000 and all related structures were razed. When the structures were razed, timbers from the original log cabin were uncovered. A small stream (Rocky Run), which flows from the springs used by the Gantzhorn Water Company, runs beside the property where two Historical Markers recognizing the site are located.
- *Cold Spring*, an active spring located along Route 611 (behind New York Pizza), south of the Learned's Tavern site, was the site of the Indian massacre in 1781 of the first settlers of the Tannersville area, the Learn family. The area was part of the original "Larner" (Learn) family's holdings and was the burial ground for the Learn family.
- *Miesertown Lake*, located near the intersections of Routes 314 and 715, was hand built for the enjoyment of boarding house guests in the early 1900's.

### **McMichael Creek:**

- *Quiet Valley Farm* is a living history museum operated by a non-profit organization. Interpretive tours and demonstrations teach about farm life in the 1800's. An annual ice harvest demonstrates this early industry. A possible project would be to build a pond on the farm, or acquire a nearby pond to assure the demonstrations can continue.
- The Old Mill in Sciota, also known as the Brinker-Snyder-Fenner Mill, on McMichael Creek, was the first stop in Monroe County of General Sullivan's troops. The mill, along with the milldam, still exists and is maintained as a historic site by Hamilton Township.
- The *Kistler* family operated a *tannery in Sciota* on McMichael Creek. The dam and pond remain and also a shed which is now part of an antique shop complex.
- A stone bridge crosses McMichael Creek on Business Route 209 in Sciota.
- Many historic homes are located along the creek in Sciota.
- The old foundry building of the *Marsh Foundry Complex* still stands beside the Pensyl Creek on Foundry Street in the Sand Hill/Kellersville area.
- A stone bridge crosses the Pensyl Creek on Foundry Street near the Marsh Foundry. Another stone bridge crosses the McMichael Creek on Easton-Belmont Pike.
- *Kellersville* is a very historic area. It had the largest mill and busiest commercial area in Hamilton Township in the late 1700's and early 1800's, rivaling Sciota. Kellersville was proposed as the site for the county seat on the ballot in the 1830's election but lost to Stroudsburg in a fraudulent election (names from tombstones and children were listed as voters). A bustling area grew along the McMichael Creek including:
  - *Keller's Mill* – Located on the Easton-Belmont Pike along McMichael Creek, this was the largest mill in the area at the time. The mill remains, but needs repair. The miller's home still stands behind the mill.
  - *Kellersville Hotel* – This was a stagecoach stop coming up from Easton to the Wyoming Valley town of Belmont. It is now the home of M/M Wm. Fabel.

- *Kellersville General Store and Post Office* – This supplied the farming area that came to the mill to do business.
- *Wheelwright Shop* – Located on the Easton Belmont Pike, this business grew as a result of the mill in Kellersville.
- *Keller / Calvert Home* – This was built in the early 1800’s by the family of the mill owner.
- *Snydersville area*: A mill was operated by Colonel Snyder on what was then known as Appenzell Creek but is now called Kettle Creek. This mill had a millrace that ran uphill. Colonel Snyder’s home is at the corner of Business Route 209 and Rimrock Drive. The home of the miller, Mr. Haney, also remains in the area.
- A sawmill on Rimrock Drive was powered by the water in Kettle Creek.
- Trout Lake and Mountain Springs Lake on Appenzell Creek were built for ice harvesting. The remains of an icehouse stand beside Mountain Springs Lake.
- Saylor’s Lake, on Lake Creek, was one of the larger ice harvesting operations in the watershed.
- In the McMichael area, the McMichael Hotel dates from the mid-1800’s and is presently owned by the Pohoqualine Fishing Club. McMichael Creek was also the location of a sawmill operated by Phillip Kresge. The Pohoqualine Club operates a hatchery which dates to the early 1900’s. Two stone arch bridges on Route 715 cross the McMichael, one in the village and one further south. Another stone arch bridge, with similar masonry work, crosses Fall Creek and is marked as a WPA project and dated in the 1930’s.
- Four grist mills operated in the Brodheadsville area: Two, which no longer exist, were run by John Wagner. Still standing are Newton Geisinger’s mill, north of Brodheadsville, and Martin Keller’s, south of the village.

**Marshalls Creek:**

- *Marshalls Creek Chert Quarries* – Archeological studies by the Pennsylvania Department of Transportation, in preparation for building the Marshalls Creek bypass, have identified quarries and workshops used by Native Americans to make arrowheads and knives. A potential project would be to develop interpretive information and access points to use these resources as a teaching tool.

- *Delaware Valley Railroad Station* (the "Dinkie" Station), built circa 1905, is privately owned and located in the Village of Marshalls Creek. The D.V.R.R. ran from East Stroudsburg to Bushkill. Marshalls Creek borders the station property.
- *Marshalls Falls* and nearby Titania House are on a 24-acre property located off Creek Road along Marshalls Creek; Titania House was a boarding house in the early 1900's. Smithfield Township is interested in acquiring the property as a pocket park and/or assuring it will remain in its present natural state.
- *Waterfront Farm Boarding House*, located in Smithfield Township Park, was built circa 1860; Marshalls Creek runs through the property which is located on Twin Falls Road. Water Front Farm was a boarding house into the 1960's. There are two waterfalls (hence Twin Falls Road) just off Route 209. Smithfield Township is interested in developing the house as a community center and Township history library.
- Double Arch Stone Bridge (one of the original "Seven Bridges" on the "Seven Bridge Road"); circa 1917; approximately 20 feet wide and 50 feet long and spans Marshalls Creek just west of Route 209; located on private property. Possible project might be to maintain the bridge as necessary to preserve original features.
- Smithfield Township plans to maintain the structural integrity and original features of other stone bridges in the township: the Green Mountain Road stone arch bridge spans Marshall's Creek, was constructed in 1910, and is located just off Rte 209. The Post Office Road stone arch bridge spans Marshalls Creek at the Minsink Hotel; constructed in 1912.
- The privately owned Pearce-Yeisley Log House - circa 1795, is the oldest existing house in Monroe County. It is located off County Bridge Road and is near Marshalls Creek.
- The Peter Zimmerman Grist Mill in Minisink Hills (originally called Experiment Mills) - built in 1849, is situated along Marshalls Creek. The mill is in good condition and is privately owned.
- The Minisink Hotel - circa 1800's – This was a stagecoach stop, a general store, and a taproom; it is located in Minisink Hills and sits along Marshalls Creek. The building presently houses a barroom.
- Wesley Water Cure Sanitarium was located at Experiment Mills (Minisink Hills). Location unknown.

- The stone dam and laid stone raceways at the East Stroudsburg Reservoir on the Sambo Creek were constructed as a WPA project probably in the 1930's. The dam is located at the upper reservoir which is in Middle Smithfield Township, but the laid stone raceways traverse much of the East Stroudsburg Water Department property in Smithfield. The dam, reservoir and raceways should remain in public ownership and be maintained as an example of WPA projects in the watershed.

### **Lower Brodhead Creek:**

- *Creepside Park at the Delaware Water Gap Train Station* – The Lackawanna Chapter of the Railway and Locomotive Historical Society is in the midst of a five-year effort to restore the historic Delaware Water Gap train station, built in 1903. Their efforts include restoration of a creek side park, located between the railroad tracks and the Brodhead Creek. This area was once a landscaped “welcoming area” for the tourists who traveled to nearby resorts by train. Plans for the area include linkages to several nearby hiking trails and the planned Pocono Mountains Welcome Center.
- Rock Tenn Paper Company – The company, originally called the "Chemical Pulp and Paper Company", was built in 1881; it is located along the Brodhead Creek in Minisink Hills.
- Analomink was the site of a second tannery operated by William S. White. Breast work for the dam remains. Also visible are tunnels built when the railroad was built thru the property. The DL&W paid White \$1.00 to go thru his property. But that gave him a convenient way to transport his products. (Pelts were brought in from South America.) Analomink was originally called Spragueville for the “spragues” (a wooden spike used in the mining industry) that were manufactured in the area.
- The following mills and other water-related businesses were identified in Stroud Township in the *County Atlas of Monroe, Pennsylvania*, published by F.W. Beers & Co.: *Saw Mills*: Shroder Brown at Analomink, Stokes Saw Mill at Stokes' Mill. *Grist Mills*: Stokes' Mill at Stokes' Mill, and, also, one near the present Sebring's Power House. *Tanneries*: William White at Analomink (about 1848), later owned by George L. Adams. *Ice Companies*: Analomink Lake (about 1900). *Foundry*: located on the bend in the Brodhead Creek south of East Stroudsburg was the Analomink Foundry which was operated in conjunction with the Oxford Furnace in New Jersey and the Henry Gun Factory near Belfast, Northampton County, Pennsylvania.
- And in Stroudsburg: *Saw Mills*: Saw and planing mill of William Wallace on McMichael Creek (1865). *Grist Mills*: William Wallace on McMichael

Creek (on site of mill built by Ephraim Coulter before the French and Indian War and later rebuilt by Jacob Stroud), William Ackerman on mill race which begins on the Pocono Creek and empties into the McMichael Creek (built by Daniel Stroud 1822). *Woolen Mill*: Wallace & Kitson on McMichael Creek (organized in 1865). *Tanneries*: Charles Stroud and Jacob Stroud, sons of Daniel Stroud (1822), Singmaster Tannery on the same mill race as William Ackerman's grist mill (about 1841), later owned by Bennett & Dunk.

- In East Stroudsburg: *Tannery*: Stephen Kistler built a tannery in 1869, later owned by George L. Adams (From the above Atlas, this tannery does not appear to have a mill race or a discharge point in a stream).

## ***Cultural Resources***

Parks in the watershed can range from small urban squares to extensive tracts of state gamelands and nature preserves. They can also be athletic complexes and settings for the arts. In addition to providing a place for recreation, parks provide corridors for wildlife. They can help to tell the story of our heritage. They can help us live longer and build strong family bonds. They build community pride and increase our property values. They attract business and industry and contribute to a healthy economy.

## **State Parks, Game Lands & Forests**

There are about 15,000 acres of state-owned land in the watershed, including state forests, gamelands, and Big Pocono State Park.

- *Delaware State Forest* – 8,638 acres of this 80,000-acre state forest are in Monroe County; about 6,630 acres fall within the Brodhead watershed. In keeping with the concept of the Poconos as a mountain playground, the State Forest provides a wide variety of outdoor recreation opportunities. Streams, lakes and ponds provide fishing. Wildlife is plentiful with deer, bear and small game. Opportunities include fishing, snowmobiling, ATV trails, trails for biking and hiking, nature study, environmental education, and camping.
- *State Gamelands* – About 6,000 acres of land in the Brodhead Watershed is owned by the Pennsylvania Game Commission. They offer outdoor recreation opportunities for hunting and trails. State Gamelands #38 in Pocono Township offers five miles of snowmobile trails. State Game Lands #186 is also found within the watershed, north of Neola. State Game Lands #221, in Barrett Township, contains headwaters land for Devils Hole Creek, Mill Creek, and Rattlesnake Creek.

- *Big Pocono State Park/Camelback Mountain* – This park consists of 1,306 acres of rugged terrain on the summit and slopes of Camelback Mountain. Recreational opportunities include:
  - Picnicking - three locations, 50 tables;
  - Hiking - seven miles of trail;
  - Mountain biking;
  - Horseback riding - three miles of trail;
  - Hunting – in State Game Lands;
  - Skiing - downhill ski area operated by Camelback Ski Resort;
  - Restaurant - operated by Camelback Ski Resort.

## **County & Municipal Recreation Lands**

### **County Nature Centers and Parks**

- *Kettle Creek Wildlife Sanctuary* - Owned by Monroe County and located in Hamilton and Jackson Townships, this 120-acre site contains the offices of the Monroe County Conservation District and the District's Environmental Education Center and grounds dedicated to environmental study and the enjoyment of nature.
- *Meesing Nature Center* - The 130-acre site is located in Middle Smithfield Township. The Meesing Nature Center is in the Delaware State Forest on ground owned by PA DCNR and leased by Monroe County. The Monroe County Conservation District operates a maple sugar demonstration site there.
- *Monroe County Park* - The County Recreation and Park Commission headquarters is located in Snydersville. The site features an administration building and an 11-acre park with ballfields, trail and restroom. It is the county's only active recreation site. This is the only county park.
- *Burnley Workshop* - The Burnley Workshop leases land from Monroe County. The Workshop allows Monroe County to use the land for athletic fields.
- *J.A. Karmilowicz, Inc. Tract* – Monroe County recently purchased this 100-acre tract with open space bond monies for permanent preservation and as a crucial connection for the planned Brodhead greenway and development of the Godfrey Ridge trail. The tract, which is adjacent to the Brodhead Creek in Stroud and Smithfield Townships, will protect nearly a mile of riparian woodland.

### **School District Facilities**

The four school districts in Monroe County are East Stroudsburg, Stroudsburg, Pleasant Valley, and Pocono Mountain. The school districts have facilities that are used for both educational and public recreational use. School facilities include ballfields, game courts, gymnasiums, classrooms, auditoriums, and cafeterias. The school districts have reported that they have

exceeded their capacity because of the rapid population increases. While all four school districts permit community use of the schools for recreation, they also report that they are not able to meet all of the requests for use of the facilities. Particularly pressing is the need for more ballfields and gymnasiums.

### **Municipal Facilities**

There are 36 municipal parks and open space lands in the watershed, totaling about 700 acres. Currently, schools are the hub of recreational activity in the community.

Monroe County has received a *Growing Greener* planning grant in which municipalities, organized as a region, will be able to develop municipal park, recreation and open space plans. In the local planning process, the municipal parks, recreation and open space inventories will be developed in detail as is appropriate for that level. At the county level, broad information about local parks is being used for planning purposes. The goal is to create a big picture of public parks and recreation as it relates to the present and projected needs of the public in order to improve and expand public parks and recreation within the County.

The following is a list of municipal parks and open space lands in the watershed:

- High Acres – Barrett Twp, 21.68 acres
- Chestnuthill Township Park – Chestnuthill Twp, 37 acres
- Dansbury Park – East Stroudsburg Borough, 15.7 acres
- Zacharius Pond – East Stroudsburg Borough, 25.1 acres
- Gregory’s Pond – East Stroudsburg Borough, 10 acres
- Miller Park – East Stroudsburg Borough, 2 acres
- Schimpf – Hamilton Twp, 21 acres
- FSR Homestead – Hamilton Twp, 5 acres
- Open Space – Hamilton Twp, 2 acres
- Jackson Memorial – Jackson Twp, 4.9 acres
- Resica – Middle Smithfield, 37 acres
- Unnamed – Middle Smithfield, 17 acres
- Open Space Natural Area – Middle Smithfield, 5 acres
- Mt. Pocono Borough Park – Mt. Pocono Borough, 2 acres
- Deerfield Oak Street Park – Mt Pocono Borough, 15 acres
- Paradise Twp Park – Paradise Twp, 10 acres
- Mountain View Park – Pocono Twp, 81 acres
- Saylorburg Playground – Ross Twp, 14.09 acres
- Waterfront Park – Smithfield Twp, 53.3 acres
- Minisink – Smithfield Twp, 25 acres
- Al Wilson Field – Smithfield Twp, 11 acres

- Big Pines – Stroud Twp, 25 acres
- Jay Albertson – Stroud Twp, 5.37 acres
- Katz Park at Wedgewood Lake – Stroud Twp, 7.2 acres
- Kovarick Lands – Stroud Twp, 13 acres
- Michael Moore – Stroud Twp, 0.51 acres
- Daily Property – Stroud Twp, 1.91 acres
- Laurel Street Pond – Stroud Twp, 1.58 acres
- McMichael Creek Conservation Lands – Stroud Twp, 107 acres
- Yetter – Stroud Twp, 15 acres
- Carl Dennis – Stroud Twp, 31.19 acres
- Pinebrook – Stroud Twp, 60 acres
- Third Street Park – Stroudsburg Borough, 3 acres
- McMichaels/Rotary – Stroudsburg Borough, 5 acres
- Glen Park – Stroudsburg Borough, 10 acres
- Stroudsburg Park – Stroudsburg Borough, 5 acres

### **Greenways, Trails & Public Access Connections**

The green infrastructure that serves to connect biological resources and human communities must be developed from a regional perspective. Corridor preservation is key to avoiding a fragmented geography that adversely affects the watershed's wildlife and fisheries. It is also important to preserve transportation and recreational opportunities that can promote alternative forms of transportation and provide health benefits close to home.

The *Monroe County Open Space Plan*, adopted by the Monroe County Commissioners in June, 2001, outlines a countywide greenway system including nine conceptual greenway spines. In addition, a demonstration greenway for the county was put forth in the *Greenway Project Feasibility Study*. This demonstration greenway, a three-mile section of trail called the "Godfrey Ridge Trail", is in the most urbanizing section of the watershed. The focus on a demonstration greenway that has high visibility and is part of a larger conceptual system is a critical first step to the realization of a greenway system throughout the watershed. This plan incorporates by reference the goals and recommendations as put forth by the *Monroe County Open Space Plan* relating to the development of greenways in the watershed.

# Glossary

**Best Management Practice (BMP)** – A structural or non-structural device designed to temporarily store or treat stormwater runoff in order to mitigate flooding, reduce pollution, and provide other amenities.

**Biodiversity** – Defined by the EPA as “the variety and variability among living organisms and the ecological complexes in which they occur”.

**Bio-monitoring** – Generally accepted as the most accurate determination of long-term impacts on the health of a stream, “bio-monitoring” refers to analysis of macroinvertebrate life in the stream. Cost effective EPA and DEP rapid bio-assessment protocols have been developed and are in use by those trained in the science.

**Brownfields** – Abandoned or under-used industrial and commercial sites where future expansion or redevelopment can be directed after site remediation for possible contamination.

**Buffer** – An area adjacent to a shoreline, wetland, or stream where development is restricted or prohibited.

**Build-out** – The total percentage of development in a watershed based on current zoning.

**Critical area** – Any area recognized as a valuable environmental resource because of its outstanding scenic, cultural, historic, recreational, natural, or geologic significance. Critical areas can include those valuable for their cultural or scenic quality, such as woodlands, farms, waterfalls, or scenic views. Critical habitat areas can include vernal pools, headwaters areas, wetlands, swamps, and riparian areas.

**Easement** – An interest in land owned by another that entitles its holder to a specific limited use or enjoyment. A right, such as a right of way, afforded a person to make limited use of another's real property

**Floodplain** – Areas adjacent to a stream or river that are subject to flooding or inundation during severe storm events (often called a 100-year floodplain, it would include the area or flooding that occurs, on average, once every 100 years.)

**Greenway** – A greenway is a corridor of open space. Greenways vary greatly in scale, from narrow ribbons of green that run through urban, suburban, and rural areas to wider corridors that incorporate diverse natural, cultural, and scenic features. They can incorporate both public and private property, and can be land or water based. They may follow old railways, canals, or ridgetops, or they may follow stream corridors, shorelines,

or wetlands, and include water trails for non-motorized craft. Some greenways are recreational corridors or scenic byways that may accommodate motorized and non-motorized vehicles. Others function almost exclusively for environmental protection and are not designed for human passage. Greenways differ in their location and function, but overall, a greenway will protect natural, cultural, and scenic resources, provide recreational benefits, enhance natural beauty and quality of life in neighborhoods and communities, and stimulate economic development opportunities.

**Groundwater recharge** – The process through which surface water is infiltrated through the ground and joins underground aquifers. Recharge rates vary according to season, land cover type, and soil type, among other factors.

**Impervious cover** – Any surface in the landscape that cannot effectively absorb or infiltrate rainfall.

**Important Bird Areas (IBAs)** – Sites that provide essential habitat for one or more species of bird. IBAs include sites for breeding, wintering, and/or migrating birds. A bird habitat conservation project administered by the National Audubon Society, the IBA program is a global effort to identify the areas that are most important for maintaining bird populations, and focus conservation efforts at protecting these sites.

**NPDES** – An acronym for the National Pollutant Discharge Elimination System. Established by Section 402 of the Clean Water Act, this federally mandated system is used for regulating point source and stormwater discharge.

**Open Space** – Land which is permanently set aside for public or private use and will not be developed with homes or commercial businesses. The space may be used for passive or active recreation, or may be reserved to protect or buffer natural areas.

**Outstanding and unique feature** – Any area recognized as a valuable environmental resource because of its outstanding scenic, cultural, historic, recreational, natural, or geologic significance.

**Stakeholder** – Any agency, organization, or individual that is involved in or affected by the decisions made in the development of a watershed plan.

**Watershed** – All the land which contributes runoff to a particular point along a waterway.

**Wetland** – Areas inundated by water at or near the surface of the land or covered by shallow water. Wetlands can be scientifically delineated by the presence of hydric soils, hydrophytic plants, and water.

**Zoning** – A set of regulations and requirements that govern the use, placement, spacing, and size of buildings and lots within a specific area or in a common class (zone).