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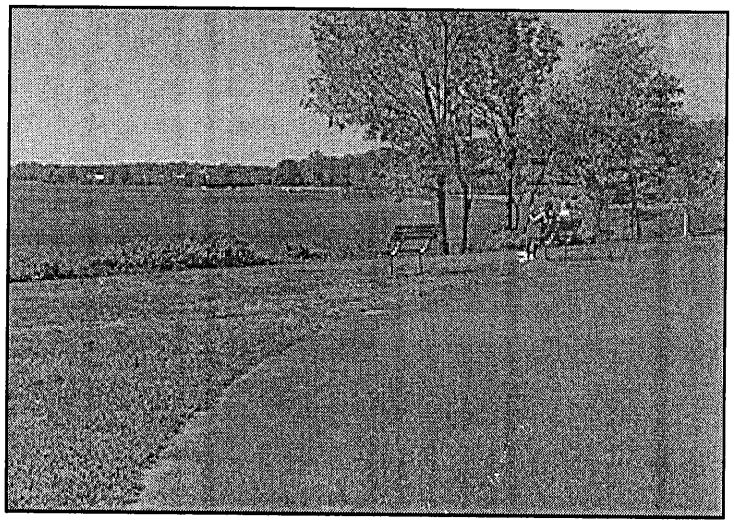
I. Project Abstract

The Lower Delaware River Conservation Plan (LDRCP) is an outgrowth of the Lower Delaware River Management Plan prepared in conjunction with the Lower Delaware National Wild and Scenic River Study. In 1996, prior to beginning the river conservation plan, an International Countryside Stewardship Exchange program was held on the Lower Delaware. The exchange brought together an international team of volunteer professionals to assist the citizens of the Lower Delaware in addressing economic development and conservation of natural and cultural resources. The goals established by the exchange program formulated the approach of the following river conservation plan.

The study area for the Exchange and Management Plan included two states (New Jersey and Pennsylvania), three counties (Bucks, Mercer and Burlington), and 23 municipalities. The river conservation plan has narrowed the scope of study to include eight municipalities within Bucks County, Pa.

The LDRCP focuses on eight key municipalities in Lower Bucks County: Bensalem Township, Bristol Borough, Bristol Township, Falls Township, Lower Makefield Township, Morrisville Borough, Tullytown Borough and Yardley Borough. These municipalities have been involved in past efforts undertaken by the Countryside Institute, National Park Service (NPS) and other organizations over the past several years. They have expressed interest in continuing study and implementation efforts, particularly with regard to recreational access and amenities and economic improvement. A dense population and mixed land uses have created a real need to coordinate river protection efforts. The major creeks within the watershed study area are portions of: Brock Creek, Buck Creek, Core Creek, Dyers Creek, Houghs Creek, Martins Creek, Mill Creek, Neshaminy Creek, Poquessing Creek, Queen Anne Creek and Rock Run.



Neshaminy Creek State Park along the Delaware River

The need for a river conservation plan became increasingly clear as population and development in the eight municipalities grew. Residential and commercial expansion, if left unrestricted, threaten the environmental stability and beauty of the Delaware River and its tributaries. Because of the commitment of citizens and government leaders in these communities, a river conservation plan will aid in protecting this vital resource, mitigate potential damage from development, and improve public access to the Delaware River and its watershed.

The LDRCP recommends a long-term course of action to protect the resources of the Lower Delaware River watershed. At the outset, the plan sought input from the eight participating municipalities through an advisory task group and from the public through a public meeting process. The first part of the plan documents conditions within the study area. Existing resource data was gathered and reviewed to understand the greater trends occurring in the study area. This information includes: land uses, zoning designations, cultural and historical resources, recreational resources, threatened and endangered species, census data and local ordinances. Public workshops were held and surveys created to seek opinions of residents, an important step in this planning process.

Analysis of the resource data and visual observations identified assets to be preserved and issues to be addressed. Issues of primary importance include: stormwater and riparian area management, future development, planning and zoning, BMPs and education and land acquisition and preservation strategies.

The final part of the LDRCP includes the recommended goals and management options. A public meeting was held to review and discuss the goals. The LDRCP provides the eight municipalities an opportunity to build a strong inter-municipal relationship to protect the watershed for all residents. Coordinating municipal plans and programs will provide strong and ongoing stewardship for this regional resource. Individual efforts will gain significant results, but cooperation is the key to long term success. The Lower Delaware River is a regional resource not governed by political boundaries. Implementing a plan of action that utilizes the best available environmental practices will help provide a healthy, stable and usable watershed.

II. Public Comment and Participation

As part of the rivers conservation planning process, four open meetings were held to inform and solicit comment from the general public, representatives of each municipality and representatives of local public agencies.

The first public meeting was held November 25, 1997 to announce the initiation of the LDRCP and to gather public input on river issues, concerns and opportunities. Approximately 20 participants gathered to begin discussing river conservation planning activities. The following list defines the substantive issues and ideas addressed at this meeting.

- A boat ramp in the Morrisville, Falls Township area is needed.
- A future plan to connect the upper and lower segments of Neshaminy Creek is possible.
- New ramps at Neshaminy State Park are needed with less slope and longer incline.
- Roads block access to the river in Bensalem Township.
- The riverfront is owned by large companies in Falls and Bristol townships.
- Trash trucks are a problem.
- Flooding and stormwater management is a concern.
- There is a desire to maximize river use with restaurants on the river and to improve boat access.
- A unified educational network is needed along the river.
- Include public access in riverfront development plans.
- Tie river access to federal enterprise zone and economic development plans for the area.
- Add fishing piers.
- Flood control is needed along Neshaminy Creek.
- Private property owners along the river have concerns regarding public access across their property and liability issues.
- Recreational facilities, including bike trails and camping, are needed.

A second public meeting was held February 26, 1999 to present the Preliminary Findings Report. A 30-day public comment period followed the public meeting. A summary of the public comments is contained in Appendix A.

Two final public meetings were held to:
- Present and solicit public comment regarding the Draft River Conservation Plan (June 9, 1999)
- Present the Final River Conservation Plan (September 21, 1999)

Project Survey

Heritage Conservancy conducted a random survey of residents within the eight municipalities of the LDRCP study area to get a sense of what

residents view as the important issues regarding the Lower Delaware River watershed. After sorting the responses by municipality, each survey was hand tallied, and the results were entered into a spreadsheet to determine totals and percentages for each question.

A total of 2,200 survey questionnaires were mailed to residential and commercial landowners/tenants within the LDRCP study area. The methodology used to determine the number of questionnaires distributed to each municipality is outlined in Appendix B. Of the 2,200 questionnaires mailed in February 1998, 176 were returned (8%).

The common thread running through the majority of responses was the recognition of the importance of the Delaware River area as a natural and historic resource that must be preserved. What is at issue is the question of responsibility and funding for river access and conservation efforts. A majority of the respondents favor government responsibility for access, with an almost even split between county, state and federal governments. This same split occurred concerning conservation plan funding, with a slightly higher portion favoring either state or federal funding. However, the majority of respondents were not in favor of higher taxes to pay for conservation.

Resources and Preservation

Asked to identify the three most important aspects of the Delaware River area:

- 75% of respondents noted its value as a natural and scenic resource,
- 58% percent noted the fact that it is home to many plant and animal species, and
- 52.8% view it as an important cultural and historic resource.

Activities and Access

Passive recreation is a popular activity as indicated by the highest percentages of respondents. Current usage includes:

- 51.7% enjoy sightseeing
- 48.9% enjoy nature walks

With regard to access:

- 62% favor improving access to the river
- 65% also view improved access, particularly boat ramps, as an incentive to increased recreational river use
- 82% favor government responsibility with an almost even split between county, state and federal governments

Preservation and Regulation

An average of 86.9% of respondents favor preservation, including preservation of undeveloped land, farmland, forested land, historic resources, scenic character and wildlife habitat.

In keeping with those values, an overwhelming majority of the respondents favor land preservation over development of any kind.

- 72% noted they would support land use regulations within the entire watershed
- 77% favor a conservation plan that focuses on the entire watershed

Appendix B contains a tally of all responses from residents in the municipalities. The tables include combined totals and percentages. Note that in many cases respondents could choose more than one answer which means that the numbers may add up to more than the total number of respondents or the percentages to more than 100%. Though this may slightly skew the specific results, the overall sentiment is still evident.

Advisory Task Group

The advisory task group consisted of representatives appointed from each municipality in the study and representatives from organizations active in conservation efforts in the region. Participating organizations included: National Park Service, Pennsylvania Environmental Council, Bucks County Department of Parks and Recreation, Philadelphia Suburban Water, Waste Management Inc. and Bucks County Planning Commission. The role of the advisory task group was to review and evaluate the completed inventory and the resident survey results, coordinate visual assessments of local watersheds, prioritize issues resulting from public comment and completed planning work, and identify implementation projects to be included in the final river conservation plan.

A series of five advisory task group meetings were held in 1998. Beginning in February, the task group met to review the survey questionnaires sent to a random sample of residents and businesses in the eight municipality region. Following dissemination of the survey, task group members assisted Heritage Conservancy in conducting windshield tours of each municipality. These tours identified key resources and utilized the local knowledge of members and municipal officials to gain insight into critical issues each municipality faces.

Following these initial projects, task group members began reviewing and recommending project sites for the Visual Stream Assessment projects funded through Pennsylvania Environmental Council. These projects were an important element in assessing current conditions of local streams. The selected sites serve as case studies in how local streams are affected by current and ongoing development practices.

When survey results and windshield tours were finalized, task group members reviewed results and provided direction to Heritage Conservancy as the resource inventory got underway. Members reviewed preliminary mapping as it became available and provided local knowledge and understanding of relationships uncovered in the inventory process.

Many task group members assisted in necessary field work for the Visual Stream Assessment projects. Tasks included walking local streams, inventorying conditions, and marking locations for photographic analysis. Their work has been incorporated into Visual Assessment Maps and the Resource Inventory.

The fifth meeting, held in November of 1998, was a critical point in the task group process. Members were asked to prioritize issues resulting from comments at the initial public meeting, the residents' survey and the completed resource inventory. From this discussion, management options were developed for inclusion in the plan. Further review and local support on specific conservation actions listed in the Preliminary Findings Report determined final recommendations included in the LDRCP.

III. Inventory Summary

The completed resource inventory provided extensive information regarding geology, soils, vegetation, wildlife, historical and cultural resources, open space, land use, zoning, population and conditions of local watersheds in the study region. The summary of the completed inventory has been organized using the six goals established in the Lower Delaware River Management Plan. These goals were developed as a basis for municipalities to implement recommendations set forth in the plan to protect the natural, economic and historic resources fo the Lower Delaware River corridor.

Water Quality

GOAL: Maintain existing water quality in the Delaware River and its tributaries from measurably degrading and improve it where practical.

While not directly assessed through the river conservation planning process, threats to water quality are critical to the health of the watershed. Land use and development are addressed in the inventory and directly impact water quality. The primary land uses in the study area are single-family residential (31%) and mining & manufacturing (13% - not including large areas of USX property classified as vacant). With nearly half of the region impacted by these two land uses, management practices on residential and corporate properties have a tremendous impact on water quality. Threats include: lawn fertilizer and chemical applications, storage and disposal of construction/manufacturing materials, water use and lawn maintenance. Non-point source pollution (NPS) from new development activities and existing land uses is a growing concern as land continues to be developed in the region. The Lower Delaware River Management Plan estimates that growth in the Lower Delaware River region will continue with population increases of about 14% by the year 2020. This growth "will put the river's ecosystem and water supplies under increasing stress."

Severe erosion along Rock Run in Lower Makefield Township

The fast pace of development is dramatically increasing non-point source pollution in local streams and waterbodies. Impervious surfaces and unmanaged stormwater are contributing to this problem. Scott Fegley, Supervisor for Lower Makefield Township, commented that, "We need to look at alternative ways, such as the use of porous paving, to control runoff and stormwater."

Natural Resources

GOAL: Preserve and protect the river's outstanding natural resources, including rare and endangered plant and animal species, river islands, steep slopes and buffer areas in the river corridor and along the tributaries.

The region's waterways are heavily impacted by stormwater runoff from continuing residential development and urbanization. Much of the riparian buffer area has been lost as adjacent property owners mow and maintain lawns to the stream bank. This loss reduces a stream's effectiveness to trap and filter out sediment and nutrients from stormwater runoff, provide wildlife habitat and be a valuable recreational resource. Increasingly, streams are carrying heavy flows during major storm events which scour the stream bottom and erode stream banks. Pressures on downstream areas have required drastic measures (including the use of riprap and concrete retaining walls) to keep waters from flooding and destroying property. While these problems continue, areas of significant wildlife habitat and beauty do exist along many of the streams.

Other important natural features include floodplains, hydric soils, wetlands and woodlands. Floodplains cover approximately 20% of the land area (11,379 acres), hydric soils 10% (5721 acres) and wetlands approximately 18% of the land area (10,172 acres). These resources are protected to a degree through municipal ordinances and state and federal guidelines. Large tracts of remaining woodlands are protected through public ownership by the municipalities (Five-Mile Woods in Lower Makefield, Gray Stones in Morrisville and Bristol Marsh in Bristol Borough), county (Delhaas Woods, Silver Lake County Park, Queen Anne County Park and Oxford Valley County Park), and state (Neshaminy State Park).

Restoration along Brock Creek in Lower Makefield Township

The loss of healthy, diverse streams and riparian areas is the most critical natural resource issue in the watershed. In addition, the health of local streams is related to water quality. Lower Makefield Township and Yardley Borough have been working together to address this issue along Brock Creek

Historic Resources

GOAL: Preserve and protect the character of historic structures, districts and sites, including landscapes, in the river corridor.

The most significant cultural resources in the region, identified as National Historic Landmarks are:

- Delaware Division of the Pennsylvania Canal which begins in Bristol Borough and continues northward through Bristol Township, Tullytown Borough, Falls Township, Morrisville Borough, Lower Makefield Township and Yardley Borough.
- Andalusia, Bensalem Township
- Summerseat, Morrisville Borough

A number of additional significant historic districts and structures have been identified in the region but are not identified as National Historic Landmarks including: Pen Ryn Mansion, Historic Bristol, Historic Fallsington and Pennsbury Manor.

The Delaware Canal is a critical resource and linkage throughout the area. But, the canal is underutilized in many areas and access to the towpath trail is limited (most notably in Falls Township). Awareness of the canal as a local and regional resource is growing. Dredging activities to restore the canal are underway in Yardley Borough and a proposal a been recently submitted by the Delaware Canal State Park seeking TEA-21 funding to upgrade access and safety along the towpath in Falls Township. Falls Township is currently developing a municipal trails plan linking community trails to the canal towpath using it as a spine for their trail network.

Recreation

GOAL: Encourage recreational use of the river corridor that has a low environmental and social impact and is compatible with public safety, the protection of private property and with the preservation of natural and cultural qualities of the river corridor.

Approximately 70 facilities, totaling nearly 3,500 acres or 6% of the land area, exist in the area providing opportunities for recreation to local residents. The demand for recreation facilities is growing and municipalities continue to develop new parks to meet the demand (e.g. the 228 acre Falls Community Park). While many activities have been provided for, there remains a limited number of access areas to the Delaware River. The following are the only developed public access sites in the eight municipalities:

Yardley Access site along the Delaware River

- Yardley Access in Lower Makefield just north of Yardley Borough
- Falls Township Riverfront Park adjacent to Pennsbury Manor (adjacent to the river but no fishing or boating access)

- Neshaminy Creek State Park in Bensalem Township
- Delaware River Access Area near Pen Ryn

A number of informal areas are used by local residents where they are able to park safely and walk along the river (e.g. in Morrisville south of Route 1, areas near the water treatment plant and near the historic 1894 pumphouse). In addition, six private marinas are located on the Delaware River and two along Neshaminy Creek.

River access is a major concern throughout the region - access not only physical (fishing, boating, and pedestrian) but also visual. Much of the land along the river has been developed for industry and private use. Driving along the river to enjoy it as an amenity is difficult. Bristol Borough is taking initiative to address this issue. River access and recreation development are planned for areas in Riverfront Park and in the Riverfront North Development area. In addition, support for recreation development needs to be built by promoting the economic benefits of recreation facilities.

Economic Development

GOAL: Identify principles for minimizing the adverse impact of development within the river corridor.

With the movement of service sector businesses from the city to suburbs and exurbs, communities are facing new demands for resources and facilities. While the region is becoming more diverse, new development places increasing pressure on remaining natural resources. Municipalities have begun to address these issues. Through local zoning, development plan reviews and enterprise programs, communities are trying to direct development away from sensitive areas, utilize existing infrastructure and reuse vacant industrial sites.

With these changes, previously used industrial lands are being vacated and new development is underway. Opportunities exist to acquire open space in vacated industrial areas and also to reuse existing industrial land and infrastructure to accommodate new development. Accommodating new development in existing industrial areas will help to reduce pressures on remaining natural resources. In addition, an alternative form of economic enhancement to be considered is the promotion of recreation, including linking to the Canal Towpath Trail and access facilities to the Delaware River.

Open Space Preservation

GOAL: Preserve open space as a means of maximizing the health of the ecosystem, preserving scenic values, and minimizing the impact of new development in the river corridor.

Through the Bucks County Open Space bond initiative, municipalities are eligible to receive funds for open space land acquisition. To receive funds, municipalities are required to prepare an Open Space Plan as a statement of vision for open space preservation. Through the planning process, communities identify current development, areas under threat from development, past open space preservation actions, opportunities for future preservation and action items to implement open space preservation objectives.

To date, Lower Makefield Township, Bensalem Township, Falls Township and Bristol Borough have completed and approved Open Space Plans. Yardley Borough and Morrisville Borough are in the process of forming Open Space Plans.

This planning process provides important information regarding critical and significant resources and community values. Through this process communities are able to prioritize resources needing protection and implement steps to preserve remaining open space.

The Open Space Plan when completed in each municipality becomes an important tool for communities to implement watershed conservation. Important to address when preserving open space is to establish the understanding that open space does not necessarily mean recreation. Areas that protect critical resources (e.g. unique habitat) need to be protected from overuse by the public. Another aspect of preservation is the need for continual maintenance and management. Communities cannot always absorb the fiscal responsibilities of managing and maintaining open space or recreation properties. Opportunities to provide revenue from open space and recreation facilities for management and maintenance need to be explored.

IV. Management Options

From public comments received at the first public meeting, the completed resident survey, resource inventory and summary, a series of 20 issues were identified to target recommendations. Through the advisory task group, five priority management options were determined, grouping the 20 issues identified during the river conservation planning process.

The advisory task group at a working meeting in November, 1998 detailed out the 20 issues. Under the facilitation of Heritage Conservancy, each municipality's priorities were assessed and through a consensus discussion, the task group determined the five priority management options to be addressed in the river conservation plan.

The priority of these issues varies from municipality to municipality. In addition to task group members, partner organizations and agencies were asked to identify their organizational priorities in relation to conservation action in the Lower Delaware River watershed. The organizational priorities assisted Heritage Conservancy in linking partners to implementation actions.

Following are the five management options in order of priority and the issues associated with each. The management options represent issues to be addressed to achieve river conservation in the Lower Delaware River watershed.

1. *Stormwater and Riparian Area Management*
   Stream Corridor Improvement
   Erosion and Sedimentation
   Stormwater Management/Flood Management

2. *Future Development*
   Greenway/Trail Development
   Economic Development
   Land Development
   Recreation Facility Development

3. *Planning and Zoning*
   Zoning Ordinances
   Development Plan Reviews
   Regional Planning

4. *BMPs and Education*
   Landscape Management
   Clean Up
   Monitoring
   Non-Point Source Pollution
   Education

5. Land Acquisition and Preservation Strategies
Land/Resource Protection Strategies
Open Space Preservation
Land Acquisition
Historic Preservation
River Access

Action is needed to realize watershed conservation along the Lower Delaware River and its tributaries. The issues determined through the inventory and analysis process provide a foundation for targeting projects critical to maintaining the overall health of the watershed.

Municipal Implementation

The planning effort has provided insights to the local watersheds and targeted key issues needing to be addressed in the region. As the plan was completed, each municipality has identified projects and strategies to focus initial implementation efforts. Following are key projects and implementation strategies identified by each municipality within the study.

Bensalem Township

Bensalem Township has unique opportunities to promote greenway development within the community. The municipality is bounded to the north by the Neshaminy Creek and to the south by the Poquessing Creek. These two tributaries are the focus of regional protection efforts headed by Bucks County for the Neshaminy and Fairmount Park Commission for the Poquessing. Philadelphia Water Company is also involved with greenway planning in an effort to protect water quality near the water intakes in the Delaware River. Bensalem Township is emphasizing the need to assist with regional efforts in connecting the local community to these recreation and open space areas. The community is also actively supporting the Delaware Heritage Trail and will be implementing sections of the trail within the community.

Stormwater and Riparian Area Management

- Prepare a study assessing the need for riparian restoration and erosion/ sediment controls along Neshaminy Creek, Poquessing Creek and the Delaware River and implement a demonstration project on a selected municipal site. Cooperation with adjoining municipalities (Middletown Township, Bristol Township and City of Philadelphia) will be needed to assess headwaters areas outside the township.
- Assess limitations of existing stormwater drainage systems and develop designs upgrading existing systems to increase retention and infiltration in the Neshaminy Creek sub-basin.

Future Development

- Repair and maintain sea wall along the Delaware River and implement improvements within the Delaware River Access Park (To be completed through cooperation with Bucks County Parks).
- Develop a municipal greenway plan protecting the Neshaminy Creek, Poquessing Creek and Delaware River corridors and connecting the local community to a regional trail network. (To be prepared in cooperation with the efforts of Fairmount Park Commission, Philadelphia Water Company, National Park Service and Bucks County).

Planning and Zoning

- Review and update the township's comprehensive plan and zoning/ subdivision ordinance to address preservation and conservation of existing significant and sensitive natural features in Bensalem Township.

BMPs and Education

- Prepare and distribute educational information to township residents on Landscaping BMPs. Implement a demonstration project and host public workshops outlining techniques, materials and benefits.
- Implement an annual volunteer clean-up day for the Neshaminy and Poquessing creeks and Delaware River.
- Coordinate with partner conservation organizations to implement monitoring programs in the Neshaminy Creek and Poquessing Creek sub-basins.
- Implement a storm drain stenciling program to raise awareness regarding dumping of toxic fluids into local streams and the Delaware River.

Land Acquisition and Preservation Strategies

- Acquire properties and access easements along the Neshaminy Creek, Poquessing Creek and Delaware River to complete greenway protection efforts and develop a recreational trail network within the community.

Bristol Borough

Bristol Borough is actively working to develop riverfront access within the community. Many of Bristol Borough's implementation projects respond to this need which is not recognized only as a local issue but also as a regional issue in the river conservation plan. In its recently completed Open Space Plan, Bristol Borough recognized this need and many new opportunities developing in this riverfront community. In addition, the borough has recognized remaining natural areas that could become important open space and recreational resource areas within the community.

Stormwater and Riparian Area Management

- Restore and stabilize streambanks along Otter Creek near the Bristol Marsh Preserve area.

- Implement riverbank protection measures (including biotechnical techniques where applicable) along the Delaware River at Riverfront North to stabilize the bank for future development of the area.

Future Development

- Develop adaptive reuse of the Grundy Power Plant building as a museum and cultural/educational attraction along the Delaware Canal and Towpath.
- Develop public access including pedestrian/biking trails, fishing, boating etc. to the Delaware River at Bristol Borough's Riverfront North Redevelopment Area.
- Construct comfort stations and amenities in Lions Park along the Delaware River.
- Extend the Bristol Spurline Park in two sections. Obtain easements or acquire railroad tracks along Railroad Avenue for pathway construction. Extend pathway to provide riverfront access at Bristol Borough's Riverfront North Redevelopment area.
- Develop a Canal Landing/Tourist Center in Downtown Bristol to stimulate economic development and attract tourism to the central business district.

Planning and Zoning

- Review and update the borough's comprehensive plan and zoning/subdivision ordinance to address preservation and conservation of existing significant and sensitive natural features in Bristol Borough.

BMPs and Education

- Implement BMPs on the borough public works yard in conjunction with restoration efforts along Otter Creek.

Land Acquisition and Preservation Strategies

- Acquire privately-owned marshlands located along the historic Delaware Canal and towpath for the purposes of conservation, pedestrian trails and interpretation.

Bristol Township

Two sub-basins are the focus of implementation efforts in Bristol Township. Neshaminy Creek forms the southern municipal border with Bensalem Township and empties into the Delaware River. Property along the Neshaminy is largely held in private hands and the community is looking to increase public access to this important natural resource. The Mill Creek sub-basin includes Black Ditch Creek and areas draining into Silver Lake. This sub-basin covers a large portion of the municipality and efforts are needed to address stormwater, riparian restoration along the streams and educate residents about landscape management practices.

Stormwater and Riparian Area Management

- Study drainageways in the Mill Creek sub-basin to assess sites in need of riparian restoration. Implement a restoration project on a selected

municipal property and use as a demonstration for educating property owners along local streams. Work cooperatively with Middletown Township to assess headwater areas outside Bristol Township.

Future Development

- Implement plans for greenway and trail development along approximately 5 miles of Black Ditch Creek.
- Implement plans completed for Riverside Park along the Neshaminy Creek, constructing recommended recreation facilities and improving public access.

Planning and Zoning

- Review and update the township's comprehensive plan and zoning/ subdivision ordinance to address preservation and conservation of existing significant and sensitive natural features in Bristol Township.

BMPs and Education

- Develop education program for residents about best landscape management practices to reduce the use of chemical fertilizers, increase infiltration and use native plants in landscaping.

Land Acquisition and Preservation Strategies

- Acquire significant properties and access easements along greenway corridors to protect remaining natural areas and connect to a regional trail network.
- Acquire open space properties identified in the Bristol Township Open Space Plan that protect stream corridors, provide access to the Delaware River or Neshaminy Creek, or meet other specific river conservation goals defined in the LDRCP.

Falls Township

Due to the urban nature of Falls Township, large quantities of surface runoff are rapidly directed to stormwater drains and streams. The result is that natural drainage systems in the township are frequently overwhelmed by even moderate storm events causing flooding and damage along streams and drainageways. The township has chosen to focus implementation efforts on addressing issues regarding stormwater, flood management and developing alternatives to traditional storm drainage systems.

Stormwater and Riparian Area Management

- Retrofit existing storm drains that receive runoff from large areas of impervious surfaces with catchment and filtration system to remove debris and pollutants from highways and parking lots.
- Develop retention and infiltration system for existing and new storm drainage systems to reduce the frequently overwhelmed drainage system during even moderate storm events.

- Restore the stream channels and vegetative buffer along Rock Run and Martins Creek to reduce erosion, sedimentation and non-point source pollution in the streams.
- Complete an engineering study of Martins Creek and Rock Run to determine the feasibility and implementation of installing stream-side retention basins.
- Develop a long-range management plan for the Rock Run/Martins Creek watershed to reduce the amount of storm water directed into the stream channel, protect the vegetative buffer along the stream, acquire easements or key properties adjacent to the stream, limit construction and filling activities near the streams and work cooperatively with Lower Makefield Township to address stormwater flows in Rock Run.

Future Development

- Develop and promote a program to target residents along Martins Creek and Rock Run on land management practices appropriate for stream-side properties.
- Remove invasive species along areas of Martins Creek from Lower Morrisville Road to Millcreek Road.
- Construct a series of walkways along Martins Creekand wetland areas in the new Community Park promoting education and understanding of the environment and habitats.
- Develop recreation and river access facilities including: walkways, pavilions and a floating bridge across the cove inlet on newly acquired riverfront property adjacent to Quaker Penn Park.
- Construct river access facilities.
- Construction of detention/retention structures in the Rock Run/Martins Creek watershed to increase infiltration and filtration of stormwater and reduce direct inputs to the stream channel.

Planning and Zoning

- Work cooperatively with Lower Makefield Township to develop consistent planning and zoning guidelines addressing new development and retrofitting existing storm drainage structures in the Rock Run/Martins Creek watershed.
- Review and update the township's comprehensive plan and zoning/subdivision ordinance to address preservation and conservation of existing significant and sensitive natural features in Falls Township.

BMPs and Education

- Train township staff and EAC members in stormwater management and bring up-to-date on best management practices (BMPs).

Land Acquisition and Preservation Strategies

- Acquire open space properties identified in the Falls Township Open Space Plan. Specifically, preserve and protect remaining coastal plain forest lands (the Sadowski property, Guzikowski property and other properties near the Five Mile Woods Forest Preserve).

- Acquire easements or properties along key stretches of Rock Run and Martins Creek to minimize disturbance of naturalized areas and protect the vegetative buffer from new development.

Lower Makefield Township

Two highly impacted streams flow through Lower Makefield Township. Brock Creek and Rock Run are experiencing tremendous development pressures within their watersheds. These pressures are raising concerns not only in Lower Makefield Township but also the neighboring communities of Yardley Borough and Falls Township. Lower Makefield Township is focusing initial efforts on developing comprehensive management plans for these two watersheds with an important component of the plans being intermunicipal cooperation and communication. As watersheds cross municipal boundaries, plans to mitigate impacts need to cross municipal boundaries. Watershed planning efforts will include participation with Middletown Township, Yardley Borough and Falls Township. In addition, Lower Makefield Township hopes to complete a greenway study of the entire municipality, a natural resource baseline of the Dyers Creek subbasin and establish an educational program targeted to property owners managing areas adjacent to local streams.

Stormwater and Riparian Area Management

- Hire a consultant to prepare a comprehensive evaluation of the Brock Creek and Rock Run stream corridors to identify and prioritize degraded reaches and identify restoration opportunities. A key component of the plan will be to establish cooperation among the multiple municipalities within the watersheds.
- Restore reaches of Brock Creek and Rock Run to stabilize soils, improve wildlife habitat and reduce NPS pollution using native plants, biotechnical remediation and applied fluvial geomorphology techniques.
- Support implementation recommendations resulting from the ongoing 319 Study of Brock Creek.
- Prepare an evaluation and baseline assessment of the natural resources of Dyers Creek. Assess areas in need of protection before development impacts the watershed.
- Develop and implement a restoration plan for the degraded wetlands colonized by invasive species at the "Falls of the Delaware".

Future Development

- Assess appropriate sites and develop public access/views to the Delaware River north of Yardley Borough in recommended areas.

Planning and Zoning

- Conduct a complete inventory and detailed greenway study of Lower Makefield Township's stream corridors to identify significant and sensitive natural resources and develop a greenway management plan.
- Prepare a riparian areas/stormwater management study for the township.

- Review and update the township's Comprehensive Plan and Zoning/ Subdivision Ordinance to address preservation and conservation of existing significant and sensitive natural features in the municipality.

BMPs and Education

- Develop and promote a program to target residents along Brock Creek and Rock Run on land management practices appropriate for streamside properties.

Land Acquisition and Preservation Strategies

- Establish cooperation among Middletown Township, Yardley Borough and Lower Makefield Township to develop a consistent and coherent watershed management plan for the Brock Creek watershed.
- Pursue acquisition for preservation and open space, private floodplain and wetlands along the Delaware River in the northern portion of Lower Makefield Township.
- Pursue acquisition for preservation and open space, private land surrounding Five-Mile Woods.

Morrisville Borough

Morrisville Borough has a unique opportunity in that significant areas along the Delaware River remain undeveloped. The river is a resource that can potentially provide a variety of recreational opportunities for local residents. If planning is done to develop recreation and improve access to the Delaware, considerations need to be given to protecting the wildlife habitat values of these areas. A detailed inventory of the flora and fauna found in these areas and a determination of the impacts of proposed plans on significant habitats can assist the community in making decisions about the best use of these areas.

Two additional areas assessed by the EAC have potential as future river conservation projects. The adjoining properties of the Morrisville sewage treatment facility and the Staley industrial facility have significant areas of woodland and open space in low-lying areas. These naturalized areas and associated drainages provide habitat and serve as a sediment and nutrient filter for stormwater drainage from surrounding properties. Another potential project is the site of an old quarry in the southwest corner of the borough. The property is currently undeveloped and remains vacant. With a small lake in the old quarry pit, the property has potential to be an important recreational facility for the community. A feasibility study and clean up program will likely be needed prior to allowing public access to the site. Clean up of this site would be a priority. Both of these projects will need to be evaluated by the borough prior to their implementation.

Stormwater and Riparian Area Management

- Hire a consultant to study the hydrology of the borough and prepare a stormwater management plan addressing issues related to subsurface drainage and flooding.

- Work cooperatively with private property owners to restore stream channels and vegetative buffers on selected sites identified in the visual assessment study.
- Complete a detailed inventory of the flora, fauna and unique habitats along the Delaware River.
- Evaluate current state of the Delaware River dike in the borough, planning for regular maintenance and construction of steps for safe public access along the river.
- Develop and implement stormwater and flood management plan in the Melvin Heights area.
- Develop a general Morrisville Riverfront Management Plan for the Delaware River.

Future Development

- Coordinate riverfront plans for the entire length of the Delaware River in Morrisville Borough, addressing public access, corridor protection, pedestrian connections to the Delaware Canal and future land acquisitions. Incorporate regional recreational efforts.
- Construct river access facilities.
- Prepare a feasibility study for the development of a public recreation facility at the site of the old quarry in the southwest corner of the borough.

Planning and Zoning

- Hire a consultant to review and update the borough comprehensive plan and zoning/subdivision ordinance addressing preservation and conservation of significant/sensitive natural and cultural resources.
- Coordinate efforts with Lower Makefield and Falls townships to manage those watersheds that cross municipal borders.

Best Management Practices (BMPs) and Education

- Develop a clean-up program for the old quarry site and lake.
- Develop materials and distribution program to educate borough residents about proper stream management including the need to eliminate dumping of yard waste and other refuse in streams, the canal and the river.
- Hold a volunteer clean-up day for clearing trash and debris along the Delaware River and support the existing clean-up day for the Delaware Canal.
- Expand programs to place markers on stormwater drains discouraging dumping of motor oil and other toxic liquids.

Land Acquisition and Preservation Strategies

- Acquisition should be coordinated with the borough open space plan.
- Acquire conservation easements on woodland and wetland areas on the Sewage Treatment and Staley Industrial properties. The easements would protect the natural areas for wildlife habitat and open space. The easements could allow for public access to be developed at a future time.

- Evaluate acquisition of the quarry property for a municipal park following a feasibility study.
- Acquire easements or additional properties along the Delaware River and Delaware Canal (as determined in riverfront plans) to protect natural areas and improve river access.

Tullytown Borough

A significant portion of this municipality consists of large water bodies and properties associated with the Tullytown Landfill. In addition, Martins Creek, an important tributary stream, flows through the borough emptying into the Delaware River. This community is addressing multiple issues involving economic development, community revitalization as well as recreation and open space preservation. Opportunities exist to redevelop outdated community centers, connect the community to a regional trail network and, in the future, acquire landfill properties for community uses.

Stormwater and Riparian Area Management

- Implement restoration measures along Martins Creek as identified in the Visual Assessment completed for the LDRCP.

Future Development

- Prepare feasibility study for the revitalization of the Levittown Shopping Center as a multi-use "smart growth" project.

Planning and Zoning

- Review and update the borough's comprehensive plan and zoning/subdivision ordinance to address preservation and conservation of existing significant and sensitive natural features in Tullytown Borough.

BMPs and Education

- Develop education program for residents about best landscape management practices to reduce the use of chemical fertilizers, increase infiltration and use of native plants in landscaping.

Land Acquisition and Preservation Strategies

- Acquire easements or properties along key stretches of Martins Creek to minimize disturbance of naturalized areas and protect the vegetative buffer from new development.

Yardley Borough

This small historic community along the Delaware River has many unique cultural features including the Delaware Canal and a designated historic district. Along with these cultural features, Brock Creek flows through the community emptying into the Delaware River. Brock and Silver creeks experience tremendous stormwater flows and extreme measures have been taken to protect nearby properties from damage. Through the implementation of the LDRCP, the borough will assess alternatives to traditional

engineering approaches that have channelized both streams and eliminated the "naturalized buffer." This work will address stormwater and stream restoration along the creeks as well as developing an education and monitoring program by landowners and school groups. In addition, the community looks to increase river access opportunities and build on the cultural resources of the community.

Stormwater and Riparian Area Management

- Hire a consultant to assess use of alternative engineering techniques to replace extensive use of riprap and concrete retaining walls along Brock Creek as is empties into the Delaware River. The plan would propose to recreate a naturalized area while addressing flooding concerns. In addition, the Brock Creek conduit crossing below the Delaware Canal is to be assessed and proposals made to reduce accumulation of debris and subsequent flooding problems.
- Utilize techniques that incorporate both structural and vegetative means to restore a riparian buffer along Brock Creek while stabilizing the streambanks.
- Evaluate stormwater impacts on Silver Creek and implement necessary riparian buffer restoration projects to mitigate issues.

Future Development

- Implement Master Plan for Buttonwood Park.
- Construct improvements for parking and access to the Delaware Canal towpath in support of regional greenways and trails programs and as recommended by the Heritage Trail plan.

Planning and Zoning

- Prepare a riparian areas/stormwater management study for the borough.
- Review and update the Yardley Borough Comprehensive Plan and Zoning/Subdivision Ordinance to address preservation and conservation of existing significant and sensitive natural features in the municipality.

BMPs and Education

- In cooperation with Lower Makefield Township and other neighboring municipalities, develop a landscape management BMP program for contributing watersheds such as Brock Creek, Buck Creek and Silver Creek. Establish an education program including a High School Environmental Science program and adult water quality monitoring system for Brock Creek, Buck Creek and Silver Creek which complements other municipalities associated with contributing watersheds.

Land Acquisition and Preservation Strategies

- Acquire open space properties as identified in the Yardley Borough Open Space Plan that protect stream corridors, provide access to the Delaware River or meet other specific river conservation goals defined in the LDRCP.

- Continue to work with the Historical Architectural Review Board promoting the designated historic district and numerous historic structures in Yardley Borough.
- Expand Buttonwood Park through acquisition of adjacent properties.
- Investigate dredging of historic Lake Afton to its original depth for enhanced recreational use.

Regional Implementation

Once the plan is completed, the municipalities will be responsible for taking the recommendations and implementing projects. An important outcome of this river conservation planning process has been the partnerships formed among the municipal environmental advisory councils (EACs) and other members of the Advisory Task Group.

This group of leaders was given the charge to spearhead the planning effort and has taken responsibility for seeing local concerns reflected in the planning process. As the plan comes to a successful completion, Heritage Conservancy will see that all necessary documentation is forwarded to PA DCNR and that all requirements are met to have the plan placed on the PA State Rivers Registry. One of the final requirements of the planning process will be to have municipalities endorse the plan and commit to implementing the recommendations. The last official responsibility of the Advisory Task Group is to see that the plan is presented to the municipal governing body and look to endorsement of the plan and recommendations.

Looking to continue the work of the plan and improve intermunicipal communication, it is proposed that the local environmental leaders continue to meet on a formal basis to discuss implementation strategies, watershed issues and guide regional projects recommended in the plan. Stronger cooperation and communication is needed among municipalities to develop intermunicipal watershed management plans, raise awareness of projects affecting adjoining communities and to share information regarding upcoming funding opportunities. This regional information sharing will assist in implementation efforts related to the river conservation plan and also build local support for the EAC advisory role in the community.

Improving intermunicipal cooperation was a major goal of this planning process and was a priority recommendation emanating from the work completed by the Countryside Stewardship Exchange Program. Carrying this cooperation forward will be important to successfully complete the following regional implementation projects.

River Access Study

A comprehensive study is needed to assess priority locations for additional river access areas and to weigh environmental impacts. Development of waterfront areas will require intermunicipal cooperation and

assistance from the private, county, state and federal sectors to successfully construct new facilities. With much of the riverfront in private holdings, acquiring addition property and access easements will be critical. This study should include extensive use of local knowledge about conditions and needs of riverfront areas during the tidal changes and during peak use times. A cursury regulatory review will be necessary to determine the appropriate permits.

Coordination and implementation of Open Space Plans will be imperative.

Regional Education and Training Programs

Effort is needed to coordinate regional projects and develop a regional education program to educate residents, student groups, township officials, public works staff, municipal park and recreation staff and EAC board members. Important education and awareness projects include:

- Develop landscape BMPs to reduce use of fertilizers and direct runoff into streams.
- Develop educational videos targeted to specific audiences on the need for and benefits of landscape BMPs, native plants, stream management and watershed planning.
- Coordinate with local schools (Pennsbury School District, Council Rock School District and larger private schools) to develop an educational program targeted to watershed-based environmental conservation and community-based, hands-on projects.
- Storm drain stenciling to reduce dumping of toxic materials into local streams.

The ideal venue for this regional approach is through regular meetings with all the identified partners. Currently, the EAC's in lower Bucks County meet quarterly to discuss activities of regional concern. Watershed-focused projects could be one topic of interest to this group. They could coordinate the activities with other identified partners. Other tangible topics could be joint submission of grants for project implementation, sharing equipment and technical skills among members, as well as ideas for multi-municipal implementation. In order to bring all partners together, regular comprehensive meetings should occur for the intention of communication. The National Park Service, in particular, feels the need to convene meetings with all municipalities, especially with the Lower Delaware National Wild and Scenic River Study currently under review by the U.S. House and Senate for designation. If approved, coordination of all watershed activities will be paramount to avoid duplication of effort and to make a positive impact within the sub-basins of the Delaware River.

Visual Watershed Assessments

Visual watershed assessments similar to those performed by the EAC's in segments of specific municipalities have yet to be completed for Core, Dyers, Houghs, Mill, Neshaminy, Poquessing and Queen Anne creeks.

Watersheds are not defined by municipal boundaries, therefore, a more holistic approach to their assessment is imperative. An intermunicipal effort is needed to complete the remaining visual assessments of these important sub-basins within the LDRCP. As watersheds are studied in greater detail to determine flooding potential, water quality and other development impacts, intermunicipal cooperation will ensure that recommended actions are consistently implemented in the multiple municipalities of a watershed.

Heritage Trail Project

The Delaware River Heritage Trail project is being directed by the National Park Service and will include all of the municipalities in the Lower Delaware River Conservation Plan. It will be important for municipalities to make critical connections in this trail network and construct needed improvements to accommodate users. As this plan is completed, regional efforts to direct construction and implementation will assist in connecting local trails into a larger regional network.

Stormwater System Retrofits

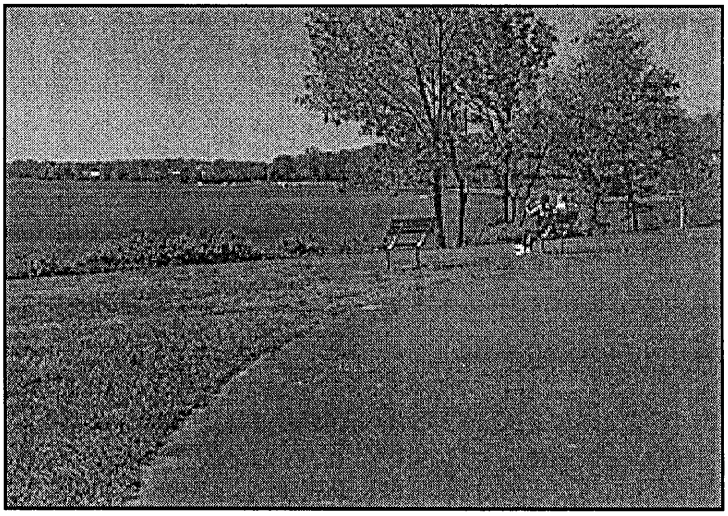
As individual municipalities upgrade storm drainage systems, regional coordination is needed to assess impacts on a watershed basis. A regional assessment of existing conditions and projected benefits of storm drainage upgrades using selected BMPs will provide a standard to measure improvements. This regional study would also recommend best techniques in addressing storm drainage in the individual local watersheds. Currently, the Bucks County Planning Commission is preparing a watershed-wide stormwater management plan for the region. When completed, this work will provide necessary information assisting in development of recommended techniques.

I. Project Abstract

The Lower Delaware River Conservation Plan (LDRCP) is the result of a partnership between state, regional and local organizations. The communities directly involved in the plan are Bensalem Township, Bristol Borough, Bristol Township, Falls Township, Lower Makefield Township, Morrisville Borough, Tullytown Borough and Yardley Borough. With the guidance and support of the other partners, the plan is being prepared by Heritage Conservancy through a grant from the PA Department of Conservation and Natural Resources (PADCNR). The major creeks within the watershed study area are portions of: Brock Creek, Buck Creek, Core Creek, Dyers Creek, Houghs Creek, Martins Creek, Mill Creek, Neshaminy Creek, Poquessing Creek, Queen Anne Creek and Rock Run.

The need for such a plan became increasingly clear as population and development in these eight municipalities grew. Residential and commercial expansion, if left unrestricted, threaten the environmental stability and beauty of the Delaware River and its tributaries. Because of the commitment of citizens and government leaders in these communities, a river conservation plan will aid in protecting this vital resource, mitigate potential damage from development, and improve public access to the Delaware River and its watershed.

The LDRCP recommends a long-term course of action to protect the resources of the Lower Delaware River watershed. At the outset, the plan sought input from the eight participating municipalities through an advisory task group and from the public through a public meeting process. The first part of the plan documents conditions within the study area. Existing resource data was gathered and reviewed to understand the greater trends occurring in the study area. This information includes: land uses, zoning designations, cultural and historical resources, recreational resources, threatened and endangered species, census data and local ordinances. Public workshops were held and surveys created to seek opinions of residents, an important step in this planning process.



Neshaminy Creek State Park along the Delaware River

Analysis of the resource data and visual observations identified assets to be preserved and issues to be addressed. Issues of primary importance include: stormwater and riparian area management, future development, planning and zoning, BMPs and education and land acquisition and preservation strategies.

The final part of the LDRCP includes the recommended goals and management options. A public meeting was held to review and discuss the goals. The LDRCP provides the eight municipalities an opportunity to build a strong inter-municipal relationship to protect the watershed for all residents. Coordinating municipal plans and programs will provide strong and ongoing stewardship for this regional resource. Individual efforts will gain significant results, but cooperation is the key to long term success. The Lower Delaware River is a regional resource not governed by political boundaries. Implementing a plan of action that utilizes the best available environmental practices will help provide a healthy, stable and usable watershed.

II. Introduction

The Delaware River is many things. It is a source of precious drinking water. It is a home for endangered plant and animal species. It is the focus of scenic vistas for motorists, cyclists and hikers. It provides recreation and enjoyment for local residents and visitors alike. Its importance is measured in individual terms, but it is also measured in community terms. It is a common link that has shaped our historical and cultural development. The river entices us to seek and preserve our past while inspiring us to unite our efforts to protect its diversity and, in turn, protect our own future.

The river entices us to seek and preserve our past while inspiring us to unite our efforts to protect its diversity and, in turn, protect our own future.

Project History

The Lower Delaware River Conservation Plan (LDRCP) is an outgrowth of the Lower Delaware River Management Plan prepared in conjunction with the Lower Delaware National Wild and Scenic River Study. In 1996, prior to beginning the river conservation plan, an International Countryside Stewardship Exchange program was held on the Lower Delaware. The exchange brought together an international team of volunteer professionals to assist the citizens of the Lower Delaware in addressing economic development and conservation of natural and cultural resources. The goals established by the exchange program formulated the approach of the following river conservation plan.

The study area for the Exchange and Management Plan included two states (New Jersey and Pennsylvania), three counties (Bucks, Mercer and Burlington), and 23 municipalities. The river conservation plan has narrowed the scope of study to include eight municipalities within Bucks County, Pa.

Study Area

The LDRCP focuses on eight key municipalities in Lower Bucks County: Bensalem Township, Bristol Borough, Bristol Township, Falls Township, Lower Makefield Township, Morrisville Borough, Tullytown Borough and Yardley Borough. These municipalities have been involved in past efforts undertaken by the Countryside Institute, National Park Service (NPS) and other organizations over the past several years. They have expressed interest in continuing study and implementation efforts, particularly with regard to recreational access and amenities and economic improvement. A dense population and mixed land uses have created a real need to coordinate river protection efforts.

Bensalem Township
Bristol Borough
Bristol Township
Falls Township
Lower Makefield Township
Morrisville Borough
Tullytown Borough
Yardley Borough

Planning Process

The following phases of the project are necessary steps in completing the LDRCP.

Develop Initial Interest

The project was first announced at a reception sponsored by Heritage Conservancy and Mayor Joseph DiGirolamo of Bensalem Township. The event was held June of 1997 at Pen Ryn Mansion on the Delaware River.

To initiate the project, an informational public meeting was held in November 1997. The discussion focused on the need for coordinated effort to protect the Delaware River as a recreational, economic, natural and cultural resource. The following goals were achieved:

- people were informed about the study, RCP Fact Sheets describing the study were distributed, the involved organizations were introduced and their missions described
- public interest for the study was determined
- preliminary information on problems and concerns was gathered
- suggestions for areas to be studied or projects to undertake were solicited, and
- interested citizens were asked to help in performing the study and to be involved in the advisory task group

Following this public information meeting, it was necessary to select a representative group from the study area to work closely with the planning team. An advisory task group was organized and included: local residents, business owners, local government officials, recreational boaters and EAC members from each of the municipalities. The final step in this initial phase was to develop a detailed scope of work that included goals, objectives, and a time line for project stages and intended completion. Once the advisory task group was in place and tasks were identified, the fact finding began.

Identify and Collect Resource Data

Inventory and mapping of the physical, natural, historic and cultural resources relating to the Lower Delaware River were done to document the significant characteristics of the region. To complete the inventory, the status of resource information was ascertained. The planning team determined readily available data resources in digitized and non-digitized form. A work plan was developed to determine what resources were to be gathered by Heritage Conservancy, in-kind services, volunteer services or subconsultant contract. Mapping included: watershed boundaries, wetlands and floodplains, soils, topography and geology, historic and cultural structures and districts, land use, recreation amenities, zoning designations and protected private and public lands. Resources were mapped using a Geographic Information Systems (GIS) where digital data was available or where coverages could be developed with available funding.

An informational survey was developed and disseminated. The survey was used to query residents, landowners and businesses about concerns raised at the initial public meeting as well as specific resources to be analyzed.

Analyze and Evaluate Resource and Survey Data

Once resource information was collected, an analysis related to concerns of an environmental or public interest nature was done within the context of the present and future conditions of the Lower Delaware River (Bucks County) region.

Prepare Preliminary Findings Report

Following completion of the inventory and analysis, a preliminary findings report was developed and distributed for comment. The following was included in the preliminary findings report:

- a history of planning activities related to the river conservation plan
- the advisory task group and the roles played by task group members
- processes and technologies used to gather and evaluate resource data
- summary of resource data collected
- summary of public concerns reported
- issues chart showing importance of each resource in plan formulation
- management options report about possible problem solutions
- options promoting resource awareness and long-term stewardship
- a catalog of implementation actions
- proposed year of accomplishment for options

Prepare Draft River Conservation Plan

The draft river conservation plan, incorporating the comments to the preliminary findings, was developed following the public meeting. The Draft Plan contained the following:

- maps describing the planning area
- zoning and land use patterns
- inventory of resources studied
- analysis of the appropriate resources
- identification of issues, concerns, opportunities and threats to river values, both natural and social, and recommendations to address them
- other pertinent information

Prepare Final River Conservation Plan

Preparation of the final plan followed the public review of the draft plan, again incorporating public comment and addressing specific issues raised in the public forum. The final plan includes:

- comments from the public meeting reviewing the draft river conservation plan
- a resolution of substantive comments received on draft plan

A final public presentation was given outlining specific features of the plan and included the introduction of the contact persons coordinating plan implementation. Finally, the Executive Summary was distributed to the public and local media.

III. Public Comment and Participation

As part of the rivers conservation planning process, four open meetings were held to inform and solicit comment from the general public, representatives of each municipality and representatives of local public agencies.

The first public meeting was held November 25, 1997 to announce the initiation of the LDRCP and to gather public input on river issues, concerns and opportunities. Approximately 20 participants gathered to begin discussing river conservation planning activities. The following list defines the substantive issues and ideas addressed at this meeting.

- A boat ramp in the Morrisville, Falls Township area is needed.
- A future plan to connect the upper and lower segments of Neshaminy Creek is possible.
- New ramps at Neshaminy State Park are needed with less slope and longer incline.
- Roads block access to the river in Bensalem Township.
- The riverfront is owned by large companies in Falls and Bristol townships.
- Trash trucks are a problem.
- Flooding and stormwater management is a concern.
- There is a desire to maximize river use with restaurants on the river and to improve boat access.
- A unified educational network is needed along the river.
- Include public access in riverfront development plans.
- Tie river access to federal enterprise zone and economic development plans for the area.
- Add fishing piers.
- Flood control is needed along Neshaminy Creek.
- Private property owners along the river have concerns regarding public access across their property and liability issues.
- Recreational facilities, including bike trails and camping, are needed.

A second public meeting was held February 26, 1999 to present the Preliminary Findings Report. A 30-day public comment period followed the public meeting. A summary of the public comments is contained in Appendix A.

Two final public meetings were held to:
- Present and solicit public comment regarding the Draft River Conservation Plan (June 9, 1999)
- Present the Final River Conservation Plan (September 21, 1999)

Project Survey

Heritage Conservancy conducted a random survey of residents within the eight municipalities of the LDRCP study area to get a sense of what

residents view as the important issues regarding the Lower Delaware River watershed. After sorting the responses by municipality, each survey was hand tallied, and the results were entered into a spreadsheet to determine totals and percentages for each question.

A total of 2,200 survey questionnaires were mailed to residential and commercial landowners/tenants within the LDRCP study area. The methodology used to determine the number of questionnaires distributed to each municipality is outlined in Appendix B. Of the 2,200 questionnaires mailed in February 1998, 176 were returned (8%).

The common thread running through the majority of responses was the recognition of the importance of the Delaware River area as a natural and historic resource that must be preserved. What is at issue is the question of responsibility and funding for river access and conservation efforts. A majority of the respondents favor government responsibility for access, with an almost even split between county, state and federal governments. This same split occurred concerning conservation plan funding, with a slightly higher portion favoring either state or federal funding. However, the majority of respondents were not in favor of higher taxes to pay for conservation.

Resources and Preservation

Asked to identify the three most important aspects of the Delaware River area:

- 75% of respondents noted its value as a natural and scenic resource,
- 58% percent noted the fact that it is home to many plant and animal species, and
- 52.8% view it as an important cultural and historic resource.

Activities and Access

Passive recreation is a popular activity as indicated by the highest percentages of respondents. Current usage includes:

- 51.7% enjoy sightseeing
- 48.9% enjoy nature walks

With regard to access:

- 62% favor improving access to the river
- 65% also view improved access, particularly boat ramps, as an incentive to increased recreational river use
- 82% favor government responsibility with an almost even split between county, state and federal governments

Preservation and Regulation

An average of 86.9% of respondents favor preservation, including preservation of undeveloped land, farmland, forested land, historic resources, scenic character and wildlife habitat.

In keeping with those values, an overwhelming majority of the respondents favor land preservation over development of any kind.

- 72% noted they would support land use regulations within the entire watershed
- 77% favor a conservation plan that focuses on the entire watershed

Appendix B contains a tally of all responses from residents in the municipalities. The tables include combined totals and percentages. Note that in many cases respondents could choose more than one answer which means that the numbers may add up to more than the total number of respondents or the percentages to more than 100%. Though this may slightly skew the specific results, the overall sentiment is still evident.

Advisory Task Group

The advisory task group consisted of representatives appointed from each municipality in the study and representatives from organizations active in conservation efforts in the region. Participating organizations included: National Park Service, Pennsylvania Environmental Council, Bucks County Department of Parks and Recreation, Philadelphia Suburban Water and Bucks County Planning Commission. The role of the advisory task group was to review and evaluate the completed inventory and the resident survey results, coordinate visual assessments of local watersheds, prioritize issues resulting from public comment and completed planning work, and identify implementation projects to be included in the final river conservation plan.

A series of five advisory task group meetings were held in 1998. Beginning in February, the task group met to review the survey questionnaires sent to a random sample of residents and businesses in the eight municipality region. Following dissemination of the survey, task group members assisted Heritage Conservancy in conducting windshield tours of each municipality. These tours identified key resources and utilized the local knowledge of members and municipal officials to gain insight into critical issues each municipality faces.

Following these initial projects, task group members began reviewing and recommending project sites for the Visual Stream Assessment projects funded through Pennsylvania Environmental Council. These projects were an important element in assessing current conditions of local streams. The selected sites serve as case studies in how local streams are affected by current and ongoing development practices.

When survey results and windshield tours were finalized, task group members reviewed results and provided direction to Heritage Conservancy as the resource inventory got underway. Members reviewed preliminary mapping as it became available and provided local knowledge and understanding of relationships uncovered in the inventory process.

Many task group members assisted in necessary field work for the Visual Stream Assessment projects. Tasks included walking local streams, inventorying conditions, and marking locations for photographic analysis. Their work has been incorporated into Visual Assessment Maps and the Resource Inventory.

The fifth meeting, held in November of 1998, was a critical point in the task group process. Members were asked to prioritize issues resulting from comments at the initial public meeting, the residents' survey and the completed resource inventory. From this discussion, management options were developed for inclusion in the plan. Further review and local support on specific conservation actions listed in the Preliminary Findings Report determined final recommendations included in the LDRCP.

IV. Resource Inventory

Henry Hudson called the Delaware "one of the best, finest, and pleasantest rivers of the world." Beginning in the Catskill Mountains of New York, it is one of the largest rivers in the Northeast, following south 300 miles through forested mountains, farmlands, small historic towns, suburban sprawl, urban development, industrial complexes and extensive wetlands to the Atlantic Ocean (*Green Spaces & Historic Places*).

"one of the best, finest, and pleasantest rivers of the world."

- Henry Hudson
(about the Delaware River)

It remains the only free-flowing major river in the eastern United States, with no dams impeding the progress of its main stem. Woodlands still cover many of the river islands, the steeply sloping hills and cliffs and much of the floodplain along both sides of the river where a multitude of wildlife coexists with human activities.

The Lower Delaware is the natural boundary between New Jersey and Pennsylvania. This region of the Delaware is rich in natural and cultural history. Given the proximity to major population centers, the river is a major recreational resource for fishing, bird watching, canoeing and other water sports.

Mapping

The natural and cultural resources of the study area were inventoried, mapped on GIS where compatible data layers were available, and analyzed to gain an understanding of their significance and relationship to the Lower Delaware Region. Map coverages include:

- study area
- geology
- hydrography
- land use
- generalized zoning
- significant resources and recreation
- visual analysis

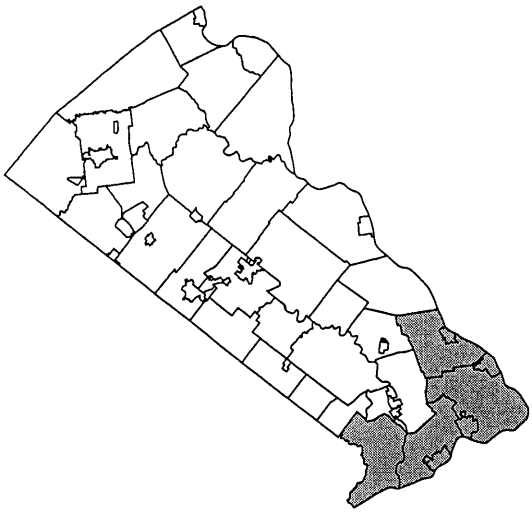
Resources and characteristics discussed and analyzed in this report include: surficial materials; soils; floodplains, hydric soils and wetlands; local ordinances; institutional, recreational, cultural, archeological and historical resources; and threatened and endangered species. Appendix C identifies the sources for data layers used on the inventory maps. Please note that tables used in this section were generated using generalized GIS data coverages. Discrepancies may exist between this planning scale data and individual municipal studies of land use and zoning.

An important step in the mapping process was the continual review and comment of Advisory Task Group members. As mapping was completed, members reviewed information and provided local insight into key relationships uncovered through the inventory process.

Study Area

The study area includes eight municipalities in Bucks County. The total area covers 57,456 acres or 90 square miles. The Delaware River forms the eastern boundary of the study, with the City of Philadelphia immediately to the south. The area is facing pressures from residential development, and the landscape is impacted by heavy industry. Active quarrying and landfill operations and the steel industry utilize large areas of land adjacent to the river in Falls Township and Tullytown Borough. Remaining rural land in Lower Makefield continues to be subdivided for new home construction. With this ongoing development, the river conservation plan explores alternatives for preserving remaining natural areas and protecting and improving water quality in the Delaware River and its tributaries.

Figure 1 - Study Area



Topography

The area is gently sloping to flat and includes floodplain areas for the Delaware River and numerous tributaries. Elevations range from five feet along tidal reaches of the Delaware River to 230 feet Mean Sea Level in the upper west corner of Lower Makefield Township. The fall line indicated on the **Geology Map** occurs along the Delaware between Morrisville and Trenton. This geologic line is the inland extent of the Coastal Plain as it meets the Piedmont Province. The Coastal Plain landscape flattens as it stretches to the Atlantic Coast due to (geologically) recent inundation by ocean waters. Steep slopes are rarely a concern except along major tributaries where water flows have carved out the soil and rock. As a result of the moderate elevations, streams in this region all flow in open valleys.

Municipality	Acres	Percent of Study Area
BENSALEM TOWNSHIP	13,404	23%
BRISTOL BOROUGH	1,250	2%
BRISTOL TOWNSHIP	10,900	19%
FALLS TOWNSHIP	16,965	30%
LOWER MAKEFIELD TWP	11,699	20%
MORRISVILLE BOROUGH	1,260	2%
TULLYTOWN BOROUGH	1,333	3%
YARDLEY BOROUGH	645	1%
Total	**57,456**	**100%**

Table 1 - Municipalities and Acreage

Geology

This study encompasses both tidal and non-tidal stretches of the Delaware River and tributaries. The fall line occurs near Morrisville, Pa. and Trenton, N.J. Below this point the landscape flattens into the Atlantic Coastal Plain. Here, the pre-Cambrian rocks that formed an ancient continental shelf appear as rapids at the Calhoun Street Bridge. A limestone ridge cuts across the river creating a series of falls. Above the falls, the river is entirely fresh water. Below the falls, the river is influenced by tides of up to eight feet. Upstream, the landscape becomes more dramatic as the river cuts through rock formations leaving magnificent cliffs. Downstream, the river enters the Delaware estuary

and passes through metropolitan areas surrounding Philadelphia. The flattening landscape and soft soils have supported tremendous development in this area.

The **Geology Map** indicates the surficial geology of the study area. The following discussion of the major geologic formation was taken from *Geology and Mineral Resources of Bucks County, Pennsylvania* published by the Pennsylvania Geological Survey and the Commonwealth of Pennsylvania in 1959.

Chickies Formation

The main body of this formation is gray crystalline quartzite and light buff to white, feldspathic, sericitic quartz schists. This narrow band of quartzite extends westward across Bucks County from Morrisville. The formation is overlain with unconsolidated sediments.

Felsic Gneiss, Pyroxene Bearing

This formation is a localized occurrence in the larger Baltimore Gneiss formation. Pyroxene occurs locally and in more felsic rocks, quartz and potash feldspar appear.

Granite Gneiss and Granite

This formation has formed as granitized areas in the Wissahickon Schist.

Lockatong Formation

This formation is comprised of dark gray to black argillite with occasional zones of limestone and black shale. It is a poor supplier of groundwater in terms of both quantity and quality. Intensive uses are not adequately supported on this formation.

Mafic Gneiss, Hornblende Bearing

This formation is part of the larger Baltimore Gneiss formation. The mafic rocks are probably igneous in origin.

Pensauken and Bridgeton Formation

This formation consists of quartz, yellowish-brown gravel and yellowish-brown, brown, and greenish-yellow sands. The gravel, in some bodies, is granular in size and well-sorted; other deposits range from pebbles to boulders.

Rock Run in Lower Makefield Township near the fall line

Stockton Formation

This formation is comprised of light colored sandstone, arkosic sandstone and conglomeratic sandstone. It also includes red to purplish-red sandstone, shale and mudstone. The formation is porous, permitting good

surface drainage and good groundwater recharge. The Stockton Formation generally provides a reliable supply of groundwater. The formation is suitable for agricultural uses and residential uses if density and coverage requirements are in place.

Trenton Gravel

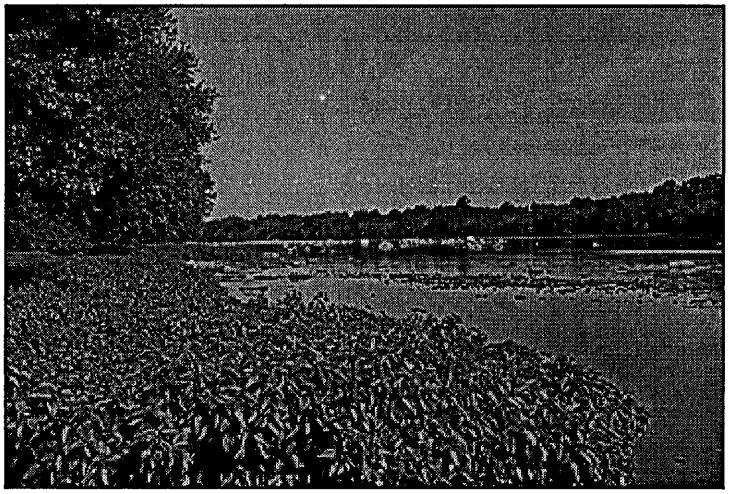
This formation consists of gravelly sand deposits. The bulk of the sand and gravel produced in Bucks County is from this formation in the Yardley-Morrisville-Tullytown area.

Wissahickon Formation (Oligioclase Mica Schist)

The Wissahickon Schist is composed of mica schist, gneiss and quartzite in which the proportions of mica, quartz and feldspar vary from bed to bed. The formation is exposed where Poquessing, Neshaminy, and Queen Anne creeks and their tributaries have cut through the overlying sediments.

Much of the area along the Delaware River is characterized by sand and gravel deposits. These deposits are typical of floodplain areas. Because they are unconsolidated and highly permeable, they can produce high water yields. However, high permeability also makes them vulnerable to groundwater contamination and pollution from the Delaware River.

The varied underlying geologic formations within the study create differing conditions along tributary streams as they flow to the Delaware River. Management practices must differ according to the underlying geology.



The Delaware River near Morrisville

Soils

A majority of the study area has been intensively developed, disturbing the native soils and precluding the use of soils for other purposes. The soils have been obscured, smoothed, disturbed, filled in or destroyed by construction of urban facilities. The four major soils associations within the study area are described in the 1975 USDA Soil Survey of Bucks and Philadelphia Counties.

Urban land-Chester association

This association includes nearly level to sloping, well-drained land types and soils on uplands.

Urban land-Howell association

This association includes nearly level and gently sloping, well-drained land types and soils on terraces.

Alton-Pope association

This association includes nearly level to gently sloping, well-drained soils on terraces and floodplains.

Lansdale-Lawrenceville association

This association includes nearly level to sloping, moderately well drained and well drained soils on uplands.

On the Chester association soils, development occurs mainly on the gentler slopes. These soils are deep, well drained and moderately permeable. Limitations on these soils are stoniness and slope in smaller areas of minor soils.

The Howell association has been developed in similar patterns as the Chester soils. Development occupies all positions within the association, with the soil being deep, well drained, and moderately slowly permeable. Main limitation within the association is restricted permeability in smaller areas of minor soils.

In smaller percentage within the study area is the Alton-Pope association. This bottomland along the Delaware River is subject to droughtiness and flooding. The soils are a good source of gravel and a large extent of the area is utilized for industrial and extraction activities.

Topography on the Lansdale-Lawrenceville association ranges from nearly level to gently sloping in valleys to sloping on ridges. The main limitations on these soils are a seasonal high water table and restricted permeability. Use of this association for industry and housing developments is increasing.

Hydrography

Hydrography is the geographic location of flowing surface water, ponds, wetlands and floodplains. The **Hydrography Map** illustrates the locations of each of these resources. Also indicated on this map are sub-basin boundaries and hydric soils.

The drainage patterns of the study area are determined by the watersheds of the major creeks. By far the largest tributary in the study area is the Neshaminy Creek. As the creek flows in its final stretch to the Delaware, it becomes tidal, with habitats unique to a coastal zone environment. Table 2 lists the major sub-basins and the acreage of each within the study area and its percentage of the study.

Basin Name	Acres	Percent of Study Area
BROCK CREEK	2,557	4%
BUCK CREEK	1,736	3%
CORE CREEK	2,091	4%
DELAWARE RIVER	22,506	39%
DYERS CREEK	542	1%
HOUGHS CREEK	1	1%
MARTINS CREEK	4,235	7%
MILL CREEK	4,303	7%
NESHAMINY CREEK	10,590	18%
POQUESSING CREEK	3,013	5%
QUEEN ANNE CREEK	2,771	5%
ROCK RUN	3,111	6%
Total	**57,456**	**100%**

Table 2 - Sub-Basins

Floodplains

Floodplains cover 11,379 acres or approximately 20 percent of the land area within the study. They serve primarily to accommodate floodwater during periods of heavy precipitation. They also recharge aquifers, create wildlife habitats and provide for recreation access. As development occurs, floodwater levels tend to rise. This happens when more impervious surfaces are built and runoff increases due to its inability to be absorbed back into the soil. Stormwater runoff volumes and velocity increase, and the length of time required for precipitation to become runoff shortens, resulting in larger and more frequent flows. Table 3 indicates the total acreage of floodplain areas and the percentage of the municipality covered by floodplain areas.

Table 3 - Floodplain Area

Municipality	Acres	Percent of Municipality
BENSALEM TOWNSHIP	1,407	11%
BRISTOL BOROUGH	274	22%
BRISTOL TOWNSHIP	2,043	19%
FALLS TOWNSHIP	5,600	33%
LOWER MAKEFIELD TWP	1,089	9%
MORRISVILLE BOROUGH	203	16%
TULLYTOWN BOROUGH	503	38%
YARDLEY BOROUGH	259	40%
Total	**11,378**	**20% of study area**

Hydric Soils

Many of the soils bordering the major creeks are hydric. Hydric soils are important because they often indicate the presence of wetlands, which serve to maintain ecosystem quality. They play a significant role in flood management and water quality. Hydric soils cover 5,721 acres or 10 percent of the study area (Table 4). Using GIS data provided by Penn State University, hydric soil classifications were selected and mapped on the **Hydrography Map**. The hydric soil classifications are outlined in Appendix D with the total area of each indicated for individual municipalities.

Municipality	Acres	Percent of Municipality
BENSALEM TOWNSHIP	1,801	13%
BRISTOL BOROUGH	24	2%
BRISTOL TOWNSHIP	1,004	9%
FALLS TOWNSHIP	1,557	9%
LOWER MAKEFIELD TWP	1,232	11%
MORRISVILLE BOROUGH	34	3%
TULLYTOWN BOROUGH	44	3%
YARDLEY BOROUGH	25	4%
Total	**5,721**	**10% of study area**

Table 4 - Hydric Soil Area

Wetlands

Wetlands are typically areas where groundwater reaches the surface or the land is covered by water. They are commonly called marshes, bogs or swamps, and occur along the Delaware River, its tributaries and ponds. Some wetlands, however, occur in upland areas where groundwater or runoff collects. Wetlands are extremely important to the health of rivers and streams. The values they provide can be grouped into the following categories:

- *Water Quality:* Wetlands act as filters, removing metals, nutrients, toxins, sediment and other pollutants.

- *Fish and Wildlife Habitat:* Hundreds of species of birds, mammals, fish, reptiles, amphibians and invertebrates depend on wetlands for nesting areas, food and cover.
- *Flood Management:* Wetlands act as sponges. They store flood water and decrease the amount and speed of flood flow, thereby reducing downstream property damage.
- *Groundwater Discharge and Recharge:* Wetlands sometimes exist in places where groundwater flows to the surface to recharge streams. Where this occurs, wetlands help maintain stream flow during dry periods. In other wetlands, the flow can be in the opposite direction, replenishing groundwater supplies.
- *Streambank Erosion Control:* Wetland plants decrease the rate of streambank erosion by anchoring the soil with their roots. They also slow water, thus decreasing its ability to erode, and help collect sediment that can stabilize or rebuild streambanks.
- *Recreation and Aesthetic Value:* Wetlands are often beautiful areas frequented by outdoor enthusiasts, hunters and fishermen.

Table 5 - Wetlands Area

Municipality	Acres	Percent of Municipality
BENSALEM TOWNSHIP	1,478	11%
BRISTOL BOROUGH	183	15%
BRISTOL TOWNSHIP	1,449	13%
FALLS TOWNSHIP	3,264	19%
LOWER MAKEFIELD TWP	584	5%
MORRISVILLE BOROUGH	141	11%
TULLYTOWN BOROUGH	239	18%
YARDLEY BOROUGH	58	9%
Total	**7,396**	**13% of study area**

The **Hydrography Map** indicates the estimated locations of protected wetlands, most of which can be found along the Delaware River and its tributaries. Over 7,000 acres, or nearly 13 percent of the total land area, is classified as wetlands (Table 5). Be sure to note, this total includes 2,827 acres of open water in the Delaware River and major tributaries.

It is important to remember that the National Wetlands Inventory (NWI) maps are produced using aerial flyovers done by the U.S. Fish and Wildlife Service. The data has not been confirmed by field surveys and may be incomplete or inaccurate in some instances. A formal delineation will be necessary to confirm the existing data for an individual parcel prior to any proposed disturbance.

Water Quality

The water quality of all streams in this area is protected for warm water fishes. The Delaware River and Neshaminy Creek are also protected for migratory fishes. Previous water quality monitoring conducted by various governmental agencies found surface water quality to range from fair to poor (LDRMP, 1997). Water quality is impacted in the region as a result of residential development, stormwater runoff and agricultural practices.

The USGS is currently conducting a water quality assessment program in the Delaware River watershed. Water quality sampling will be conducted

beginning in 1999. The PA DEP is also currently conducting an unassessed waters program that includes the tributaries to the Lower Delaware River. Results of these studies can be used as a basis for identifying impaired waters and implementing water quality management.

To date, the DEP program has identified impaired water quality in several tributaries of the Neshaminy Creek within Bensalem and Bristol townships. As a result of this and other studies, the Neshaminy Creek watershed is considered a high priority for water quality improvements. The DEP has also determined that water quality of Martins Creek is not impaired, based on biological sampling.

The watersheds of other tributaries to the Delaware River in the study area have not been assessed, to date.

Vegetation

The native vegetation grows in response to the underlying soils, geology and hydrology. The study region is uniquely situated as it is the border between the Atlantic Coastal Plain and the Piedmont Regions.

The Coastal Plain has a considerable southern floral element which gains its entrance northward into this area along the Delaware River. Most of the plants do not occur above the fall line (*The Flora of Bucks County*). Predominant woodland communities occurring in the Coastal Plain include the River Birch-Swamp Maple and Sweet Gum-Willow Oak forests.

The River Birch-Swamp Maple forest is found along the Delaware River and its tributaries. It usually occurs on low-lying tracts and on the floodplains of streams. This forest association is predominantly comprised of hardwoods. Some of the species associated with River Birch-Swamp Maple forest community include:

- Silver Maple (*Acer saccharinum*)
- Red Maple (*Acer rubrum*)
- Box Elder (*Acer negundo*)
- White Oak (*Quercus alba*)
- Swamp White Oak (*Quercus bicolor*)
- Swamp Hickory (*Carya cordiformis*)
- Sycamore (*Platanus occidentalis*)
- River Birch (*Betula nigra*)
- White Ash (*Fraxinus americana*)
- Black Walnut (*Juglans nigra*)
- Red Osier (*Cornus sericea*)
- Various species of Willow (*Salix spp.*)

The Sweet Gum-Willow Oak forest community occurs along the Coastal Plain. Characteristic species of this community include:

- Willow Oak (*Quercus phellos*)
- Sweet Gum (*Liquidambar styraciflua*)
- Laurel Magnolia (*Magnolia virginiana*)
- Common Highbush Blueberry (*Vaccinium corymbosum*)
- Coast Pepperbush (*Clethra alnifolia*)
- Red Chokeberry (*Pyrus arbutifolia*)

The Piedmont region has a much larger proportion of a northern floral element although it is not without a southern element (*The Flora of Bucks County*). The prevailing forest community in Bucks County and found in the Piedmont Region is the Oak-Hickory community. This forest community occurs in valleys and hillsides. The forest includes a greater number of forest tree species than other forest types in the region. Typical species found in an Oak-Hickory forest include:

- White Oak (*Quercus alba*)
- Red Oak (*Quercus rubra*)
- Black Oak (*Quercus velutina*)
- Scarlet Oak (*Quercus coccinea*)
- Pignut Hickory (*Carya glabra*)
- Mockernut Hickory (*Carya glabra*)
- Shagbark Hickory (*Carya ovata*)
- Black Walnut (*Juglans nigra*)
- Sassafras (*Sassafras albidum*)
- Black Birch (*Betula lenta*)
- Tulip Poplar (*Liriodendron tulipifera*)

Significant Resources

Resources both cultural and natural are under intense pressures due to the concentration and continued growth of development and industry in the area. Significant sites continue to be protected through actions at the state, county and local levels. Inventories are ongoing for cataloging rare plant species, and efforts continue to protect sensitive tidal marsh areas such as Bristol Marsh.

Threatened and Endangered Species

Many significant occurrences of sensitive habitats with threatened and endangered species of plants and animals appear within the area. These unique and significant biotic resources have been identified using data obtained from the Pennsylvania Natural Diversity Inventory (PNDI).

Known species and community occurrences (elements) are provided with a one-mile diameter buffer on the **Significant Resources** map. Each point's x- and y-coordinate is offset by a specified distance. In this manner, the buffer encompasses the element location without the location being the actual center of the circle. Locations are offset for two reasons: to ensure

that the species are not exploited and to ensure the privacy of landowners whose land contains rare species.

The rankings used in the inventory are described in Appendix E. Both global and state element rankings are indicated. This system of rankings was developed by The Nature Conservancy and is outlined in the *Natural Heritage Program Operations Manual*.

Many imperiled species are located along the Neshaminy, Martins and Poquessing creeks and the Delaware River. Additional areas containing significant habitats are already protected as open space. Five Mile Woods, Silver Lake, and Bristol Marsh have been protected as open space and provide passive recreation and environmental education opportunities for residents of the area. A short description of these open space areas follows.

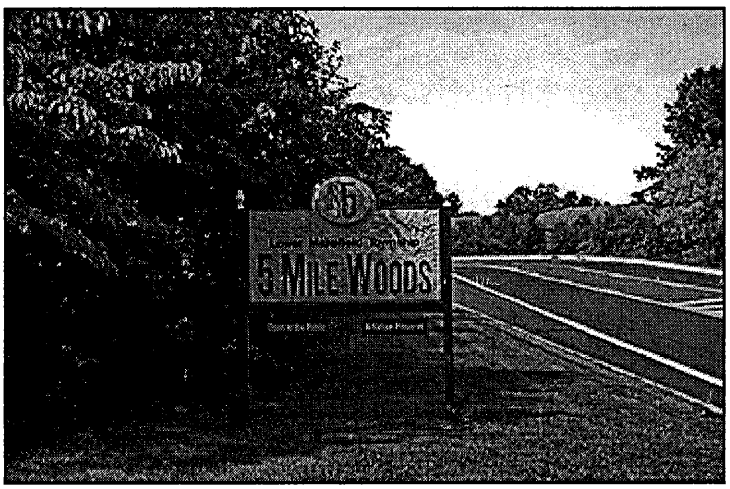
Open Space Resources

Approximately 3,000-3,500 acres, or six percent of the land area is in open space and recreation facilities within the eight municipalities. Properties include state, county, municipal and privately-owned lands. A table of all known facilities is contained in Appendix F.

A few of these areas provide unique recreational opportunities and protect valuable natural resources for area residents. Following are descriptions of selected areas containing significant natural resources in the region.

Five Mile Woods

Five Mile Woods is one of the largest remaining pieces of Coastal Plain forest in southeastern Pennsylvania. The site is important because it contains representative Coastal Plain plants and animals and includes an undisturbed segment of the fall line, the geologic boundary between the Coastal Plain and the Piedmont. The woods is a nature preserve owned by Lower Makefield Township.



Five-Mile Woods in Lower Makefield Township

The woods is considered one of the best examples of a Coastal Plain Forest natural community in Pennsylvania and contains four plant and one animal species of special concern. In poorly-drained areas, the young to mature forest is dominated by a canopy of Red Maple (*Acer rubrum*), Sweet-Gum (*Liquidambar styraciflua*), Beech (*Fagus grandifolia*) and a shrub layer of Sweet Pepperbush (*Clethra alnifolia*). In better-drained areas, beech predominates. Under protection of the township, the

site will continue to provide Coastal Plain flora and fauna with a refuge from surrounding development and to offer educational and recreational opportunities for local residents (TNC 1992).

Delhaas Woods

Delhaas Woods is one of the most important natural areas in southeastern Pennsylvania. The property consists of woods and wetlands crossed by a high tension electrical line. It provides one of the best examples of a Coastal Plain Forest community in Pennsylvania. It is very important because of its size and great diversity. Red Maple (*Acer rubrum*) and Sweet-Gum (*Liquidambar styraciflua*) dominate the canopy, while Blueberry (Vaccinium sp.) and Viburnums (*Viburnum* sp.) dominate the shrub layer. In wetter areas, Willow Oak (*Quercus phellos*) predominates while drier sites support different Oak species (*Quercus* sp.). Past disturbances affecting Delhaas Woods included illegal dumping, hunting, logging and all-terrain vehicle riding. These problems have been drastically reduced within the boundaries of the park owned and managed by the Bucks County Department of Parks and Recreation (TNC 1992).

Bristol Marsh

Bristol Marsh is a preserve owned by the Borough of Bristol and TNC, with a conservation easement on additional land owned by Rohm and Haas. Bristol Marsh provides a good example of a Freshwater Intertidal Marsh community. Pickerelweed (*Pontederia cordata*), Arrow-Arrum (*Peltandra virginica*), Spatter-Dock (*Nuphar luteum*) and Three-Square (*Scirpus pungens*) dominate the central part of the 25-acre marsh. Narrow-Leaved Cattail (*Typha angustifolia*) dominates the marsh edge. Seven plant species of special concern grow within the marsh (TNC 1992).

Silver Lake Park

At Silver Lake Park, owned by the Bucks County Parks and Recreation Department, one finds forested wetlands surrounding emergent marshes dominated by mild Water-Pepper (Polygonum hydropiperoides), Rose Mallow (Hibiscus moscheutos) and Spatter-Dock. Silver Lake, a narrow water body slightly in excess of a mile in length, resulted from damming of Mill Creek just north of the Pennsylvania Railroad's Main Line tracks. Two species of plants and two species of animals of special concern grow within the park (TNC 1992). This county facility provides a nature center and environmental education programming for local residents.

Bristol Marsh

Graystones

Graystones, located in Morrisville Borough, is one of only two remaining old growth woods in Bucks County. The property is also the starting point for the first survey of William Penns's land grant in the 1600s. The steep, wooded property is a unique natural area containing significant geological, botanical, historical and site resources. The property lies adjacent to the Delaware Canal State Park.

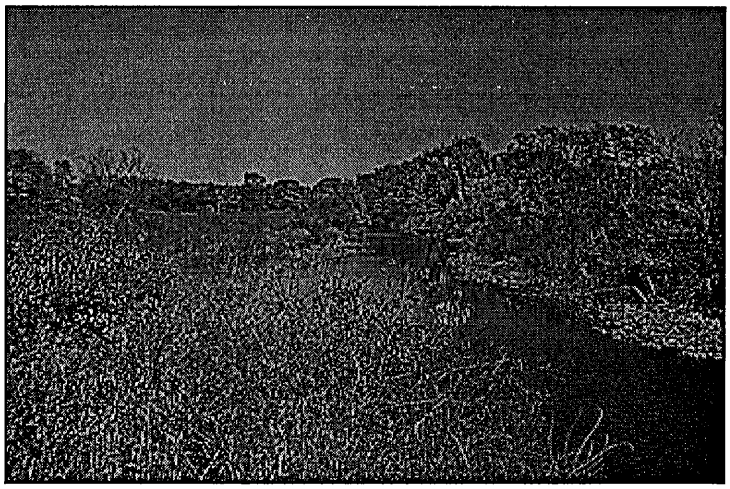
Bristol Borough and Bensalem Township have recently completed open space plans identifying priority areas for conservation and acquisition. Tullytown completed a Comprehensive Recreation Plan in 1981.

Wildlife

Silver Lake Nature Center has provided a listing of faunal species occurring in the area. This listing is based on known geographic ranges and habitat preferences and includes a limited number of documented identifications. Following is a summary of the listing; the complete listing is contained in Appendix G. The work was compiled by George Carmichael around 1990.

Mammals

Most mammals are nocturnal but Cottontail Rabbits, Woodchucks and Gray Squirrels are frequently encountered on trails or attracted to bird feeders. Opossums, Raccoons and Norway Rats have been observed raiding feeders at night. Deer are attracted to fallen apples in the old orchards and have ventured from Delhaas Woods. Bats are often observed but are difficult to identify in the field. Bats tend to migrate and wander far from breeding areas, so any eastern species might occur. Confirmed mammal species include: Northern Short-tailed Shrew, Eastern Mole, Star-nosed Mole, Little Brown Myotis, Big Brown Bat, Red Bat, Hoary Bat, Eastern Cottontail, Woodchuck, Gray Squirrel, White-footed Mouse, Meadow Vole, Muskrat, Norway Rat, Meadow Jumping Mouse, Red Fox, Gray Fox, Raccoon, Mink, Striped Skunk and White-tailed Deer.



Silver Lake Park

Birds

Birds are usually the most conspicuous and familiar animals and the best recorded group of wildlife. Among the most mobile animals, the species populations not only shift from season to season and year to year, but they are less confined to specific habitats. They are often opportunistic feeders (thus easily attracted by artificial feeding) and often are observed out of expected habitat if a food source becomes available

there. Despite this, each species is remarkably predictable, both as to season and habitat. Following is a sample listing of known or probable breeding species in Silver Lake Nature Center.

Open Wetlands:
Canada Goose, Mallards, Wood Duck, American Woodcock, Eastern Phoebe, Willow Flycatcher, Yellow Warbler, Northern Yellowthroat, Red-winged Blackbird, Swamp Sparrow and Song Sparrows.

Forest and Forest Edge:
Residents - Mourning Dove, Great Horned Owl, Eastern Screech Owl, Red-bellied Woodpecker, Downy Woodpecker, Hairy Woodpecker, Blue Jay, American Crow, Tufted Titmouse, Carolina Chickadee, White-breasted Nuthatch, Carolina Wren, Northern Cardinal, Rufous-sided Towhee, Brown-headed Cowbird and Common Grackle

Migrants - Yellow-billed Cuckoo, Great Crested Flycatcher, Eastern Wood Peewee, House Wren, Wood Thrush, Veery, American Robin, Gray Catbird, Brown Thrasher, Red-eyed Vireo, Ovenbird, Rose-breasted Grosbeak and Northern Oriole

Fields and Old Fields:
Field Sparrow, American Gold Finch and Indigo Bunting

Human-made Structures/Environments:
European Starling, House Sparrow, Barn Swallow, House Wren, House Finch and Chipping Sparrow

Reptiles

This group of animals tends to be secretive and, even when abundant, may seldom be seen. Documented species include: Common Musk Turtle, Common Snapping Turtle, Eastern Box Turtle, Painted Turtle, Red-eared Slider *(alien species competing with the Redbelly Turtle)*, Redbelly Turtle, Eastern Garter Snake, Northern Water Snake and Northern Black Racer.

Blue Heron along the Delaware Canal

Amphibians

Amphibians are dependent on water for breeding. The destruction of wetlands, especially the small, fishless often temporarily wet areas have restricted populations. Documented species: Northern Red Salamander, Redback Salamander, American Toad, Fowler's Toad, Northern Spring Peeper, Wood Frog, Bullfrog, Green Frog and Coastal Plain Leopard Frog.

Additional information regarding fish and invertebrates is included in Appendix G.

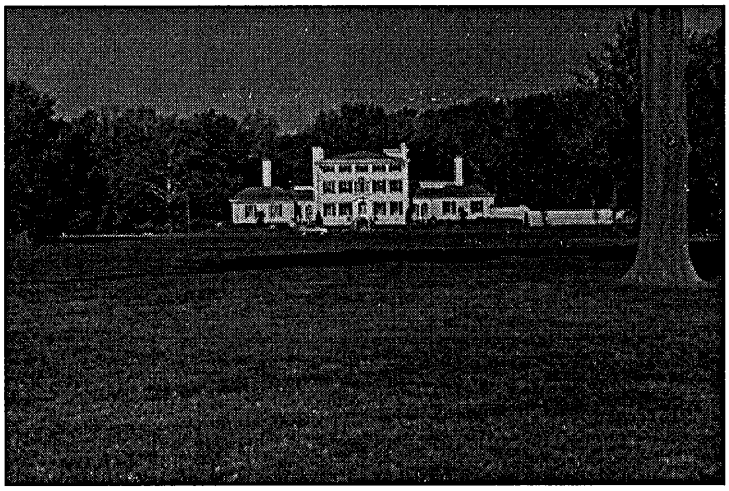
Cultural, Historical and Archeological Resources

The following resources were edentified in the Lower Delaware region: those designated as National Historic Landmarks; those listed on the National Register of Historic Places; those deemed eligible for listing on the National Register of Historic Places through an official review and additional properties which Heritage Conservancy staff felt were significant but which have never been reviewed for state or national designation.

The NPS maintains an official list of properties worthy of preservation called the National Register of Historic Places. This list includes properties that are significant to the nation, state or community which have been nominated by state or federal agencies and have been approved by NPS. In the course of various state or federal programs, government agencies must seek a "determination of eligibility" for listing on the National Register so that they are not adversely impacted.

Listing on the National Register is not the highest historic designation a resource can achieve. For properties deemed important to the history of the United States there is the National Historic Landmark listing. National Historic Landmark resources in the study area are:

- Delaware Division of the Pennsylvania Canal which passes through Lower Makefield Township, Yardley Borough, Morrisville Borough, Falls Township, Tullytown Township and Bristol Township before terminating in Bristol Borough.
- Andalusia, Bensalem Township
- Summerseat, Morrisville Borough



Pen Ryn in Bensalem Township, property on the National Register of Historic Places

Following is a discussion of the cultural resources within each of the eight municipalities.

Bensalem Township

A comprehensive survey of historic resources was completed by Heritage Conservancy for the Bensalem Historical Society and the Township of Bensalem over the winter of 1994 - 1995. The Historic Sites Survey of Bensalem revealed a large number of historic resources from the eighteenth, nineteenth and early twentieth century. The most dramatic of these historic buildings were the series of mansions located along the Delaware River. The river front portion of Bensalem, from Philadelphia County to Bristol Township, revealed the impact of

Bensalem's proximity to the city of Philadelphia and the industrial potential of the Delaware River. On one hand, its location prompted the construction of many mansions in the eighteenth and nineteenth centuries. Bensalem has the finest collection of large, elegant "country seat" types of houses in the county. On the other hand, its prime location attracted industrialization and suburbanization in the twentieth century. As such, it represents the finest and saddest examples of the story of historic buildings in Bucks County.

The collection of river front properties from the Dell to the south through the Andalusia complex to the Pen Ryn property is one of the county's most outstanding collections of houses and would seem to be the most significant area in the township and worthy of listing on the National Register of Historic Places.

Properties in Bensalem on the National Register of Historic Places are:

- Andalusia, State Road
- Belmont, 3779 Bristol Road
- Little Jerusalem (Bensalem) A. M. E. Church, 1200 Bridgewater Road
- Pen Ryn, State Road
- St. Elizabeth's Convent, 1663 Bristol Pike

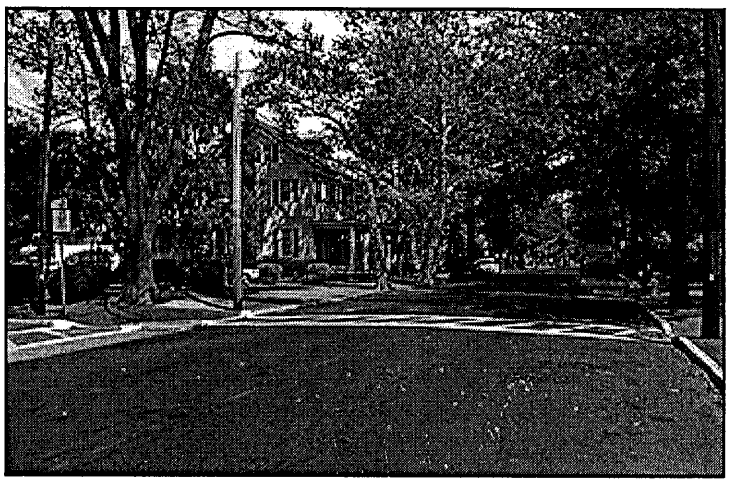
Properties in Bensalem that have received a "determination of eligibility" for listing in the National Register of Historic Places are:

- Belmont, 3779 Bristol Road (subsequently listed on National Register)
- Allen Family Cemetery, Vandegrift Lane
- Bensalem Public School, 3462 Bristol Pike

Bristol Borough

Bristol Borough has four National Register Historic Districts and a locally ordinanced historic district as well. The National Register districts are as follows:

- Bristol Historic District
- Bristol Industrial Historic District
- Harriman Historic District
- Jefferson Land Company Historic District



Historic District in Bristol Borough

During the last quarter of the nineteenth century and the first quarter of the twentieth century, Bristol was an important industrial center. A number of resources from this era have been listed on the National Register. These include:

- Bristol Carpet Mills (demolished), Beaver Dam Road
- Dorrance Mansion, 300 Radcliffe Street
- Grundy Mill Complex, Jefferson Ave. & Canal Street
- Jefferson Avenue School, Jefferson Ave. & Pond Street

Other properties have been deemed eligible for the register:

- Bristol Post Office, Prospect & Beaver Streets
- Bristol Railroad Station, Washington Street
- Frank Bell House, 824 Radcliffe Street

Bristol was the terminus of the Delaware Division of the Pennsylvania Canal which operated from 1832 until 1932. Unfortunately, most of the canal related resources, ie. locks, locktenders' houses and the canal basin have not been preserved. There is a lot of effort from the Grundy Foundation, D & L Heritage Corridor, the borough and other groups to help Bristol with heritage tourism issues. National Register nomination is ongoing for the Bristol Train Station.

Bristol Township

This area has not had any comprehensive historic site surveys completed. There seem to be a number of early twentieth century housing developments, ie. Croyden and Edgely which may have potential historic districts, as well as a few isolated eighteenth and nineteenth century resources. There was an effort to have Newportville placed on the National Register, but this never was completed. A reconnaissance level historic sites survey of the study area was completed as part of this project.

The only extant resource listed on the National Register in Bristol Township is the Burlington-Bristol Bridge over the Delaware River. The central core of "White Hall of Bristol College" which was listed on the register was demolished due to its poor condition. The most significant resources identified within the study area in Bristol Township were:

- Alexander Graydon House, Coates & Pitt Avenue
  parcel 05-74-160
- Shadyside, 6934 Radcliffe Street
  parcel 05-78-052-003
- Bloomsdale Ferry House, 6206 North Radcliffe Street
  parcel 05-68-34

Falls Township

Falls Township has historic associations spanning the entire recorded history of Bucks County. It is one of the key townships in the early settlement of the county by European settlers. It is closely associated with William Penn and Pennsbury Manor which has been declared eligible for the National Register.

Much of Falls Township's history revolves around transportation. Its location at the "falls", which gave the township its name, marks the

northernmost point of river travel to the ocean. In the nineteenth century, the canal, railroads and trolleys influenced growth.

Important changes in the early 20th century affected the township and the entire region. The Starkey and King farms were important, large scale truck farms that served the entire East Coast. The Warner and Van Sciver companies operated gravel quarries that literally changed the face of the township.

The cultural landscape was forever changed with post World War II industrialization and suburban growth. TheU. S. Steel plant and the giant residential developments of Fairless Hills and Levittown represent changes of national significance which, as they are now reaching the fifty year period generally required to be considered historic, are potential historic resources worthy of documentation and preservation.

Lower Makefield Township

The portion of Lower Makefield which is included within the study area has become highly suburbanized in the post World War II era. Prior to this time, the river front areas of the township, particularly in areas north and south of Yardley Borough, were developed in the early twentieth century and a number of large houses and small bungalows were constructed. The National Register resources in the study area are:

- Slate Hill Cemetery, Yardley-Morrisville Road
- Delaware River Railroad Bridge south of Yardley

Morrisville Borough

Morrisville has a large number of late nineteenth/early twentieth century historic resources, but there seems to be no central downtown to give the area any cohesiveness. It has several significant individual properties such as Summerseat which is a National Historic Landmark, the highest historic designation. This area is being studied as part of the Canal Towns project.

Cultural resources listed on the National Register are:

- Summerseat, Hillcrest & Legion avenues
  Parcel 24-09-107-1
- Calhoun Street Bridge
- Pennsylvania Railroad Bridge
- Gershom Craft House, 105 Barnsley Avenue
  Parcel 24-03-102

Among the other individually significant sites are:

- 1894 pumphouse at Trenton and Delmorr avenues
- Gray Stones marker (location of first Penn land survey and first treaty with Lenni Lenape)
- Ferry House, South Delmorr Avenue

- Morrisville Grove (19th century farmhouses) between Gallen and Moreau
- Victorian house at Harrison & South Pennsylvania avenues
- "Trenton Makes" bridge

Tullytown Borough

Tullytown is a small borough located on what was once a portion of Pennsbury Manor. In the late eighteenth century, Thomas Riche began selling small lots in what he called Riche-town, apparently a sort of early real estate development plan.

The site developed in the nineteenth century as a stopping point for stages traveling from Philadelphia to New York. Passengers transferred to steamboats at this point to finish the trip south on the river. The village got its first post office in 1829 and continued to grow in the 1830's and 1840's when Thomas Headley and his son Joseph sold a number of lots there. Tullytown became a separate borough in 1891.

There is a collection of historic resources along Main Street (Fallsington Avenue) and Brown Street which warrant designation as a historic district. As part of a Determination of Eligibility study completed March 6, 1985, a number of individual properties were designated as being National Register eligible. These were as follows:

- 742 Brown Street
- 749 Brown Street
- 755 Brown Street
- 51 Fallsington Avenue
- 73 Fallsington Avenue
- 75 Fallsington Avenue
- 100 Fallsington Avenue
- 112 Fallsington Avenue
- 129 Fallsington Avenue

Among the other individually significant buildings are:

- Tullytown Methodist Episcopal Church, 465 Main Street
  Parcel 46-13-01
- The William Shafer House, 412 Main Street
  Parcel 41-12-71

Yardley Borough

Yardley is a well preserved town that was established early in the eighteenth century. It was the site of an early grist mill and a ferry crossing. In the early nineteenth century the town received a boost when a bridge was constructed across the Delaware River. The canal also directly influenced the growth of the town.

The Yardley Historic District, encompassing the majority of the center of the borough including North & South Main Streets, East & West Afton

Avenues and some of the side streets along the canal, has been declared eligible for the National Register.

There are a number of individually significant properties as well, including:

- The old Ferry House along the Delaware River near Letchworth Avenue
- The Yardley Mansion "Lakeside" across from Lake Afton

Archaeological Sites

The river front area of Bucks County has been inhabited for at least 11,000 years. There are a number of locations within the study area that are prehistoric or historic places of habitation. Due the ongoing development of the area, most of these habitation sites have undergone disturbance. In more recent years, archaeological study surveys were completed prior to state or federally funded projects. Pennsylvania Archaeological Survey Site (PASS) forms have been completed for many of the sites. These include:

- 91-0804-017 study, Bensalem Township
- 36BU211 Neshaminy State Park site, Bensalem Township
- 94-1057-042 study, Bensalem and Bristol Township
- 93-3944-017 study, Bristol Borough
- 85-0080-017 study, Bristol Township
- 84-1708-042 study, Bristol Township
- 36BU19 Pennsbury Manor site, Falls Township
- 36BU198 Nineteenth century site, Falls Township
- 84-0822-017B study, Falls Township
- 84-1708-042 study, Falls Township
- 88-1269-017 study, Falls Township
- 36BU44 Paleo-Indian Clovis Point site, Lower Makefield Township
- 36BU216 Summerseat historical archaeological site, Morrisville Borough

Delaware Canal

The Delaware Canal was constructed between 1827 and 1832 to transport coal from the Upper Lehigh Valley to Philadelphia, Pa., New York and the eastern seaboard. During its century of operation, the canal played a key role in the development of the anthracite industry in northeastern Pennsylvania and the flow of commerce to communities along its route. In 1940, the Lehigh Canal and Navigation Company turned the canal over to the Commonwealth to be used for recreational, natural and historic purposes.

The Delaware Canal is the only remaining continuously intact remnant of the canal era that took place during the early to mid 19th century. The canal runs 60 miles from Easton to Bristol. It traverses through historic villages, farmland and forested lands along the Delaware River north of

New Hope. To the south, the canal follows a more populated inland course through lower Bucks County. The towpath is an earthen hiking-bicycling trail linking communities and providing access to the canal's important historic heritage.

The entire Delaware Canal is a Registered National Historic Landmark, and the towpath has been designated a National Heritage Hiking Trail. In conjunction with the Lehigh Canal, it is the backbone of the Delaware and Lehigh National Heritage Corridor and State Heritage Park (PA DCNR 1997).

Recreation and Open Space

Approximately 3,400 acres, or 6% of the land in the study area are used for recreation and open space. Appendix F identifies specific recreation and open space facilities in the area internally as well as externally. The region is facing issues regarding increased river access, a need for trails and active recreation facilities.

Delaware River Access

While many recreational activities have been provided for, there remains a limited number of access areas to the Delaware River. The following are the only developed public access sites in the eight municipalities:

- Yardley Access in Lower Makefield just north of Yardley Borough
- Falls Township River front Park adjacent to Pennsbury Manor (adjacent to the river but no fishing or boating access)
- Neshaminy Creek State Park in Bensalem Township
- Delaware River Access Area near Pen Ryn

A number of informal areas are used by local residents where they are able to park safely and walk along the river (e.g. in Morrisville south of Route 1 and near the Waterworks). In addition, six private marinas are located on the Delaware River and two along Neshaminy Creek.

Trails

Existing trails and proposed trail plans provide important recreational opportunities for local residents and visitors alike. Existing trails include the Delaware Canal Towpath Trail which begins in Bristol Borough and continues north for 60 miles ending in Easton, Pa. This trail provides a spine connecting local recreation facilities and trails into a regional network.

Planning is underway for two significant regional trail networks that would link the Lower Delaware River region with surrounding communities and link the region to an Atlantic Coast Trail Network.

The NPS in partnership with local representatives is proposing a Delaware River Heritage Trail. The trail would create a multiuse pathway as close

to the shores of the Delaware River as possible. The trail will connect communities with parks, historical sites and natural assets. The trail will be planned as a loop, extending from Morrisville to Philadelphia in Pennsylvania and Trenton to Palmyra in New Jersey, crossing the river via the Tacony-Palmyra and Calhoun Street bridges.

In addition, the East Coast Greenway Alliance is locating a trail route through the region to link an urban trail route along the entire East Coast. Preliminary work has begun in Philadelphia and connections in the Lower Delaware River region are being determined.

Open Space Planning

Bucks County has established a County Open Space Program designed to provide funding to support the permanent protection of open space.

This fast-growing county has lost some 5,000 acres of open space each year to development over the past decade. The county projects that this pace will continue for the next 20 years.

The Bucks County Commissioners are committed to balancing development pressure with an open space preservation program that will protect the rural heritage of the county. Acting on recommendations of their Open Space Task Force and the overwhelming (71 percent) voter approval of a $59 million bond issue in the May 1997 election, the commissioners are taking steps to implement a 10-year Open Space Program. The steps include:

- Guidelines for municipal open space plans, municipal acquisition programs and development plans
- A countywide natural areas inventory to identify and prioritize important natural sites that need to be protected
- Appoint a citizen, nine-member Open Space Review Board
- Issue a $35.9 million bond issue for the initial phase of activity, to be followed by two additional issues over the next seven years, totaling up to $59 million

The county program has been structured into four programs - farmland preservation, county parks and greenways preservation, natural areas protection, and a municipal grant program (Bucks County Municipal Open Space Program Guidelines, 1997).

Land Use and Economic Development

The **Land Use Map** indicates the general coverages of land uses. Data was obtained from Bucks County Planning Commission. Table 6 identifies total acreage and percent of study area within each land use classification. Land use acreages for each municipality are outlined in Appendix D, Mapping data calculations.

Table 6 - Land use Area and Percent Coverage

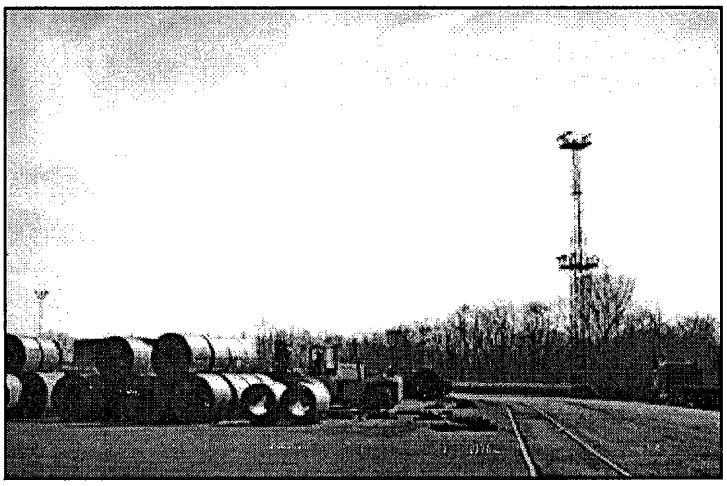
Land Uses	Acreage	Percent of Study Area
AGRICULTURAL	3,146	5.8%
COMMERCIAL	343	6.3%
GOVERNMENT & INSITUTIONAL	3,118	5.7%
MINING & MANUFACTURING	7,227	13.2%
MULTI-FAMILY RESIDENTIAL	1,484	2.7%
PARKS,REC, & OPEN SPACE	3,486	6.4%
RURAL RESIDENTIAL	1,214	2.2%
SINGLE-FAMILY RESIDENTIAL	16,948	31.0%
TRANSPORTATION & UTILITIES	4,279	7.8%
VACANT, NO DATA	7,812	14.2%
WATER	2,552	4.7%

Source: Bucks County Planning Commission

The major land use within the study area is for single-family residential homes which cover nearly one-third of the land area. Also, important to note is the large percentage of area used for mining and manufacturing. Land use in the region has been determined in large part to be economic and industrial development.

Industry

Attracted by the shipping channels of the Delaware River to move raw materials and finished goods, numerous industries have located in the region. Most notably is the Fairless Works, built by U.S. Steel. The operation was constructed on nearly 4,000 acres of land in Falls Township. Activity peaked in 1973 when nearly 10,000 people were employed. Since that time the operations have declined and recent announcements indicate that remaining operations will be shut down in the near future. The area will be hard hit economically, however, the closure is becoming an impetus for planning efforts and attracting new industry to Falls Township.



USX facility along the Delaware River in Falls Township

Landfills

Landfill operations have been ongoing in the region since the early 1970's. Operations continue in Falls Township and Tullytown Borough.

The Warner Company, through its subsidiary Geological Reclamation Operations and Waste Systems, Inc. (G.R.O.W.S.), was issued permits to operate a 46-acre solid waste disposal facility at Bordentown and New Ford Mill Roads in August 1970. The G.R.O.W.S subsidiary was sold to Waste Management, Inc. which continues to operate this company today.

Over the years the facility was expanded with the largest expansion occurring in 1989 when development began on an additional 160-acres. The facility has now exceeded 230 acres.

Waste Management also operates the Tullytown Landfill in Tullytown Borough. This landfill was approved in the mid-1990's to expand operations to include an additional 153.4 acres, 113 of which will be in Falls Township. In total the operation is expected to cover nearly 273 acres.

The operations of the landfills have required mining of nearby lands to provide the necessary base and cover materials. Lands including Turkey Hill and the Penn Warner Tract at New Ford Mill and Tyburn Roads, as well as other sites, have been mined. The land mining in conjunction with a high water table has resulted in the creation of numerous lakes which dot the region.

Transportation

A variety of transportation networks transect the study region. These networks include highways, rail lines and a deep water port on the Delaware River.

Arterial and secondary highways crossing the region include Interstate 95, Pennsylvania Turnpike (I-276), the U.S. Route 1 Bypass, U.S. Route 13, and Tyburn Road, as limited access highways.

- I-95 is the primary north/south transportation link along the East Coast.
- The Route 1 Bypass extends from the Pennsylvania Turnpike (I-276) in Bensalem Township north to New Jersey. The highway serves regional transportation needs.
- Route 13 extends through the region as a four lane limited access highway.

G.R.O.W.S. Landfill in Falls Township

CONRAIL, SEPTA and Amtrak rail lines serve communities in the study region. A number of major industrial parks are served by rail. In addition, CONRAIL operates a large intermodal switchyard in Falls Township. This facility allows for the transfer of cargo from truck to rail car, and vice versa.

The Port of Bucks County is situated approximately 21 nautical miles North of Philadelphia on the Delaware River below Trenton, N.J. The port serves the USX Industrial Park site at the USS Fairless Works in Falls Township. The port is privately operated by the Port of Bucks County.

The Pennsylvania Turnpike Commission (PTC), in conjunction with the Pennsylvania Department of Transportation (PennDOT) and the Federal Highway Administration (FHWA), is conducting a study of a proposed connection between I-95 and the Pennsylvania Turnpike (I-276) and redesignating sections of both the Pennsylvania and New Jersey turnpikes as I-95. The study area extends approximately nine miles along I-276 from a point west of Interchange 28, across the Turnpike bridge over the Delaware River to the New Jersey Turnpike Authority Toll Plaza in Florence Township, Burlington County, New Jersey. The study also includes three miles along I-95 between the terminus of Reetz Avenue in Middletown Township and the east bank of Neshaminy Creek.

The project has three components: the mainline toll plaza section; the interchange section along I-95 and I-276; and the Delaware River bridge section. A new I-276 mainline toll plaza is required since the free flowing movement of traffic through the interchanges requires the PTC's ticket system to be relocated to west of the proposed interchange. The interchange includes associated widening of I-276 and I-95 and is necessary since it is the only reasonable transportation alternative that adequately addresses the project needs. An additional Delaware River bridge structure that parallels the existing bridge is needed to accommodate widening of the PA Turnpike (future I-95).

The I-95/PA Turnpike Interchange Project has completed the first five steps of a 10-step process. The completed steps involved preparation of a Needs Report, a Congestion Management Systems Analysis, a Major Investment Analysis, a Preliminary Alternatives Analysis and a Detailed Alternative Analysis. The project is currently in Step 6 of the process, preparing a Draft Environmental Impact Statement (DEIS).

The DEIS is scheduled to be released in late 1999 for review and a formal comment period. The DEIS will assess the impacts, both environmental and socioeconomic, of the alternatives proposed for construction. The Final Environmental Impact Statement (FEIS) is scheduled for completion in late 2000.

The extensive public involvement process has been underway for the project, including the establishment of a Community Advisory Committee. Concerns have been raised regarding the economic impacts of the project on local communities. Bristol Township has taken a position to oppose the project due to the displacement of residences and businesses. In addition, how the project would benefit or cost the local communities' tax bases is a major priority to municipalities of the region.

The environmental impacts of the design alternatives are an important issue as well. Widening of I-276 will impact Silver Lake County Park and also impact a number of local wetland areas. Any impacts to environmentally sensitive areas must be minimized whenever feasible and if impacts are unavoidable, steps must be taken to mitigate damages.

Economic Development

Development in the region has concentrated in the vicinity of Routes 1 and 13, I-95, the Pennsylvania Turnpike, and in and around the commercial cores of Oxford Valley and Bensalem and industrial areas of Falls and Bristol townships. Nonresidential development in this region could be attributed to such factors as: a large population base; proximity to major urban/suburban markets in both Pennsylvania and New Jersey; good transportation network; access to major regional markets; widespread availability of water and sewer; and possibly lower land prices relative to surrounding areas on both sides of the Delaware (Bucks County Nonresidential Development 1989-1994).

Lower Bucks is the most urbanized region in the county. This condition can be attributed to several factors including concentrations of industry in the region, the construction of the Levittown and Fairless Hills subdivisions in the late 1950s and development pressures spilling over from the Philadelphia and Trenton areas (Bucks County Continuum).

The economy of the region has been influenced by the Delaware River. Historically large employers have been industries relying on transportation of raw materials and finished goods in the navigable portions of the river. The region contains the largest overall percentage of mining and manufacturing acreage in Bucks County. The region is intensely developed (nearing 70%). Those areas not currently developed are limited and much of the remaining land is either restrictive natural resource areas or idle/vacant lands left over from manufacturing operations. With extensive transportation and infrastructure, development is expected to continue throughout the region although at a lower rate than in the past. As open space for development becomes scarce and various areas reach build-out capacity, growth will decrease significantly. With minimal land left for development, potential future growth will be linked to infill, adaptive reuse, and redevelopment in urbanizing areas along with improvements and upgrades in infrastructure (Bucks County Continuum, BCPC). The economic atmosphere is changing. Large industries continue to downsize while the small industry and service sectors of the economy are growing.

Bucks County Enterprise Program

Bucks County, through the Planning Commission, has established an Enterprise Zone Program to assist financially disadvantaged communities in the preparation and implementation of business development strategies within municipal enterprise zones in order to increase both the quantity and the quality of available job opportunities. The enterprise zone includes five municipalities all within the Lower Delaware River Conservation Plan study. The municipalities include: Bristol Borough, Bristol Township, Falls Township, Morrisville Township and Falls Township. Portions of these municipalities totaling 15 square miles (35 percent of the total land area) are within the Enterprise Zone.

The Enterprise Zone provides opportunities for the communities to compete for a variety of grant opportunities to stimulate business and additional public sector investment for implementation of the business development strategy. Examples of grant programs include: Business Infrastructure Development Program (BID), Employment and Community Conservation Program (ECC), Customized Job Training (CJT) funds, Pennsylvania Industrial Development Authority (PIDA) funds, Transportation Assistance, Neighborhood Assistance Program (NAP), Enterprise Zone Tax Credit Program (EZTC), and Pennsylvania Minority Business Development Authority Act loans.

Zoning

Zoning analysis reflects the compatibility of current use designations with other area activities and natural characteristics. The generalized **Zoning Map** shows the current zoning in the eight municipalities. The data was obtained from the Bucks County Planning Commission, combining all municipal zoning into a generalized form. The information primarily dates from the mid-1990's.

Table 7 - Zoning Area and Percent Coverage

Generalized Zoning	Acreage	Percent of Study Area
M-1 - MIXED USES	12,037	22.0%
R-4 - RES - >4 DU/AC	9,438	17.2%
R-3 - RES - 2 DU/AC TO 4 DU/AC	8,884	16.2%
R-2 - RES - 1 DU/AC TO 2 DU/AC	6,743	12.3%
R-1 - RESIDENTIAL - <1 DU/AC	6,316	11.5%
C-3 - COMMERCIAL COMBINED	3,564	6.5%
I-2 - HEAVY INDUSTRIAL	2,815	5.1%
I-3 – EXTRACTION	1,632	3.0%
OPS - OPEN SPACE	1,288	2.4%
IST – INSTITUTIONAL	1,005	1.8%
I-1 - LIGHT INDUSTRIAL	904	1.7%
C-1 – RETAIL	92	0.2%
C-2 – OFFICE	30	0.1%

Source: Bucks County Planning Commission

The pie chart **Zoning Districts as Percent of the Study Area** (shown on the Zoning Map), generated from the GIS database, clearly illustrates the high percentage of zoned residential areas and mixed uses. Residential zoning classifications cover 57 percent of the study area with higher density zoning (greater than 2 DU/AC) covering 33 percent of the area. Mixed uses occupy 22 percent of the area. This combined classification identifies areas where three or more uses are intermingled or in close proximity to one another. Important to note is that a large area of industrial and extraction activity is indicated as mixed use zoning as well as smaller borough areas where multiple uses intermingle in a village atmosphere.

Ordinances

Zoning ordinances are in effect for all of the eight municipalities in the study area. Development impacts on the river and tributaries are regulated primarily through floodplain and stormwater management ordinances with varying degrees of limitations. These ordinances regulate construction in flood-prone areas, restrict grading modifications to and obstruction in the floodplain, and require protection and/or floodproofing for any uses that do occur in flood-prone areas. Table 8 indicates types of ordinances in effect for municipalities within the study area.

Table 8 - Municipal Conservation Ordinances

Protective Ordinances	Bensalem Twp	Bristol Borough	Bristol Twp	Falls Twp	Lower Makefield Twp	Morrisville Borough	Tullytown Borough	Yardley Borough
Floodplain Ordinance (within 100 year)	Y	Y	Y	Y	Y	Y	Y	Y
Floodplain Ordinance (floodplain fringe)	N	Y	Y	N	N	Y	Y	Y
Floodplain Soils / Alluvial Soils Ordinance	Y	N	N	N	Y	N	N	Y
Steep Slope Ordinance	Y	N	N	Y	Y	Y	N	Y
Wetland Ordinance	Y	N	N	Y	Y	Y	N	Y
Wetland Margin Ordinance	Y	N	N	N	Y	N	N	Y
Woodlands Ordinance	Y	N	N	Y	Y	Y	N	Y
Lakes/ Ponds/ Watercourses Ordinance	Y	N	N	N	Y	Y	N	Y
Lakes/ Ponds/ Watercourses Margin Ordinance	N	N	N	N	Y	N	N	Y
Erosion and Sedimentation Controls	Y	Y	Y	Y	Y	Y	N	Y
Stormwater Runoff Controls/Mngmnt Plan	Y	Y	Y	Y	Y	Y	Y	N
Critical Wildlife Habitat Protection	N	Y	N	Y	Y	N	Y	Y
Rare Plant Communities Protection	Y	N	Y	N	Y	N	N	N
Historic Districts Ordinance	N	Y	N	Y	Y	N	N	Y

Source: Bucks County Planning Commission, Municipal Natural Resource Protection Summary accompanying the Bucks County Natural Resource Plan

Bensalem Township

The zoning ordinance for Bensalem was adopted in June 1996 and last revised in January 1998. Protection and conservation of natural resources have been provided for in the zoning ordinance through an overlay classification. "The Natural Resource Preservation district (NRP) endeavors to preserve and protect environmental resources unique to the district,....while permitting, to the extent possible, a reasonable use of land in a manner consistent with other applicable district classifications." The primary areas of concern include:

- woodlands
- wetlands

- significant natural features (e.g. critical wildlife habitat, rare plant communities and significant geologic sites)
- floodplain areas
- steep slopes (greater than eight percent)

Bristol Borough

In 1996, Bristol Borough last amended their zoning ordinance passed in 1989. The borough has provided for natural resource protection through a Conservation District. The purpose of this category "is to prescribe a zoning category for those areas where, because of natural geographic factors and existing land uses, it is considered feasible and desirable to conserve open spaces, water supply sources, woodland areas, wildlife and other natural resources." Uses permitted by right include: parks, recreation, historic and conservation areas.

In addition to the Conservation District, the borough has enacted a number of "Environmental Protection" regulations. These regulations include: environmental protection requirements, development along waterbodies, alluvial soils areas, floodplain regulations and others.

Bristol Township

Bristol Township uses Floodplain District overlays for public protection from flood events. Three categories, the floodway, flood fringe, and the approximated floodplain districts, are determined using Flood Insurance Study data. Activities within these areas are regulated to prevent restricting the floodplain area and pollution.

Falls Township

The primary tools restricting development on sensitive areas are a series of floodplain districts overlays with associated regulations. These areas include the 100-year floodplain and are delineated based upon the Flood Insurance Study prepared by the Federal Insurance Administration. The districts include:

- the floodway district (FW)
- the flood-fringe district (FF)
- the general floodplain district (FA)

Also, outlined in the zoning ordinance are requirements for Impact Studies including environmental impacts and restrictions on river front uses within 100 feet of the mean high-tide line of the Delaware River.

Lower Makefield Township

Lower Makefield has enacted numerous protection regulations that "provide for the protection and preservation of the natural resources within the township." Also of significance is a primary objective to "preserve prime agriculture and farmland." The township is the first in the study area to enact a detailed wetland buffer ordinance. As indicated in Table

8, the various ordinances provide protection for nearly all types of significant resource areas (e.g. natural resource areas, wetlands, floodplains and the Delaware Canal). No single tool, but a combination of protective regulations, provide for future community development while protecting and preserving natural resources and farmland. The ordinance was updated last in February 1998.

Morrisville Borough

The borough's ordinance was last amended in 1993. Environmental protection is controlled through performance standards. Areas to be documented prior to development include: floodplains; open waterways; steep slopes; forests; and lakes, ponds, wetlands or marshes. Standards for development in these areas are outlined in the ordinance as well as standards for tree protection zones and the design, maintenance, ownership and administration of open space areas.

An impact statement is required when submitting a petition for a change in zoning. Included in this statement are environmental impacts documenting stormwater runoff, erosion, scenic areas and the general amenities of the community. Morrisville is currently updating their zoning ordinance and will include recommendations from this plan in the update.

Tullytown Borough

The zoning ordinance for Tullytown was prepared in 1974 and was most recently amended in 1990. Protections for significant areas are primarily found in the regulations for floodplain areas. The municipality has defined floodway, flood fringe and approximate floodplain district areas. As in Falls Township, determinations are based upon the National Flood Insurance Program studies. Regulations prevent changes to floodplain areas which diminish the flood-carrying capacity of a waterway to prevent an increase in flood levels within Tullytown during a 100-year flood event.

Yardley Borough

The borough has provided for resource protection by enacting natural resource protection standards. These standards regulate any changes made to, or uses proposed for, the following areas:

- floodplains
- steep slopes
- woodlands
- streams, watercourses, wetlands, lakes and ponds
- wetland margin
- lake or pond shorelines

Permits are required for activity on any site containing one of the above resources. Standards are in effect for these areas as well as areas adjoining the Delaware Canal.

Population Profile

The Lower Delaware River Management Plan estimates that growth in the Lower Delaware River region will continue with population increases of about 14% by the year 2020. This growth "will put the river's ecosystem and water supplies under increasing stress." The urban landscape of the study area impacts not only the environmental resources of the river but the economic resource as well. As recreation continues to grow, the beauty of the river becomes a vital economic resource drawing visitors to the region.

The following tables show estimates for population and housing within the study area. Projections for 2010 and 2020 are moderate estimates developed by Bucks County Planning Commission.

Table 9 - Population Estimates for LDRCP Study

Municipality	1990	1997	2010	2020
BENSALEM TWP	56,788	57,111	64,550	64,580
BRISTOL BOROUGH	10,405	10,449	10,300	10,240
BRISTOL TOWNSHIP	57,129	57,864	55,690	55,670
FALLS TOWNSHIP	35,047	35,028	34,700	34,700
LOWER MAKEFIELD TWP	25,083	31,832	32,900	35,730
MORRISVILLE BOROUGH	9,765	10,131	9,830	9,820
TULLYTOWN BOROUGH	2,339	2,316	2,390	2,390
YARDLEY BOROUGH	2,288	2,375	2,310	2,300
Totals	**203,122**	**209,103**	**214,680**	**244,410**

The projections for the eight municipalities in Bucks County agree with estimates made in the Lower Delaware Management Plan, showing a 16% growth in population by 2020 and a 11% growth in housing.

Table 10 - Housing Estimates for LDRCP Study

Municipality	1990	1997	2010	2020
BENSALEM TOWNSHIP	22,713	23,016	27,940	29,220
BRISTOL BOROUGH	4,137	4,186	4,150	4,170
BRISTOL TOWNSHIP	20,073	20,487	20,860	21,400
FALLS TOWNSHIP	13,332	13,421	13,800	14,100
LOWER MAKEFIELD TWP	8,861	11,331	12,790	14,400
MORRISVILLE BOROUGH	4,185	4,375	4,320	4,510
TULLYTOWN BOROUGH	873	871	930	960
YARDLEY BOROUGH	1,085	1,135	1,160	1,260
Totals	**78,334**	**80,819**	**87,960**	**90,020**

Visual Stream Assessment

In support of the Lower Delaware River Conservation Plan (LDRCP), Pennsylvania Environmental Council (PEC) has funded visual stream assessment projects for major tributaries within the study area. Through Advisory Task Group recommendations, key project sites were determined.

In cooperation with local EAC groups, Heritage Conservancy has completed projects in the following municipalities:

- Falls Township - *Rock Run and Martins Creek*
- Yardley Borough - *Brock, Buck, and Silver Creek*s
- Lower Makefield Township - *Brock Creek and Rock Run*
- Bristol Borough - *Otter and Adams Hollow Creeks*
- Morrisville Borough - *Delaware River*
- Tullytown Borough - *Martins Creek*

These selected streams and associated watersheds served as case study analyses for developing specific conservation actions. The watersheds varied in predominant land uses and stream dynamics providing important local understanding of critical issues in regional watershed planning.

Heritage Conservancy developed and provided survey assessment forms to EAC members and conducted one field session to review stream assessment procedures. EAC members then walked the streams using the assessment forms and provided a detailed inventory of conditions along streams in their municipality. With this information, Heritage Conservancy mapped and photographed the conditions using the latest technology in GPS, GIS and digital photography and scanning. Using this data, recommendations were developed for restoring stream buffers in the region.

Falls Township - Rock Run and Martins Creek

Rock Run headwaters are located in Lower Makefield Township in the vicinity of Stony Hill Road. This stream flows in a east/southeasterly direction through wooded and residential areas where it enters Falls Township in the vicinity of Louise Drive and Valley Drive. From this point the flow direction becomes more southerly and a tributary coming from the north is added. From this point the stream flow is primarily through a wooded region until crossing under Route 1 near Snipes Nursery. From Route 1, Rock Run flows south, roughly parallel to Route 13. South of Tyburn Road, a tributary from the east is added and the stream becomes Martins Creek. As the stream flows south, it goes through the new Falls Township Park, crosses Bristol Pike and flows into Tullytown Borough where it discharges into a cove of the Delaware River.

The history of the creek is significant in that a considerable length of it passes through active or abandoned sand and gravel quarrying operations. The stream bed has been altered by these activities and does not appear to have a meandering course. Many areas are virtually inaccessible due to dense vegetative growth and steep slopes. Buffers range from 10 to 50 feet in width. Flooding appears to have caused disturbance in some existing woodland areas, killing the overstory canopy and allowing exotics to invade (purple loosestrife).

Specifically noted land uses adjacent to the creek include a salt house and paving for commercial areas infringing on the stream buffer. The stream does have points where flow is restricted causing flooding during major storm events due to jams of trash and debris.

A possibility may exist for the community to create a greenway along this stream corridor. Much of the land is not divided into small parcels, but owned by large quarrying operations. The new community park could extend further north and include an additional .5 to one mile of the stream. Also, the Delaware Canal is adjacent to the existing park property and is a resource to be linked to a greenway in the future.

Appendix H contains field notes, photographs and maps of the assessed areas along Rock Run and Martins Creek.

Morrisville Borough - Delaware River

As the borough developed, small streams and drainages have been directed into culverts and buried. When streams do surface often they are channelized with stone walls or riprap to prevent destruction of adjacent properties. The streams have lost their natural character, and few areas of native riparian vegetation remain. During storm events, these underground streams often exceed their capacity flooding nearby properties. A better understanding of the hydrology and stormwater drainage through the borough is needed to address localized flooding and the impacts of current land use and future development on the storm drainage system.

With few surface streams, the borough has lost a natural linkage to plan and build upon when considering development of recreational facilities, trails or a borough-wide open space network. Existing greenways and corridors can provide pedestrian connections through a community allowing residents to access a variety of recreation facilities.

The Delaware River provides an exception to the drainage and stream conditions found in the borough. Extensive wooded areas along the riverbank extend from Trenton Avenue north to the borough line and from Bridge Street south to the borough line. While the width of these wooded areas is limited due to Delmorr Avenue paralleling the river north to south through the borough, the woodlands are part of the habitat corridor and greenway of the Delaware River.

With the recent acquisition of the Gray Stones property, the borough has taken a first step in protecting remaining natural areas of the borough. Developing strategies to maintain and enhance natural areas such as Gray Stones as well as the Delaware Canal and the flood control dike along the Delaware River are a continuing priority.

Morrisville Borough has a unique opportunity in that significant areas along the Delaware River remain undeveloped. The river is a resource that can potentially provide a variety of recreational opportunities for

local residents. If planning is done to develop recreation and improve access to the Delaware, considerations need to be given to protecting the wildlife habitat values of these areas. A detailed inventory of the flora and fauna found in these areas and a determination of the impacts of proposed plans on significant habitats can assist the community in making decisions about the best use of these areas.

Appendix H contains the full report, maps and recommendations identified in the visual assessment project.

Tullytown - Martins Creek

Martins Creek enters Tullytown Borough flowing south from Falls Township. Through Tullytown, land uses along Martins Creek vary from industrial to residential to park and recreation areas. The creek empties into the cove near the Tullytown Marina.

Impacts along the creek include concrete retaining walls and gabions used to stabilize stream banks and mowing in the corridor by adjacent property owners maintaining lawn. In addition, junked automobiles and buildings have been placed adjacent to the creek in areas leaving only a few feet to the edge of the creek with intermittent trees. Invasive species such as purple loosestrife and crown vetch are becoming established in disturbed areas.

The Tullytown Landfill is very visible from the creek as it flows south of Bordentown Road through the community park and Lucisano Brothers properties. Existing trees and industrial buildings screen much of the landfill's existing height, but operations will continue upward for at least another 60 feet. Strategically placed buffer plantings could better screen the landfill and industrial activities near the municipal park.

View of Tullytown Landfill from Martins Creek

Yardley Borough - Brock and Silver Creeks

Brock Creek empties into the Delaware River in Yardley Borough. With much of the watershed developed for residential homes, the creek receives tremendous amounts of storm water runoff and sediment.

Extreme measures have been needed to protect property and infrastructure in Yardley Borough from damaging flows in Brock Creek. Near the mouth, extensive use of riprap has replaced vegetation and stabilizes steep banks along Afton Avenue and around the Yardley Inn. Upstream, adjacent property owners continue to mow to the edge of the creek, preventing buffer vegetation from stabilizing the bank. Unprotected sections of the creek are

experiencing severe bank erosion. Encroachment into the corridor continues to disturb existing vegetative cover, aiding colonization of invasive exotics including Purple Loosestrife and Multiflora Rose. In addition, debris deposited during flooding restricts and diverts stream flows in areas causing damage to adjacent properties.

Silver Creek runs through the south portion of Yardley Borough. The headwaters are in Lower Makefield Township, with a large private lake just outside Yardley Borough. The stream is heavily impacted by intensive management as it passes through the Yardley Country Club golf course. Both sides of the creek are mown to the edge of the streambank. No riparian vegetation exists. Riprap has been used where a pedestrian bridge crosses the creek. Properties encroach into the riparian area and invasive exotics are colonizing in many areas as the creek flows through the borough before emptying into the Delaware Canal.

The headwaters and a majority of the watersheds for Brock and Silver Creek are outside of Yardley Borough and lie in Lower Makefield Township. It is important that projects along the creeks include both municipalities.

Lower Makefield Township - Brock Creek and Rock Run

Brock Creek flows from the southwest corner of Lower Makefield Township northeast into Yardley Borough where it joins Buck Creek and then empties into the Delaware River. The township has recently completed a streambank restoration on a portion of Brock Creek and continues to work to improve this stream.

Rock Run begins in the area of Stoney Hill Road and flows east/southeast through wooded areas and residential developments before entering Falls Township where it joins an unnamed stream to form Martins Creek. Martins Creek flows south through Falls Township and Tullytown Borough before emptying into Franklin Cove and the Delaware River.

Residential development and detention basin near Rock Run in Lower Makefield Township

The watersheds for both Brock Creek and Rock Run are heavily impacted by residential development. The creeks experience tremendous flows due to stormwater drainage during storm events. Issues affecting the creeks include: streambank erosion, mowing in riparian areas, exotic vegetation and heavy sediment deposition.

Encroachment in corridor areas continues to be a primary cause of degradation along Brock Creek and Rock Run. While development is impacting many segments of the streams, natural areas do remain that retain much of their natural beauty and are important areas to be considered for open space protection.

Detailed field notes, photographs and maps are included in Appendix H. Field work was completed by Lower Makefield Township EAC members.

Bristol Borough - Otter and Adams Hollow Creeks

Through the open space planning process, Bristol Borough has designated Otter and Adam's Hollow creeks as areas suitable for consideration for preservation or improved management. These areas have been encroached upon by development over the years, and the borough desires to preserve and manage the remaining open space and resources associated with these stream corridors that are currently unprotected.

Otter Creek is fed from the waters of Silver Lake in Bristol Township and its upstream waters. The creek proceeds from the lake, crosses under Route 13, follows the township-borough border and flows in land owned by Rohm and Haas until it empties into the Bristol Marsh area. While the creek is located through some densely developed, industrial land uses and piped underground for some length, it is still worth noting in this report. It remains a significant natural feature within the borough and a flood management facility for the local municipalities. It also provides a natural linkage from Silver Lake County Park to the Delaware River.

Adams Hollow Creek is fed from Silver Lake. It originates at Silver Lake in Bristol Township, crosses under Route 13, follows the township-borough border, connects with the canal under the AMTRAK line and proceeds to the Delaware River through residential neighborhoods. It exists with open watered sections to the west and is primarily piped underground through residential areas until it reaches the Delaware River. Adams Hollow Creek represents a potential to link Silver Lake Nature Center and Silver Lake Park to Delaware Canal State Park and Delaware River.

V. Inventory Summary

The completed resource inventory provided extensive information regarding geology, soils, vegetation, wildlife, historical and cultural resources, open space, land use, zoning, population and conditions of local watersheds in the study region. The summary of the completed inventory has been organized using the six goals established in the Lower Delaware River Management Plan. These goals were developed as a basis for municipalities to implement recommendations set forth in the plan to protect the natural, economic and historic resources fo the Lower Delaware River corridor.

Water Quality

GOAL: Maintain existing water quality in the Delaware River and its tributaries from measurably degrading and improve it where practical.

While not directly assessed through the river conservation planning process, threats to water quality are critical to the health of the watershed. Land use and development are addressed in the inventory and directly impact water quality. The primary land uses in the study area are single-family residential (31%) and mining & manufacturing (13% - not including large areas of USX property classified as vacant). With nearly half of the region impacted by these two land uses, management practices on residential and corporate properties have a tremendous impact on water quality. Threats include: lawn fertilizer and chemical applications, storage and disposal of construction/manufacturing materials, water use and lawn maintenance. Non-point source pollution (NPS) from new development activities and existing land uses is a growing concern as land continues to be developed in the region. The Lower Delaware River Management Plan estimates that growth in the Lower Delaware River region will continue with population increases of about 14% by the year 2020. This growth "will put the river's ecosystem and water supplies under increasing stress."

Severe erosion along Rock Run in Lower Makefield Township

The fast pace of development is dramatically increasing non-point source pollution in local streams and waterbodies. Impervious surfaces and unmanaged stormwater are contributing to this problem. Scott Fegley, Supervisor for Lower Makefield Township, commented that, "We need to look at alternative ways, such as the use of porous paving, to control runoff and stormwater."

Natural Resources

GOAL: Preserve and protect the river's outstanding natural resources, including rare and endangered plant and animal species, river islands, steep slopes and buffer areas in the river corridor and along the tributaries.

The region's waterways are heavily impacted by stormwater runoff from continuing residential development and urbanization. Much of the riparian buffer area has been lost as adjacent property owners mow and maintain lawns to the stream bank. This loss reduces a stream's effectiveness to trap and filter out sediment and nutrients from stormwater runoff, provide wildlife habitat and be a valuable recreational resource. Increasingly, streams are carrying heavy flows during major storm events which scour the stream bottom and erode stream banks. Pressures on downstream areas have required drastic measures (including the use of riprap and concrete retaining walls) to keep waters from flooding and destroying property. While these problems continue, areas of significant wildlife habitat and beauty do exist along many of the streams.

Other important natural features include floodplains, hydric soils, wetlands and woodlands. Floodplains cover approximately 20% of the land area (11,379 acres), hydric soils 10% (5721 acres) and wetlands approximately 18% of the land area (10,172 acres). These resources are protected to a degree through municipal ordinances and state and federal guidelines. Large tracts of remaining woodlands are protected through public ownership by the municipalities (Five-Mile Woods in Lower Makefield, Gray Stones in Morrisville and Bristol Marsh in Bristol Borough), county (Delhaas Woods, Silver Lake County Park, Queen Anne County Park and Oxford Valley County Park), and state (Neshaminy State Park).

Restoration along Brock Creek in Lower Makefield Township

The loss of healthy, diverse streams and riparian areas is the most critical natural resource issue in the watershed. In addition, the health of local streams is related to water quality. Lower Makefield Township and Yardley Borough have been working together to address this issue along Brock Creek

Historic Resources

GOAL: Preserve and protect the character of historic structures, districts and sites, including landscapes, in the river corridor.

The most significant cultural resources in the region, identified as National Historic Landmarks are:

- Delaware Division of the Pennsylvania Canal which begins in Bristol Borough and continues northward through Bristol Township, Tullytown Borough, Falls Township, Morrisville Borough, Lower Makefield Township and Yardley Borough.
- Andalusia, Bensalem Township
- Summerseat, Morrisville Borough

A number of additional significant historic districts and structures have been identified in the region but are not identified as National Historic Landmarks including: Pen Ryn Mansion, Historic Bristol, Historic Fallsington and Pennsbury Manor.

The Delaware Canal is a critical resource and linkage throughout the area. But, the canal is underutilized in many areas and access to the towpath trail is limited (most notably in Falls Township). Awareness of the canal as a local and regional resource is growing. Dredging activities to restore the canal are underway in Yardley Borough and a proposal a been recently submitted by the Delaware Canal State Park seeking TEA-21 funding to upgrade access and safety along the towpath in Falls Township. Falls Township is currently developing a municipal trails plan linking community trails to the canal towpath using it as a spine for their trail network.

Recreation

GOAL: Encourage recreational use of the river corridor that has a low environmental and social impact and is compatible with public safety, the protection of private property and with the preservation of natural and cultural qualities of the river corridor.

Approximately 70 facilities, totaling nearly 3,500 acres or 6% of the land area, exist in the area providing opportunities for recreation to local residents. The demand for recreation facilities is growing and municipalities continue to develop new parks to meet the demand (e.g. the 228 acre Falls Community Park). While many activities have been provided for, there remains a limited number of access areas to the Delaware River. The following are the only developed public access sites in the eight municipalities:

Yardley Access site along the Delaware River

- Yardley Access in Lower Makefield just north of Yardley Borough
- Falls Township Riverfront Park adjacent to Pennsbury Manor (adjacent to the river but no fishing or boating access)

- Neshaminy Creek State Park in Bensalem Township
- Delaware River Access Area near Pen Ryn

A number of informal areas are used by local residents where they are able to park safely and walk along the river (e.g. in Morrisville south of Route 1, areas near the water treatment plant and near the historic 1894 pumphouse). In addition, six private marinas are located on the Delaware River and two along Neshaminy Creek.

River access is a major concern throughout the region - access not only physical (fishing, boating, and pedestrian) but also visual. Much of the land along the river has been developed for industry and private use. Driving along the river to enjoy it as an amenity is difficult. Bristol Borough is taking initiative to address this issue. River access and recreation development are planned for areas in Riverfront Park and in the Riverfront North Development area. In addition, support for recreation development needs to be built by promoting the economic benefits of recreation facilities.

Economic Development

GOAL: Identify principles for minimizing the adverse impact of development within the river corridor.

With the movement of service sector businesses from the city to suburbs and exurbs, communities are facing new demands for resources and facilities. While the region is becoming more diverse, new development places increasing pressure on remaining natural resources. Municipalities have begun to address these issues. Through local zoning, development plan reviews and enterprise programs, communities are trying to direct development away from sensitive areas, utilize existing infrastructure and reuse vacant industrial sites.

With these changes, previously used industrial lands are being vacated and new development is underway. Opportunities exist to acquire open space in vacated industrial areas and also to reuse existing industrial land and infrastructure to accommodate new development. Accommodating new development in existing industrial areas will help to reduce pressures on remaining natural resources. In addition, an alternative form of economic enhancement to be considered is the promotion of recreation, including linking to the Canal Towpath Trail and access facilities to the Delaware River.

Open Space Preservation

GOAL: Preserve open space as a means of maximizing the health of the ecosystem, preserving scenic values, and minimizing the impact of new development in the river corridor.

Through the Bucks County Open Space bond initiative, municipalities are eligible to receive funds for open space land acquisition. To receive funds, municipalities are required to prepare an Open Space Plan as a statement of vision for open space preservation. Through the planning process, communities identify current development, areas under threat from development, past open space preservation actions, opportunities for future preservation and action items to implement open space preservation objectives.

To date, Lower Makefield Township, Bensalem Township, Falls Township and Bristol Borough have completed and approved Open Space Plans. Yardley Borough and Morrisville Borough are in the process of forming Open Space Plans.

This planning process provides important information regarding critical and significant resources and community values. Through this process communities are able to prioritize resources needing protection and implement steps to preserve remaining open space.

The Open Space Plan when completed in each municipality becomes an important tool for communities to implement watershed conservation. Important to address when preserving open space is to establish the understanding that open space does not necessarily mean recreation. Areas that protect critical resources (e.g. unique habitat) need to be protected from overuse by the public. Another aspect of preservation is the need for continual maintenance and management. Communities cannot always absorb the fiscal responsibilities of managing and maintaining open space or recreation properties. Opportunities to provide revenue from open space and recreation facilities for management and maintenance need to be explored.

VI. Management Options

From public comments received at the first public meeting, the completed resident survey, resource inventory and summary, a series of 20 issues were identified to target recommendations. Through the advisory task group, five priority management options were determined, grouping the 20 issues identified during the river conservation planning process.

The advisory task group at a working meeting in November, 1998 detailed out the 20 issues. Under the facilitation of Heritage Conservancy, each municipality's priorities were assessed and through a consensus discussion, the task group determined the five priority management options to be addressed in the river conservation plan.

The priority of these issues varies from municipality to municipality. In addition to task group members, partner organizations and agencies were asked to identify their organizational priorities in relation to conservation action in the Lower Delaware River watershed. The organizational priorities assisted Heritage Conservancy in linking partners to implementation actions.

Following are the five management options in order of priority and the issues associated with each. The management options represent issues to be addressed to achieve river conservation in the Lower Delaware River watershed.

1. *Stormwater and Riparian Area Management*
   Stream Corridor Improvement
   Erosion and Sedimentation
   Stormwater Management/Flood Management

2. *Future Development*
   Greenway/Trail Development
   Economic Development
   Land Development
   Recreation Facility Development

3. *Planning and Zoning*
   Zoning Ordinances
   Development Plan Reviews
   Regional Planning

4. *BMPs and Education*
   Landscape Management
   Clean Up
   Monitoring
   Non-Point Source Pollution
   Education

5. Land Acquisition and Preservation Strategies
Land/Resource Protection Strategies
Open Space Preservation
Land Acquisition
Historic Preservation
River Access

Action is needed to realize watershed conservation along the Lower Delaware River and its tributaries. The issues determined through the inventory and analysis process provide a foundation for targeting projects critical to maintaining the overall health of the watershed.

Stormwater and Riparian Area Management

Most critical to the conservation and protection of water-related resources and water quality is the protection and management of adjacent lands along the Delaware River and its tributaries. The impacts of stormwater flows degrade the natural character of these areas. Efforts to retain and infiltrate stormwater are needed to reduce the pressure on these natural channels to move stormwater downstream. Important steps to achieve better management include riparian buffer restoration, erosion and sediment control, stormwater management and flood management.

Riparian Buffer Restoration

The bands of vegetation growing along our streams and rivers are referred to as the riparian corridor. These plants play a key role in protecting water quality in the Lower Delaware River Watershed. Healthy vegetation along a stream helps to regulate water temperatures and provide a food source for aquatic life. Root systems stabilize stream banks and filter out nutrients such as nitrogen and phosphorous from chemical fertilizers. Grasses and other herbaceous growth trap sediment from disturbed landscapes. Riparian corridors are key to maintaining a healthy environment in our communities.

Riparian corridors, also known as buffers, are an important open space and recreation link in many communities. A continuous ribbon of vegetation along a stream provides opportunities for passive recreation and needed filtration of runoff from developing areas. Mature, health corridors diversify the landscape adding scenic value to our communities as seen from passing automobiles, boats and the occasional scenic overlook. Whenever possible, healthy riparian areas should be protected from disturbance. Rivers and streams without healthy riparian buffers need to be restored.

A riparian buffer restoration project provides a demonstration of best management practices (BMPs) for residents and property managers in the area. Funding and technical assistance are available from many sources

to stabilize stream banks and plant riparian buffers. Successful restoration projects rely on many factors and each site is unique. Examples of successful projects can provide needed insight into how to restore a specific site. Many successful projects have been recently completed in Southeast Pennsylvania and can be visited prior to starting a new project.

Currently, Lower Makefield Township has completed a restoration project along Brock Creek near Edgewood Road and is planning future projects along the creek. Falls Township, in partnership with Heritage Conservancy, has implemented a riparian restoration and non-point source pollution mitigation project along Martins Creek in the new Falls Township Community Park. The project was funded through the PA DEP Watershed Restoration and Assistance Program (WRAP).

Specific sites for additional projects occur along Silver Creek in Yardley Borough, Rock Run in Lower Makefield and Falls townships and Otter Creek in Bristol Borough. These planning efforts involving the public, build local support and interest in watershed conservation and are an excellent opportunity to begin educating local citizens about the benefits of healthy streams.

Erosion and Sedimentation Control

Soil erosion and sedimentation from new development and construction contribute to the degradation of local streams and waterways. The basic principles of effective soil erosion and sediment control include:

- Using effective site planning to avoid sensitive areas, minimizing the area disturbed, and minimizing the time of disturbance
- Stabilizing disturbed soils as soon as possible
- Filtering and trapping eroded sediments before they leave the site
- Controlling runoff onto and through the construction site and avoiding concentrated flows
- Routinely inspecting construction sites and maintaining control measures

BMPs are available for effectively controlling soil erosion and sedimentation. *The Pennsylvania Handbook of Best Management Practices for Developing Areas* addresses this issue and provides guidelines for municipalities to effectively administer controls and enforcement.

Stormwater Management

Managing stormwater is a priority issue for all of the municipalities in the study area. Developed and developing areas are placing great strain on existing stormwater infrastructure and demanding that new control measures be implemented. The most effective measure to control stormwater runoff is through on-site measures and in many municipalities this is a mandatory statute.

An effective system for draining and controlling stormwater should:

- Safely and economically convey excess runoff through the site
- Maximize opportunities for attenuating, infiltrating, and filtering surface runoff close to where it is generated

Continued growth in the region will demand improvement of existing techniques to adequately control stormwater. In many cases, existing controls are not effectively controlling stormwater. Traditional controls such as detention basins are not enough to prevent damage to local streams and waterways and in some cases new regulations call for stronger controls. Retrofitting BMPs in areas where development occurred prior to existing regulations can upgrade traditional systems to today's standards. Many of the same techniques used in new development can be used when retrofitting existing developments. What is needed is a more creative use of available space and resources as well as changes in how land is developed and redeveloped. Specific measures to accomplish retrofitting are sited in the *Pennsylvania Handbook of Best Management Practices for Developing Areas*. Examples include:

- Filter strips to filter runoff from roof tops and paved areas
- Infiltration measures, including infiltration trenches, permeable pavement and bioretention areas
- Upgrading detention areas to provide greater hydrologic and water-quality benefits as well as flood prevention

Flood Management

All of the municipalities in the study area have floodplain protection ordinances to control and manage floodprone areas. Municipalities need to adhere to these ordinances and see that protections are enforced within the community to protect the quality of the watershed.

The most visible flooding problem in the study area occurs along the Neshaminy Creek. Efforts are ongoing to address the problems of flooding along the creek. The NRCS and Bucks County are updating the Neshaminy Watershed Plan in an effort to reduce flood damage in the lower Neshaminy. Pursuant to the original Watershed Plan, eight flood control dams have been built in the last 20 years.

The updated plan is considering the following list of options:

- Move, elevate and/or floodproof buildings
- Relocate ("buyout") homes and businesses
- Flood warning system
- Stormwater management
- Dike(s)
- Dry dam
- Floodplain ordinances

- Channel modification
- Bridge modification
- Flood bypass channel
- Riparian Buffers
- Stormwater basins

Both structural and non-structural controls are being considered. Continued participation in this planning effort is important to ensuring the final plan addresses needs of the study area communities. Implementation of the final plan recommendations will provide benefits for the study area communities reducing flooding and sedimentation and improving water quality in the Neshaminy Creek.

Future Development

The communities in the study area are moving forward to meet the demands of new business and industry and a changing population. Smaller businesses and industries are replacing traditionally large employers. As new residents look for housing they demand greater accommodation for recreation facilities and open space areas. As communities move into the 21st Century, they need to look for new ways to accommodate a changing economy and citizenry.

Economic Development

Continued growth in the economic fabric of the region is an extremely high priority for a number of municipalities. Providing incentives to attract new business and industry give municipalities a means to entice prospective businesses and developers to the region. The existing Bucks County Enterprise Zone provides many benefits including the lowest interest rate offered by the Pennsylvania Industrial Development Authority grants, job training, tax credits, and minority business development. The enterprise zone includes areas in Bristol Borough, Bristol Township, Falls Township, Morrisville Borough and Tullytown Borough. In addition to this existing program, two new innovative programs were identified. These programs are being developed to assist communities and businesses in the region.

In Falls Township, a LERTA District has been designated, providing the Township with a favorable climate to attract and preserve business. These zones created under the "Local Economic Revitalization Tax Assistance Law" offer zero real estate taxes the first year and low taxes for the next four years of a project's operation.

Heritage Conservancy in Doylestown, Pa. has initiated an incentive program, the Conservation Enterprise Program (CEP) Loan Fund. The CEP Loan Fund offers financial assistance to small businesses whose practices and outcomes integrate preservation and conservation with community economic goals. It is designed to encourage:

- Adaptive reuse and restoration of significant historic sites and properties
- Niche markets for goods and/or services which reflect positively on the community's character, culture, history and/or natural environment
- Business initiatives that support open space conservation and/or capitalize on environmental, scenic, historic, natural and recreational resources to attract visitors to the area and promote heritage and ecotourism development
- Development or improvement of recycling/composting technologies, industrial ecology, pollution abatement, waste and wastewater systems, renewable energy technologies, environmental equipment, services, and/or related technologies
- "Green" businesses that incorporate environmental responsibility into their business practices to meet the needs of "green" consumers
- Businesses and products which are based upon the sustainable harvest and use of natural resources and which support "value-added" industries that enhance the local economy.

Additional programs and tax incentives should be explored including state and federal brownfields programs to promote reuse of existing industrial sites and infrastructure and to provide benefits to new businesses and industry locating in the region.

The creation of new economic enterprises can also assist municipalities as they look to revitalize local communities. The Delaware River offers many opportunities to develop new enterprises. Ecotourism related activities along the river and the historic canal are just one way of creating a new economic niche in the region.

Land Development

Development is often seen as inevitable. With much of the Lower Delaware River region developed and urbanized, remaining areas offer the opportunity to explore alternatives to protect remaining natural and cultural resources and promote quality of life for communities.

Smart Growth provides one means for looking at development from a different viewpoint. The goal of smart growth is to seek a balance between the need for jobs, tax revenues, and amenities that come with development without degrading the environment, raising local taxes, increasing traffic congestion, or busting budgets. Increasingly, more and more local governments are finding that current development patterns frequently fail to provide this balance (International City/County Management Association with Geoff Anderson).

An important future "smart growth" project could include the Levittown Shopping Center. This declining commercial and social center has the potential to become once again an important resource to its surrounding community. A revitalization project for this property would seek to revamp the property providing space for not only commercial but also office,

civic and residential space. In addition, the restoration of the Delaware Canal could become an integral part of the project, building on the cultural heritage of the community. The canal was covered with asphalt and turned into a parking lot when the shopping center was built in the 1950s.

The adaptive reuse of existing infrastructure builds on resources already within the community not being utilized to their full potential. In addition, impacts to remaining natural resources are minimized and the opportunity to enhance an important cultural and historic resource could be realized. The success of the smart growth approach on one project will provide incentives for surrounding communities revitalizing their once thriving community centers.

Greenway/Trail Development

Greenways and trails are an integral part of the "green infrastructure" of our communities. Utilizing abandoned rail corridors and streams, communities can connect parks, historical areas, natural resources and cultural centers. A greenway can be many things but most importantly it is a connector. Often locating a trail along an existing right-of-way or local waterway can provide for a multiple of uses and achieve numerous goals. These areas are often the remaining natural areas in a developed landscape, providing much needed habitat to remaining wildlife species. Protected from development due to a need for security in the case of a railroad right-of-way or due to flooding potential in the case of streamside properties, these areas offer a unique opportunity to connect a community to its resources and also connect it with regional resources. While providing a pedestrian connection, the resource value of these remaining undeveloped areas should not be compromised.

Looking to the future can be an important step in implementing a greenway or trail. Not only do we need to plan for immediate connections but also look to the possibility of being a part of a larger regional network of greenways and trails.

One important regional project is the proposed Delaware River Heritage Trail. The objective of the proposed trail is to create a multi-use pathway as close to the shores of the Delaware River as possible, a trail that will connect communities with parks, historical sites and natural assets. The trail is envisioned as a loop, extending from Morrisville to Philadelphia in Pennsylvania and Trenton to Palmyra in New Jersey, crossing the river via the Tacony-Palmyra and Calhoun Street Bridges.

Recreation Facility Development

Parks and recreation are a means to improving the quality of life in the region. In this capacity, parks and recreation can facilitate economic development, deter crime, foster community pride, boost the image of communities, stimulate tourism, build family unity, improve cultural relationships, protect the environment and provide for effective commu-

nity involvement. Recreation programs, services and facilities provide for the creation of a healthy, thriving community with opportunities for people to reach their full human potential. Both the intrinsic value and potential economic impact of parks, open space and trails are vital to the community. The range and scope of economic, social and environmental impacts are exceptionally well described in Falls Township's Comprehensive Park, Recreation and Open Space Plan:

- Property values are higher where located near or adjacent to open space.
- One of the benefits of support for cultural development is job creation that produces additional tax revenues.
- The U.S. Congress Joint Economic Committee reported that a city's quality of life is more important than business factors alone when it comes to locating a business.
- Recreation facilities are a source of great community pride. Participation in leisure opportunities and events leaves people with an enhanced sense of the community. Studies that focus on the quality of life always zero in on parks and recreation. Community pride can be used by municipal officials as a vehicle to tackle major issues successfully.
- The most effective tool for fostering a sensitivity for the environment is outdoor education. Parks and recreation departments can provide nature-based activities and facilities to do this.
- Voluntary environmental groups help communities develop an awareness of recreation opportunities and environmental values.
- Partnerships with citizens on a wide variety of environmental issues are productive ways of addressing municipal environmental issues and programs. Memberships in conservation organizations are soaring and are ripe for harvesting by municipalities.

Falls Township and Bristol Borough are working to build additional recreation facilities for their citizens. Falls Township is currently in the first phases of construction for a new municipal park including 84 acres of active recreation development, 39 acres of passive recreation uses, and a 70-acre lake.

Bristol Borough is completing the Spurline Trail project connecting the community along an abandoned railroad right-of-way as well as pursuing additional trail connections between the Delaware River and Silver Lake County Park. In addition, through their open space planning effort, the borough is considering recreation and river access in the Riverfront North Redevelopment property. This would provide a key access point not only for the immediate community but also for the region.

A recreation development project is under consideration in Bristol Township. Plans have been developed for Riverside Park along the Neshaminy Creek but no construction has begun. This property is one of few remaining locations where public access can be gained along the Neshaminy in Bristol Township.

Morrisville has pursued a number of recreation enhancements within the borough. Development projects have included the Williamson Park ball fields, Imagination Island, renovation of the community pool and construction of the new Manor Park playground. Proposed redevelopment of the historic 1894 waterworks pumphouse will include provisions for recreation (bike and boating facilities), observation deck and theater.

Yardley Borough is investigating construction of an overlook site on a property adjacent to the Delaware River. As access, both visual and physical, is limited along the Delaware, this could be an important project for local residents to reconnect with the river. In addition, the community is presently seeking funds to begin construction of a new municipal park site, Buttonwood Park, in the town center area.

Planning and Zoning

Zoning is one of the strongest tools municipalities have to guide growth and development in their community. Zoning districts define where new development can occur. Zoning ordinances set minimum guidelines and performance criteria and provide protection for important resources in a community. An up-to-date zoning ordinance assists municipal officials in guiding their community into the 21st Century.

Zoning Ordinances

Zoning is a method of regulating land use in which districts or zones are designated throughout a community. The regulations within each zoning district are designed to protect, enhance or create an area with a certain character. Zoning ordinances also regulate the location of structures through natural resource protection standards, which limit the amount of features such as woodlands or wetlands that can be disturbed by development (Tools and Techniques - Bucks County Land Use Plan).

Overlay districts are one way to protect resources. Preserving existing resources often requires adjusting permitted uses, as well as requiring siting that will limit the impacts of any use on the resource. Common uses of overlay districts include: historic preservation, floodplain management, riverfront protection, wellhead protection and scenic corridor protection.

An example of this type of ordinance is the Yardley Borough Delaware Canal overlay district. This district protects the historic and recreational qualities of this cultural resource in the borough.

Morrisville Borough is currently revising their entire municipal ordinance. An important part of this revision will be assessment of new protection measures for natural resources in the borough. An important first step in unifying watershed conservation efforts is for all municipalities to upgrade their natural resource protection ordinances and develop design

guidelines to a uniform level and agree on standards they would like to achieve.

Development Plan Reviews

All of the municipalities in Bucks County have enacted subdivision and land development ordinances. These ordinances guide the division of land and the development of sites. The goal is to ensure that development in a community is orderly, of a size and pattern, and with necessary improvements to protect the health, safety, and general welfare of current and future residents. In addition, this ordinance sets out a review process to ensure that all relevant development regulations are followed. Plans are submitted to the municipality and reviewed by the planning commission, county agencies and state agencies.

This process provides municipalities with the opportunity to ensure compliance to minimum standards. But often the process can require excessive design standards and limit the ability for development to new concepts and solutions to common problems. An important step in future design reviews is to look for flexibility in the design review process to allow for unique and innovative solutions addressing problems in the community. New techniques to protect riparian areas, manage stormwater and reduce impervious surface are available. Through the design review process, proposed development utilizing new techniques to achieve conservation goals can be given priority and reviews expedited.

Regional Planning

Developing a regional review process to assess impacts of new development on downstream areas is an important consideration when implementing a watershed conservation plan. Precedent throughout Pennsylvania is limited in terms of establishing a formal joint municipal review process. But, in Bucks County, an excellent example of regional planning exists in the Newtown Area Joint Municipal Planning Commission. This joint municipal effort includes Newtown Borough, Newtown Township, Upper Makefield Township and Wrightstown Township.

While formal establishment of a regional effort may be a long-term solution, creation of an informal regional review committee to assess impacts of new development is a viable alternative. The goal of this committee would be to raise awareness of the impacts of proposed developments on adjacent and downstream communities. Working closely with municipal planning commissions, local interest groups and Environmental Advisory Councils (EACs) the committee would bring forth important issues regarding social, environmental and economic impacts to the regional community.

BMPs and Education

Municipal and regional projects are only one aspect of watershed conservation. A second major task is to educate local residents on how they can contribute to the effort. One step in this direction is to bring technical

experts in to work with local residents to establish a series of Best Management Practices (BMPs) to be implemented throughout the community. Once these have been established, workshops and printed materials are needed to inform residents. When this work is complete, incentives can be provided to homeowners and property managers to voluntarily implement BMPs on their property.

Landscape Management

Residential, industrial and municipal properties require regular maintenance. Each home and property has the opportunity to reduce runoff, impervious paving and promote the use of native plants in the landscape. BMPs for landscape management include opportunities for not only homeowners but also corporate and industrial park managers and municipal property managers. Examples of recommended BMPs include:

- Native Plant List
- Plant List for Wet Areas, Slopes, Wildlife Habitat and Erosion Control
- Water Diversions
- Surface Drainage
- Porous Paving
- Gutter and Downspout Splashguards, Energy Dissipaters, Rain Barrels
- Managing Pet Waste
- Removal of Invasive and Exotic Plants
- Native Plant List
- Restoring, Stabilizing and Managing Streams and Riparian Areas
- Decreasing Impervious Surfaces
- Managing Wetlands
- Alternatives to Mowing and Managing Lawns
- Integrated Pest Management (IPM) Techniques

Clean Up

Organizing volunteer "clean-up days" at least once a year is an important step in maintaining healthy streams and waterways. These efforts involve removing trash and invasive plants and should be coordinated with adjacent property owners. An important opportunity to consider when planning cleanup efforts is to work with local school groups and scout troops. Raising awareness with youth of the importance of a clean and healthy environment carries into continued care of their community throughout their lives.

Monitoring

Testing the water in local streams is a good way to note any improvements resulting from watershed conservation efforts. The general health of a stream can be determined by examining the aquatic insect species in the stream. The healthier a stream, the more diverse the insect species. Simple chemical tests can help identify the reasons for water quality problems. This information is important in determining the sources of pollutants.

Non-Point Source Pollution

Primary non-point source (NPS) pollution problems in the region are contaminants carried in stormwater runoff to local streams and waterways. These contaminants include: nitrogen from residential, commercial and institutional lawn care; spillage and leakage of automotive fluids in parking areas and service stations; road salt for de-icing, and sediment from construction activities.

NPS controls can minimize impacts from potential pollution sites through a number of different techniques. Examples include diverting runoff from paved surfaces to lawn areas, creating sand and gravel catchment areas to capture the first flush of stormwater during a storm event, and utilizing integrated pest management (IPM) techniques to reduce nitrogen applications.

Education

Producing materials in combination with public workshops is an excellent way to raise public awareness of local conservation issues and disseminate information to local residents. Environmental programs exist in local school districts and also at local nature centers like Five-Mile Woods and Silver Lake County Park. Area high school science classes can participate like Pennsbury High School in stenciling storm drains. Building on these programs to include specific watershed conservation can bring added awareness and understanding of local issues regarding the environment.

Land Acquisition and Preservation Strategies

The final implementation objective is to acquire and preserve those resources deemed to be so valuable to the community they warrant outright purchase or legal protection from any future change. Direct intervention is needed to ensure that these resources are maintained for the enjoyment of the current and future community. These resources define the character of the community or relate directly to the cultural or natural history of the region. A number of preservation techniques are available and planning efforts are underway to ensure that these resources are protected.

Land/Resource Protection Strategies

Permanently protecting land can require a long-lasting commitment on the part of municipalities. Alternatives to fee simple purchase and regular maintenance of lands exist and can achieve permanent protection goals while minimizing a community's commitment to long-term management. Alternatives to fee simple purchase include:

- conservation easements
- deed restrictions
- bargain sales

- conservation-based development
- purchase/transfer of development rights

Local non-profit organizations such as Heritage Conservancy provide technical assistance to communities looking to protect historical, cultural and environmental resources.

Open Space Preservation

The Bucks County Open Space Program provides an opportunity for municipalities to plan for and partially fund the protection of open space areas. Through the required planning process, municipalities determine priority protection areas and are then able to use county bond funds to purchase the lands. Currently, four municipalities (Falls Township, Lower Makefield Township, Bensalem Township and Bristol Borough) have completed plans. Plans are underway in Morrisville and Yardley boroughs. If purchase of areas designated in the open space plans also meet watershed conservation goals, the opportunity exists to solicit acquisition grant funding through DCNR for the required municipal match funds.

Land Acquisition

Acquiring new lands for parks and recreation facilities will be necessary for communities experiencing a growing population and increasing demands for recreation. When acquiring new properties, communities must assess the capability of the community to maintain the property. As described above, opportunities exist to minimize the costs of purchase and maintenance and these should be explored prior to purchase. But, for active recreation facilities, the community may need to purchase and maintain the land adding to their municipal properties.

Natural Areas Inventory

The recently completed Natural Areas Inventory of Bucks County (NAI) identifies numerous significant natural resources within the LDRCP study area. These natural resources include freshwater tidal marshes along the Delaware River and its tributaries as well as several excellent examples of coastal plain forest. Protection of these natural resources is critical as, in many instances, they are the last remaining examples in Pennsylvania of these unique natural habitats. Communities should look to preserve and protect these outstanding natural resources in working towards watershed conservation.

Historic Preservation

Local historical societies and non-profit organizations can assist municipalities in determining the significance of sites and properties in the community. If areas are deemed significant, action can be taken to establish an historic district (through overlay zoning), a historic architectural review board (HARB) and designation of the sites or districts at the state and national levels.

River Access

River access is an important issue in the region. The Delaware River waterfront is primarily in private ownership and utilized by industry. Action is underway to study the feasibility of increasing public access to the river. The Bucks County Planning Commission is undertaking a Waterfront Activities Study through a Coastal Zone Management Grant. Participation by local residents and municipal officials is needed in this effort. Future development of waterfront areas may require intermunicipal cooperation and assistance from the non-profit, private, county, state and federal sectors. Local boating clubs and recreation groups can assist in any efforts by providing on the ground knowledge of local conditions and user needs.

Municipal Implementation

The planning effort has provided insights to the local watersheds and targeted key issues needing to be addressed in the region. As the plan was completed, each municipality has identified projects and strategies to focus initial implementation efforts. Following are key projects and implementation strategies identified by each municipality within the study.

Bensalem Township

Bensalem Township has unique opportunities to promote greenway development within the community. The municipality is bounded to the north by the Neshaminy Creek and to the south by the Poquessing Creek. These two tributaries are the focus of regional protection efforts headed by Bucks County for the Neshaminy and Fairmount Park Commission for the Poquessing. Philadelphia Water Company is also involved with greenway planning in an effort to protect water quality near the water intakes in the Delaware River. Bensalem Township is emphasizing the need to assist with regional efforts in connecting the local community to these recreation and open space areas. The community is also actively supporting the Delaware Heritage Trail and will be implementing sections of the trail within the community.

Stormwater and Riparian Area Management

- Prepare a study assessing the need for riparian restoration and erosion/ sediment controls along Neshaminy Creek, Poquessing Creek and the Delaware River and implement a demonstration project on a selected municipal site. Cooperation with adjoining municipalities (Middletown Township, Bristol Township and City of Philadelphia) will be needed to assess headwaters areas outside the township.
- Assess limitations of existing stormwater drainage systems and develop designs upgrading existing systems to increase retention and infiltration in the Neshaminy Creek sub-basin.

Future Development

- Repair and maintain sea wall along the Delaware River and implement improvements within the Delaware River Access Park (To be completed through cooperation with Bucks County Parks).
- Develop a municipal greenway plan protecting the Neshaminy Creek, Poquessing Creek and Delaware River corridors and connecting the local community to a regional trail network. (To be prepared in cooperation with the efforts of Fairmount Park Commission, Philadelphia Water Company, National Park Service and Bucks County).

Planning and Zoning

- Review and update the township's comprehensive plan and zoning/ subdivision ordinance to address preservation and conservation of existing significant and sensitive natural features in Bensalem Township.

BMPs and Education

- Prepare and distribute educational information to township residents on Landscaping BMPs. Implement a demonstration project and host public workshops outlining techniques, materials and benefits.
- Implement an annual volunteer clean-up day for the Neshaminy and Poquessing creeks and Delaware River.
- Coordinate with partner conservation organizations to implement monitoring programs in the Neshaminy Creek and Poquessing Creek sub-basins.
- Implement a storm drain stenciling program to raise awareness regarding dumping of toxic fluids into local streams and the Delaware River.

Land Acquisition and Preservation Strategies

- Acquire properties and access easements along the Neshaminy Creek, Poquessing Creek and Delaware River to complete greenway protection efforts and develop a recreational trail network within the community.

Bristol Borough

Bristol Borough is actively working to develop riverfront access within the community. Many of Bristol Borough's implementation projects respond to this need which is not recognized only as a local issue but also as a regional issue in the river conservation plan. In its recently completed Open Space Plan, Bristol Borough recognized this need and many new opportunities developing in this riverfront community. In addition, the borough has recognized remaining natural areas that could become important open space and recreational resource areas within the community.

Stormwater and Riparian Area Management

- Restore and stabilize streambanks along Otter Creek near the Bristol Marsh Preserve area.

- Implement riverbank protection measures (including biotechnical techniques where applicable) along the Delaware River at Riverfront North to stabilize the bank for future development of the area.

Future Development

- Develop adaptive reuse of the Grundy Power Plant building as a museum and cultural/educational attraction along the Delaware Canal and Towpath.
- Develop public access including pedestrian/biking trails, fishing, boating etc. to the Delaware River at Bristol Borough's Riverfront North Redevelopment Area.
- Construct comfort stations and amenities in Lions Park along the Delaware River.
- Extend the Bristol Spurline Park in two sections. Obtain easements or acquire railroad tracks along Railroad Avenue for pathway construction. Extend pathway to provide riverfront access at Bristol Borough's Riverfront North Redevelopment area.
- Develop a Canal Landing/Tourist Center in Downtown Bristol to stimulate economic development and attract tourism to the central business district.

Planning and Zoning

- Review and update the borough's comprehensive plan and zoning/subdivision ordinance to address preservation and conservation of existing significant and sensitive natural features in Bristol Borough.

BMPs and Education

- Implement BMPs on the borough public works yard in conjunction with restoration efforts along Otter Creek.

Land Acquisition and Preservation Strategies

- Acquire privately-owned marshlands located along the historic Delaware Canal and towpath for the purposes of conservation, pedestrian trails and interpretation.

Bristol Township

Two sub-basins are the focus of implementation efforts in Bristol Township. Neshaminy Creek forms the southern municipal border with Bensalem Township and empties into the Delaware River. Property along the Neshaminy is largely held in private hands and the community is looking to increase public access to this important natural resource. The Mill Creek sub-basin includes Black Ditch Creek and areas draining into Silver Lake. This sub-basin covers a large portion of the municipality and efforts are needed to address stormwater, riparian restoration along the streams and educate residents about landscape management practices.

Stormwater and Riparian Area Management

- Study drainageways in the Mill Creek sub-basin to assess sites in need

of riparian restoration. Implement a restoration project on a selected municipal property and use as a demonstration for educating property owners along local streams. Work cooperatively with Middletown Township to assess headwater areas outside Bristol Township.

Future Development

- Implement plans for greenway and trail development along approximately 5 miles of Black Ditch Creek.
- Implement plans completed for Riverside Park along the Neshaminy Creek, constructing recommended recreation facilities and improving public access.

Planning and Zoning

- Review and update the township's comprehensive plan and zoning/ subdivision ordinance to address preservation and conservation of existing significant and sensitive natural features in Bristol Township.

BMPs and Education

- Develop education program for residents about best landscape management practices to reduce the use of chemical fertilizers, increase infiltration and use native plants in landscaping.

Land Acquisition and Preservation Strategies

- Acquire significant properties and access easements along greenway corridors to protect remaining natural areas and connect to a regional trail network.
- Acquire open space properties identified in the Bristol Township Open Space Plan that protect stream corridors, provide access to the Delaware River or Neshaminy Creek, or meet other specific river conservation goals defined in the LDRCP.

Falls Township

Due to the urban nature of Falls Township, large quantities of surface runoff are rapidly directed to stormwater drains and streams. The result is that natural drainage systems in the township are frequently overwhelmed by even moderate storm events causing flooding and damage along streams and drainageways. The township has chosen to focus implementation efforts on addressing issues regarding stormwater, flood management and developing alternatives to traditional storm drainage systems.

Stormwater and Riparian Area Management

- Retrofit existing storm drains that receive runoff from large areas of impervious surfaces with catchment and filtration system to remove debris and pollutants from highways and parking lots.
- Develop retention and infiltration system for existing and new storm drainage systems to reduce the frequently overwhelmed drainage system during even moderate storm events.

- Restore the stream channels and vegetative buffer along Rock Run and Martins Creek to reduce erosion, sedimentation and non-point source pollution in the streams.
- Complete an engineering study of Martins Creek and Rock Run to determine the feasibility and implementation of installing stream-side retention basins.
- Develop a long-range management plan for the Rock Run/Martins Creek watershed to reduce the amount of storm water directed into the stream channel, protect the vegetative buffer along the stream, acquire easements or key properties adjacent to the stream, limit construction and filling activities near the streams and work cooperatively with Lower Makefield Township to address stormwater flows in Rock Run.

Future Development

- Develop and promote a program to target residents along Martins Creek and Rock Run on land management practices appropriate for stream-side properties.
- Remove invasive species along areas of Martins Creek from Lower Morrisville Road to Millcreek Road.
- Construct a series of walkways along Martins Creekand wetland areas in the new Community Park promoting education and understanding of the environment and habitats.
- Develop recreation and river access facilities including: walkways, pavilions and a floating bridge across the cove inlet on newly acquired riverfront property adjacent to Quaker Penn Park.
- Construct river access facilities.
- Construction of detention/retention structures in the Rock Run/Martins Creek watershed to increase infiltration and filtration of stormwater and reduce direct inputs to the stream channel.

Planning and Zoning

- Work cooperatively with Lower Makefield Township to develop consistent planning and zoning guidelines addressing new development and retrofitting existing storm drainage structures in the Rock Run/Martins Creek watershed.
- Review and update the township's comprehensive plan and zoning/ subdivision ordinance to address preservation and conservation of existing significant and sensitive natural features in Falls Township.

BMPs and Education

- Train township staff and EAC members in stormwater management and bring up-to-date on best management practices (BMPs).

Land Acquisition and Preservation Strategies

- Acquire open space properties identified in the Falls Township Open Space Plan. Specifically, preserve and protect remaining coastal plain forest lands (the Sadowski property, Guzikowski property and other properties near the Five Mile Woods Forest Preserve).

- Acquire easements or properties along key stretches of Rock Run and Martins Creek to minimize disturbance of naturalized areas and protect the vegetative buffer from new development.

Lower Makefield Township

Two highly impacted streams flow through Lower Makefield Township. Brock Creek and Rock Run are experiencing tremendous development pressures within their watersheds. These pressures are raising concerns not only in Lower Makefield Township but also the neighboring communities of Yardley Borough and Falls Township. Lower Makefield Township is focusing initial efforts on developing comprehensive management plans for these two watersheds with an important component of the plans being intermunicipal cooperation and communication. As watersheds cross municipal boundaries, plans to mitigate impacts need to cross municipal boundaries. Watershed planning efforts will include participation with Middletown Township, Yardley Borough and Falls Township. In addition, Lower Makefield Township hopes to complete a greenway study of the entire municipality, a natural resource baseline of the Dyers Creek sub-basin and establish an educational program targeted to property owners managing areas adjacent to local streams.

Stormwater and Riparian Area Management

- Hire a consultant to prepare a comprehensive evaluation of the Brock Creek and Rock Run stream corridors to identify and prioritize degraded reaches and identify restoration opportunities. A key component of the plan will be to establish cooperation among the multiple municipalities within the watersheds.
- Restore reaches of Brock Creek and Rock Run to stabilize soils, improve wildlife habitat and reduce NPS pollution using native plants, biotechnical remediation and applied fluvial geomorphology techniques.
- Support implementation recommendations resulting from the ongoing 319 Study of Brock Creek.
- Prepare an evaluation and baseline assessment of the natural resources of Dyers Creek. Assess areas in need of protection before development impacts the watershed.
- Develop and implement a restoration plan for the degraded wetlands colonized by invasive species at the "Falls of the Delaware".

Future Development

- Assess appropriate sites and develop public access/views to the Delaware River north of Yardley Borough in recommended areas.

Planning and Zoning

- Conduct a complete inventory and detailed greenway study of Lower Makefield Township's stream corridors to identify significant and sensitive natural resources and develop a greenway management plan.
- Prepare a riparian areas/stormwater management study for the township.

- Review and update the township's Comprehensive Plan and Zoning/ Subdivision Ordinance to address preservation and conservation of existing significant and sensitive natural features in the municipality.

BMPs and Education

- Develop and promote a program to target residents along Brock Creek and Rock Run on land management practices appropriate for streamside properties.

Land Acquisition and Preservation Strategies

- Establish cooperation among Middletown Township, Yardley Borough and Lower Makefield Township to develop a consistent and coherent watershed management plan for the Brock Creek watershed.
- Pursue acquisition for preservation and open space, private floodplain and wetlands along the Delaware River in the northern portion of Lower Makefield Township.
- Pursue acquisition for preservation and open space, private land surrounding Five-Mile Woods.

Morrisville Borough

Morrisville Borough has a unique opportunity in that significant areas along the Delaware River remain undeveloped. The river is a resource that can potentially provide a variety of recreational opportunities for local residents. If planning is done to develop recreation and improve access to the Delaware, considerations need to be given to protecting the wildlife habitat values of these areas. A detailed inventory of the flora and fauna found in these areas and a determination of the impacts of proposed plans on significant habitats can assist the community in making decisions about the best use of these areas.

Two additional areas assessed by the EAC have potential as future river conservation projects. The adjoining properties of the Morrisville sewage treatment facility and the Staley industrial facility have significant areas of woodland and open space in low-lying areas. These naturalized areas and associated drainages provide habitat and serve as a sediment and nutrient filter for stormwater drainage from surrounding properties. Another potential project is the site of an old quarry in the southwest corner of the borough. The property is currently undeveloped and remains vacant. With a small lake in the old quarry pit, the property has potential to be an important recreational facility for the community. A feasibility study and clean up program will likely be needed prior to allowing public access to the site. Clean up of this site would be a priority. Both of these projects will need to be evaluated by the borough prior to their implementation.

Stormwater and Riparian Area Management

- Hire a consultant to study the hydrology of the borough and prepare a stormwater management plan addressing issues related to subsurface drainage and flooding.

- Work cooperatively with private property owners to restore stream channels and vegetative buffers on selected sites identified in the visual assessment study.
- Complete a detailed inventory of the flora, fauna and unique habitats along the Delaware River.
- Evaluate current state of the Delaware River dike in the borough, planning for regular maintenance and construction of steps for safe public access along the river.
- Develop and implement stormwater and flood management plan in the Melvin Heights area.
- Develop a general Morrisville Riverfront Management Plan for the Delaware River.

Future Development

- Coordinate riverfront plans for the entire length of the Delaware River in Morrisville Borough, addressing public access, corridor protection, pedestrian connections to the Delaware Canal and future land acquisitions. Incorporate regional recreational efforts.
- Construct river access facilities.
- Prepare a feasibility study for the development of a public recreation facility at the site of the old quarry in the southwest corner of the borough.

Planning and Zoning

- Hire a consultant to review and update the borough comprehensive plan and zoning/subdivision ordinance addressing preservation and conservation of significant/sensitive natural and cultural resources.
- Coordinate efforts with Lower Makefield and Falls townships to manage those watersheds that cross municipal borders.

Best Management Practices (BMPs) and Education

- Develop a clean-up program for the old quarry site and lake.
- Develop materials and distribution program to educate borough residents about proper stream management including the need to eliminate dumping of yard waste and other refuse in streams, the canal and the river.
- Hold a volunteer clean-up day for clearing trash and debris along the Delaware River and support the existing clean-up day for the Delaware Canal.
- Expand programs to place markers on stormwater drains discouraging dumping of motor oil and other toxic liquids.

Land Acquisition and Preservation Strategies

- Acquisition should be coordinated with the borough open space plan.
- Acquire conservation easements on woodland and wetland areas on the Sewage Treatment and Staley Industrial properties. The easements would protect the natural areas for wildlife habitat and open space. The easements could allow for public access to be developed at a future time.

- Evaluate acquisition of the quarry property for a municipal park following a feasibility study.
- Acquire easements or additional properties along the Delaware River and Delaware Canal (as determined in riverfront plans) to protect natural areas and improve river access.

Tullytown Borough

A significant portion of this municipality consists of large water bodies and properties associated with the Tullytown Landfill. In addition, Martins Creek, an important tributary stream, flows through the borough emptying into the Delaware River. This community is addressing multiple issues involving economic development, community revitalization as well as recreation and open space preservation. Opportunities exist to redevelop outdated community centers, connect the community to a regional trail network and, in the future, acquire landfill properties for community uses.

Stormwater and Riparian Area Management

- Implement restoration measures along Martins Creek as identified in the Visual Assessment completed for the LDRCP.

Future Development

- Prepare feasibility study for the revitalization of the Levittown Shopping Center as a multi-use "smart growth" project.

Planning and Zoning

- Review and update the borough's comprehensive plan and zoning/subdivision ordinance to address preservation and conservation of existing significant and sensitive natural features in Tullytown Borough.

BMPs and Education

- Develop education program for residents about best landscape management practices to reduce the use of chemical fertilizers, increase infiltration and use of native plants in landscaping.

Land Acquisition and Preservation Strategies

- Acquire easements or properties along key stretches of Martins Creek to minimize disturbance of naturalized areas and protect the vegetative buffer from new development.

Yardley Borough

This small historic community along the Delaware River has many unique cultural features including the Delaware Canal and a designated historic district. Along with these cultural features, Brock Creek flows through the community emptying into the Delaware River. Brock and Silver creeks experience tremendous stormwater flows and extreme measures have been taken to protect nearby properties from damage. Through the implementation of the LDRCP, the borough will assess alternatives to traditional

engineering approaches that have channelized both streams and eliminated the "naturalized buffer." This work will address stormwater and stream restoration along the creeks as well as developing an education and monitoring program by landowners and school groups. In addition, the community looks to increase river access opportunities and build on the cultural resources of the community.

Stormwater and Riparian Area Management

- Hire a consultant to assess use of alternative engineering techniques to replace extensive use of riprap and concrete retaining walls along Brock Creek as is empties into the Delaware River. The plan would propose to recreate a naturalized area while addressing flooding concerns. In addition, the Brock Creek conduit crossing below the Delaware Canal is to be assessed and proposals made to reduce accumulation of debris and subsequent flooding problems.
- Utilize techniques that incorporate both structural and vegetative means to restore a riparian buffer along Brock Creek while stabilizing the streambanks.
- Evaluate stormwater impacts on Silver Creek and implement necessary riparian buffer restoration projects to mitigate issues.

Future Development

- Implement Master Plan for Buttonwood Park.
- Construct improvements for parking and access to the Delaware Canal towpath in support of regional greenways and trails programs and as recommended by the Heritage Trail plan.

Planning and Zoning

- Prepare a riparian areas/stormwater management study for the borough.
- Review and update the Yardley Borough Comprehensive Plan and Zoning/Subdivision Ordinance to address preservation and conservation of existing significant and sensitive natural features in the municipality.

BMPs and Education

- In cooperation with Lower Makefield Township and other neighboring municipalities, develop a landscape management BMP program for contributing watersheds such as Brock Creek, Buck Creek and Silver Creek. Establish an education program including a High School Environmental Science program and adult water quality monitoring system for Brock Creek, Buck Creek and Silver Creek which complements other municipalities associated with contributing watersheds.

Land Acquisition and Preservation Strategies

- Acquire open space properties as identified in the Yardley Borough Open Space Plan that protect stream corridors, provide access to the Delaware River or meet other specific river conservation goals defined in the LDRCP.

- Continue to work with the Historical Architectural Review Board promoting the designated historic district and numerous historic structures in Yardley Borough.
- Expand Buttonwood Park through acquisition of adjacent properties.
- Investigate dredging of historic Lake Afton to its original depth for enhanced recreational use.

Regional Implementation

Once the plan is completed, the municipalities will be responsible for taking the recommendations and implementing projects. An important outcome of this river conservation planning process has been the partnerships formed among the municipal environmental advisory councils (EACs) and other members of the Advisory Task Group.

This group of leaders was given the charge to spearhead the planning effort and has taken responsibility for seeing local concerns reflected in the planning process. As the plan comes to a successful completion, Heritage Conservancy will see that all necessary documentation is forwarded to PA DCNR and that all requirements are met to have the plan placed on the PA State Rivers Registry. One of the final requirements of the planning process will be to have municipalities endorse the plan and commit to implementing the recommendations. The last official responsibility of the Advisory Task Group is to see that the plan is presented to the municipal governing body and look to endorsement of the plan and recommendations.

Looking to continue the work of the plan and improve intermunicipal communication, it is proposed that the local environmental leaders continue to meet on a formal basis to discuss implementation strategies, watershed issues and guide regional projects recommended in the plan. Stronger cooperation and communication is needed among municipalities to develop intermunicipal watershed management plans, raise awareness of projects affecting adjoining communities and to share information regarding upcoming funding opportunities. This regional information sharing will assist in implementation efforts related to the river conservation plan and also build local support for the EAC advisory role in the community.

Improving intermunicipal cooperation was a major goal of this planning process and was a priority recommendation emanating from the work completed by the Countryside Stewardship Exchange Program. Carrying this cooperation forward will be important to successfully complete the following regional implementation projects.

River Access Study

A comprehensive study is needed to assess priority locations for additional river access areas and to weigh environmental impacts. Development of waterfront areas will require intermunicipal cooperation and

assistance from the private, county, state and federal sectors to successfully construct new facilities. With much of the riverfront in private holdings, acquiring addition property and access easements will be critical. This study should include extensive use of local knowledge about conditions and needs of riverfront areas during the tidal changes and during peak use times. A cursury regulatory review will be necessary to determine the appropriate permits.

Coordination and implementation of Open Space Plans will be imperative.

Regional Education and Training Programs

Effort is needed to coordinate regional projects and develop a regional education program to educate residents, student groups, township officials, public works staff, municipal park and recreation staff and EAC board members. Important education and awareness projects include:

- Develop landscape BMPs to reduce use of fertilizers and direct runoff into streams.
- Develop educational videos targeted to specific audiences on the need for and benefits of landscape BMPs, native plants, stream management and watershed planning.
- Coordinate with local schools (Pennsbury School District, Council Rock School District and larger private schools) to develop an educational program targeted to watershed-based environmental conservation and community-based, hands-on projects.
- Storm drain stenciling to reduce dumping of toxic materials into local streams.

The ideal venue for this regional approach is through regular meetings with all the identified partners. Currently, the EAC's in lower Bucks County meet quarterly to discuss activities of regional concern. Watershed-focused projects could be one topic of interest to this group. They could coordinate the activities with other identified partners. Other tangible topics could be joint submission of grants for project implementation, sharing equipment and technical skills among members, as well as ideas for multi-municipal implementation. In order to bring all partners together, regular comprehensive meetings should occur for the intention of communication. The National Park Service, in particular, feels the need to convene meetings with all municipalities, especially with the Lower Delaware National Wild and Scenic River Study currently under review by the U.S. House and Senate for designation. If approved, coordination of all watershed activities will be paramount to avoid duplication of effort and to make a positive impact within the sub-basins of the Delaware River.

Visual Watershed Assessments

Visual watershed assessments similar to those performed by the EAC's in segments of specific municipalities have yet to be completed for Core, Dyers, Houghs, Mill, Neshaminy, Poquessing and Queen Anne creeks.

Watersheds are not defined by municipal boundaries, therefore, a more holistic approach to their assessment is imperative. An intermunicipal effort is needed to complete the remaining visual assessments of these important sub-basins within the LDRCP. As watersheds are studied in greater detail to determine flooding potential, water quality and other development impacts, intermunicipal cooperation will ensure that recommended actions are consistently implemented in the multiple municipalities of a watershed.

Heritage Trail Project

The Delaware River Heritage Trail project is being directed by the National Park Service and will include all of the municipalities in the Lower Delaware River Conservation Plan. It will be important for municipalities to make critical connections in this trail network and construct needed improvements to accommodate users. As this plan is completed, regional efforts to direct construction and implementation will assist in connecting local trails into a larger regional network.

Stormwater System Retrofits

As individual municipalities upgrade storm drainage systems, regional coordination is needed to assess impacts on a watershed basis. A regional assessment of existing conditions and projected benefits of storm drainage upgrades using selected BMPs will provide a standard to measure improvements. This regional study would also recommend best techniques in addressing storm drainage in the individual local watersheds. Currently, the Bucks County Planning Commission is preparing a watershed-wide stormwater management plan for the region. When completed, this work will provide necessary information assisting in development of recommended techniques.

Partner Organizations

Many local, state, and federal organizations can provide technical assistance to municipalities working on recommended watershed conservation projects. These organizations offer a variety of services, review procedures, educational materials and technical advice.

Bucks Conservation District (BCD)

The Bucks Conservation District is a unit of state government and was authorized and formed by the Bucks County Board of Commissioners in 1961 under the provisions of the Conservation District Law, Act 217 of 1945, as amended. The mission of the Bucks Conservation District is to provide for the wise use, management and development of the county's soil, water and related natural resources. This is accomplished with the cooperation of both public agencies and private groups and individuals, especially landowners. The major priority at BCD is the control of soil erosion and the resulting sedimentation. The district oversees the imple-

mentation of Erosion and Sediment Control Plans on new development including reviews and compliance inspections.

Bucks County Department of Parks and Recreation

The Bucks County Department of Parks and Recreation (BCDPR) is the county agency which provides for the development, management and operation of the recreational needs of county citizens. Programs of the BCDPR include: coordinating with municipalities and non-profit organizations in providing facilities for special needs; providing resource-based programs including nature centers, hiking, boating, fishing, camping and environmental education; providing for active recreation, including athletic events, concerts, festivals, and other leisure activities; and providing programs and activities related to the environment and natural sciences.

Silver Lake Nature Center (SLNC)

Silver Lake Nature Center is one of three fully staffed nature center facilities managed through the Bucks County Department of Parks and Recreation. The center provides nature/environmental education programs and recreation to all citizens of the county. The staff has developed specific programs for K-8 designed to assist teachers address the PA Department of Education, Ecology and Environment Standards. In addition, work is continuing with several senior high schools to develop specific programs. Other successful activities include scout programs and a summer camp. The center also maintains a resource library.

Bucks County Penn State Cooperative Extension

Cooperative Extension is an informal educational partnership with county, state and federal governments. Penn State University Extension extends its campus to communities through county offices staffed by university professionals. Through this system, the latest research and technical information of the university is accessible to county residents. Priority issues focus on the economic, social and environmental progress of families and communities. Cooperative Extension accomplishes education through short courses, seminars, meetings, newsletters, publications, personal consultation and mass media.

Bucks County Planning Commission (BCPC)

The planning commission provides functional and comprehensive planning to Bucks County and its 54 municipalities. Programs of the commission include sewage and water facilities, solid waste management, parks and open space, natural resources and housing planning, development of zoning, subdivision and land development ordinances and regulations. Commission staff provides consultation on planning and plan implementation. The commission also manages an extensive resource library.

USDA NRCS

The Natural Resources Conservation Services is the federal public service agency that helps individuals, groups, organizations and city, town,

county and state governments to protect and promote the wise use of land and water resources. Programs of the NRCS include soil and water conservation, natural resource and soil surveys, community resource protection and management, and agricultural conservation programs. NRCS can provide on-site consulting assistance to land users with soil and water problems.

Bucks County Audubon Society

Bucks County Audubon Society (BCAS) is a private, non-profit organization whose mission is to foster awareness, understanding and a sense of stewardship of the environment through education. BCAS operates the Honey Hollow Environmental Education Center which hosts the annual Bucks County Envirothon and provides environmental education programs to some 10,000 students and teachers each year. They also have a native plant nursery.

Heritage Conservancy

Since its inception in 1958, Heritage Conservancy, a non-profit membership organization, has established itself as a regional leader in land conservation and historic preservation. To meet its mission to "preserve our natural and historic heritage," the conservancy promotes open space conservation, natural resource protection, historic preservation, wildlife habitat restoration and biodiversity through land use planning and design, adaptive reuse of historic structures, identification of key natural resources, and innovative land conservation and historic preservation strategies. Heritage Conservancy provides technical assistance to municipalities and individual landowners through grants and fee-for-service.

Management Options Table

On the following pages, the issues discussed in this section have been expanded to identify specific tasks, primary partners, supporting partners and projected implementation timing. The table identifies the roles each partner can play in planning and implementing conservation actions.

Issues and Concerns	*Conservation Actions*	*Primary Partners*	*Supporting Partners*	*Projected Implementation*
1. Stormwater and Riparian Area Management				
Stream Corridor Improvement	Plant riparian buffers using native plantings	Municipalities/EACs – planning and organization Watershed groups – planning, organization and volunteers HC - design and planning DEP/DCNR – funding, technical assistance DRG – planning and organization	NRCS - technical assistance BHWP - native plant selection and materials PEC – planning, coordination, education Scout troops – volunteers School groups – volunteers DEP, PA Stream Releaf – technical assistance	1-2 Years
	Protect existing riparian buffers	Municipalities – pass local ordinances, plan greenways Non-profit organizations – negotiate purchase or easement of properties Homeowners associations – donate easements, manage riparian areas on common land Private landowners – manage riparian areas, donate easements	HC – protection strategies BC - land management DCNR – funding DRG – protection strategies DRK – protection strategies	2-5 Years
	Educate adjacent property owners on managing stream corridor areas	Municipalities/EACs – initiate volunteer programs NRCS – programs, materials, public awareness Watershed groups – administer programs	PSCES –materials SLNC – programming, facilities FMWP – programming, facilities DCNR – funding HC – expertise	Ongoing
Erosion and Sedimentation Control	Establish recommended BMPs to meet minimum criteria for effective soil erosion and sediment control	Municipalities – support adoption of required BMPs BCD – determine most effective BMPs, technical assistance HC – technical assistance	Watershed groups – provide innovative ideas and strategic sites needing attention Scout troops – volunteers School groups – volunteers	1-2 Years

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Issues and Concerns	*Conservation Actions*	*Primary Partners*	*Supporting Partners*	*Projected Implementation*
	Enforce erosion and sedimentation plans during new construction	Municipalities – clearly document new construction activities BCD – plan review, provide on-site inspections, enforcement	DRG – technical assistance DRK – technical assistance	Ongoing
	Identify mandatory controls in zoning ordinances	Municipalities – adopt stricter controls for new construction HC – technical assistance	BCPC – technical assistance DRG – technical assistance	2-5 Years
Stormwater Management	Study impacts of stormwater runoff on local waterways	Municipalities – initiate local studies Conservation district – provide local data County planning – initiate regional studies	BCD – technical assistance BCPC – planning/technical assistance HC – planning DCNR – funding, technical assistance	1-2 Years
	Update retention and detention controls for new development	Municipalities – adopt new controls through local zoning to achieve greater management BCD - technical assistance BCPC - planning/technical assistance	HC – design Engineers – design, technical assistance Landscape Architects – design, technical assistance Homebuilders Association	2-5 Years
	Implement incentive program for volunteer homeowner BMP implementation	Municipalities – seek funding to implement a cost-share program Watershed groups – promote program and educate	DEP/DCNR – funding Private landowners – implement program DRG – technical assistance DRK – technical assistance	Ongoing
	Retrofit new BMPs in existing developments, explore infiltration and filtering practices	NRCS - design/technical assistance BCD - technical assistance Homeowners associations – implement strategies through incentive program Private landowners – implement strategies through incentive program	Engineers – design, technical assistance Landscape Architects – design, technical assistance	5-10 Years

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Issues and Concerns	*Conservation Actions*	*Primary Partners*	*Supporting Partners*	*Projected Implementation*
Flood Control	Study impacts of flooding on local waterways	Municipalities – initiate local study Watershed groups – provide local knowledge and expertise of conditions DRK – provide planning and expertise	NRCS - technical assistance USGS – data BCPC - technical assistance DRBC – technical assistance Consultants – planning, technical assistance DRG - coordination	2-5 Years
	Participate in Neshaminy Creek flood studies	Municipalities – participate Watershed groups – provide local knowledge, attend meetings Private landowners – provide local knowledge, attend meetings		Ongoing

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Issues and Concerns	*Conservation Actions*	*Primary Partners*	*Supporting Partners*	*Projected Implementation*
2. Future Development				
Greenway/Trail Development	Develop municipal greenway/trail plans	Municipalities – initiate local studies and planning HC – planning, technical assistance Landscape Architects – planning, technical assistance DRG - planning	DCNR - funding NPS - technical assistance Greenspace Alliance – planning, data DVRPC – planning	1-2 Years
	Implement trail projects	Municipalities – plan and organize construction HC – design, planning DRG – planning	NPS – design, planning BCDPR – design, planning DCNR – funding Scout troops – volunteers School groups – volunteers	2-5 Years
	Develop regional trail network	County planning – initiate regional trail planning Non-profit organizations – provide vision for future trail connections NPS – planning, technical assistance DRG – planning, visioning	Local Residents	5-10 Years
Economic Development	Develop plans to reuse existing industrial sites and infrastructure	Private enterprise – design and implement reuse plans	BCPC – technical assistance Consultants – technical assistance	2-5 Years
	Provide incentives to attract new industry and business	Municipalities – implement tax credit programs County & state governments – provide grant and cost-sharing programs	BC – grant program State Government – grants, cost-share programs HC – Conservation Enterprise Program (CEP)	5-10 Years

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Issues and Concerns	*Conservation Actions*	*Primary Partners*	*Supporting Partners*	*Projected Implementation*
	Revitalize dated shopping centers	Private enterprise – work with municipalities to design facilities to meet local needs and business needs	Municipalities – tax incentives Private Industry - funding Consultants – planning and design	5-10 Years
Land Development	Provide incentives to design "Green" developments	Municipalities – implement innovative zoning options for design Consultants - planning and design	HC – Conservation Enterprise Program (CEP) State government – funding and cost-sharing Economic Development Councils Chamber of Commerce	2-5 Years
Recreation Development	Develop new facilities to meet needs of growing population	Municipalities – plan, design and construction County parks – plan, design and construction	BCDPR – planning Consultants – design DCNR – funding	2-5 Years
	Provide additional river access	Municipalities – acquisition and construction County parks – acquisition and construction Private landowners – allow access easements	BCDPR – planning Consultants – design DCNR – funding PAF&BC – funding, design and construction	5-10 Years

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Issues and Concerns	*Conservation Actions*	*Primary Partners*	*Supporting Partners*	*Projected Implementation*
3. Planning and Zoning				
Zoning Ordinances	Review existing natural resource protection ordinances	Municipalities – solicit reviews of current ordinances HC - technical assistance BCPC - technical assistance	DCNR – funding Consultants – technical assistance	1-2 Years
	Update necessary ordinances to implement watershed conservation	Municipalities – draft and adopt new ordinances	BCPC – model ordinances Consultants - technical assistance DCNR – funding	2-5 Years
Development Plan Reviews	Promote intermunicipal reviews of development plans affecting adjacent and/or downstream communities	Municipalities – respond to regional issues Consultants – planning	State Government - incentive program Watershed groups – raise awareness of regional issues	5-10 Years
Regional Planning	Establish a committee representing regional municipalities to discuss regional concerns and address intermunicipal communication	Municipalities - delegate representative to regional review committee Consultants – planning BOLD – Countryside Exchange Implementation Committee DRG – planning, coordination	State Government - incentive program DRBC – technical assistance for watershed planning	5-10 Years

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Issues and Concerns	*Conservation Actions*	*Primary Partners*	*Supporting Partners*	*Projected Implementation*
4. Best Management Practices (BMPs) and Education				
Landscape Management	Develop recommended BMPs for homeowners	Municipalities/EACs – review and recommend new BMPs HC - technical assistance Non-profit organizations – assist in design and implementation PSCES – technical assistance	Consultants - technical assistance Private landowners – implement BMPs Watershed groups – educate and raise awareness	1-2 Years
	Develop recommended BMPs for industry and business	Municipalities/EACs – review and recommend new BMPs HC - technical assistance Non-profit organizations – assist in design and implementation	Consultants - technical assistance Private enterprise – implement BMPs Watershed groups – educate and raise awareness	1-2 Years
	Develop recommended BMPs for municipal properties	Municipalities – adopt BMPs and implement program	NRCS - technical assistance HC - technical assistance	1-2 Years
	Provide incentives for implementing BMP programs	Municipalities – develop program with funding assistance	BC - grants/cost-sharing DEP/DCNR – funding US EPA - funding	2-5 Years
	Develop and distribute BMP education materials	Municipalities – promote BMP program Watershed groups – promote program and distribute materials Non-profit organizations – assist in publication	DEP/DCNR- funding HC - technical assistance, funding, develop materials PSCES – materials, technical assistance DRG – technical assistance DRK – technical assistance	Ongoing
	Host workshops on BMP implementation	HC – provide local expertise, workshop facilities Schools – provide workshop facilities	SLNC - technical assistance FMWP - technical assistance	Ongoing

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Issues and Concerns	*Conservation Actions*	*Primary Partners*	*Supporting Partners*	*Projected Implementation*
Clean Up	Organize volunteer "Clean-up Days" for the Delaware River and tributary watersheds	Municipalities/EACs – planning, organization Watershed groups – planning, organization and volunteers	DRK - technical assistance Scout troops – volunteers School groups – volunteers	Annual
Monitoring	Establish monitoring stations	Municipalities/EACs – locate local stations Watershed groups – locate local stations DRBC with DRK and DRG – water quality monitoring program	DRBC - technical assistance DRK - technical assistance DCNR – funding Philadelphia Water Dept.	1-2 Years
	Organize volunteer monitoring network	Municipalities/EACs – manage program Watershed groups – manage program DRK – organization	DRK - technical assistance DCNR – funding Scout troops – volunteers School groups – volunteers	Ongoing
Non-Point Source Pollution	Educate local citizenry about impacts of non-point source pollution	Watershed groups – promote program, distribute information NRCS – materials BCD – provide expertise DRK and DRG with DRBC – non-point source pollution monitoring	BCD – materials, expertise SLNC - workshop planning FMWP - workshop planning PEC – expertise PSCES – technical assistance	1-2 Years
	Develop NPS reduction strategies	Watershed groups – provide local knowledge Municipalities – adopt recommended strategies	BCD - technical assistance NRCS - technical assistance HC – technical assistance DRBC/DRK/DRG – technical assistance	2-5 Years

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Issues and Concerns	*Conservation Actions*	*Primary Partners*	*Supporting Partners*	*Projected Implementation*
	Implement model NPS projects	Municipalities/EACs – coordinate projects Watershed groups – provide local knowledge and projects HC – coordination Non-profit organizations – plan and design projects Consultants – design	BCD - technical assistance NRCS - technical assistance Homeowners associations – implement projects Private landowners – implement projects Private enterprise – implement projects	2-5 Years
Education	Raise public awareness and develop education materials on BMPs and watershed conservation targeting homeowners, property managers and public works employees	Municipalities/EACs – design and implement program Watershed groups – promote program, distribute materials, provide local expertise Non-profit organizations – design program materials	NRCS – materials BCD – materials, technical assistance HC - technical assistance DRK – technical assistance PSCES – technical assistance	Ongoing
	Work with local schools to include watershed conservation in the curriculum	Municipalities/EACs – raise local awareness BCAS – curriculum Watershed groups – provide local knowledge	PAEE Region 6 – curriculum Bucks County Intermediate Unit – curriculum	Ongoing
	Develop programs at local environmental centers to build understanding of watershed conservation issues	Watershed groups – provide local expertise Non-profit organizations – provide experts SLNC, FMWP – programming and facilities		Ongoing
	Organize lecture series addressing watershed conservation strategies	Municipalities/EACs – host Watershed groups –local experts Non-profit organizations – solicit regional experts Nature centers – host lectures	HC – lecture coordination	Ongoing

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Issues and Concerns	*Conservation Actions*	*Primary Partners*	*Supporting Partners*	*Projected Implementation*
5. Land Acquisition and Preservation Strategies				
Land/Resource Protection Strategies	Work with local non-profit organizations to assess benefits of various protection strategies	Municipalities – review available strategies Private enterprise – funding, implement protection measures Non-profit organizations – negotiate protection measures DRG – support and promote actions	HC – technical assistance BC - cost-sharing DCNR – funding	1-2 Years
Open Space Preservation	Utilize county open space preservation program funds to protect critical resource areas and promote watershed conservation	Municipalities – develop plans, purchase property for protection	HC - technical assistance BC - cost-sharing DCNR – funding	1-2 Years
	Implement municipal open space plans	Municipalities – prepare plan and follow recommendations	HC - technical assistance BC - cost-sharing	2-5 Years
Land Acquisition	Work through county open space preservation program to protect lands with significant resources and protect water quality in the watershed	Municipalities – purchase property for protection County parks – purchase adjoining lands to existing facilities Non-profit organizations – assist in purchase/easement negotiations	HC - technical assistance BC - cost-sharing DCNR – funding	Ongoing
Historic Preservation	Support nomination of historic structures and districts	Municipalities – pass resolutions supporting nominations Non-profit organizations – prepare nominations	HC - technical assistance Private landowners – support local efforts Historic societies – provide local knowledge	Ongoing

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Issues and Concerns	*Conservation Actions*	*Primary Partners*	*Supporting Partners*	*Projected Implementation*
	Promote historic areas through tourism initiatives	PA Tourism and Promotion Chamber of commerce – provide local funding and promotion County tourism promotion – regional distribution	Municipalities – promote resources Historic societies – provide local knowledge	1-2 Years
	Promote adaptive reuse of historic structures	Municipalities –flexibility in zoning and plan reviews Historic societies – promote preservation of structures Non-profit organizations – develop reuse alternatives	HC - technical assistance	2-5 Years
	Establish HARBs	Municipalities – adopt review boards	HC - technical assistance BC - technical assistance	1-2 Years
	Perform historic site surveys	Historic societies – provide local knowledge Non-profit organizations – provide regional expertise	HC - technical assistance	1-2 Years
River Access	Work with Bucks County Planning Commission and the Waterfront Activities Study to define need for additional river access	Municipalities – participate in regional planning effort NPS - technical assistance BC – funding, planning, technical assistance Recreation interest groups – provide local knowledge BOLD/DRG – regional planning, support and promotion	Private enterprise – provide public access where feasible DEP/DCNR – funding D&L Canal Commission Delaware Canal State Park PAF&BC – funding, technical assistance	1-2 Years
	Coordinate construction of facilities with adjacent municipalities and Bucks County Dept. of Parks and Recreation	Municipalities – acquisition and construction County parks – acquisition and construction	BCDPR – technical assistance PAF&BC – technical assistance DCNR – funding	2-5 Years

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HERITAGE
CONSERVANCY

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LDRCP Public Meeting
11-25-97

Issues/Ideas for the future:

Boat ramp in the Morrisville, Falls area.
Neshaminy Creek- future plan to connect the upper and lower segments is possible.
New ramps at Neshaminy State Park, less slope- longer incline.
Roads block access to river in Bensalem Township

- How do we open up the river to prospective users.
- Connectors of some kind are needed

Riverfront is owned by large companies in Falls and Bristol Townships

- Trash trucks are a problem

Flooding and Stormwater management.
Maximize river use with restaurants on the river and improve boat access.

- Create a network of attractions along the river that could become an appropriate length for day trips and beyond.
- Talk to boating clubs about opening up dining services to non-members and perhaps eventually expanding into a full time restaurant if it is profitable and practical.

Unified educational network along the river.
Include public access in river front development plans.
Tie access to federal enterprise zone and economic development plans for the area.
Add fishing piers.
Flood control on Neshaminy Creek.
Private property owner's concerns

- Old estates in particular (Andalusia) will not be interested in the development of a trail through their property.
- Control undesirables
- Liability concerns for children using piers and other artificial access

Bike trail
Camping facilities needed.

Lower Delaware River Conservation Plan – Preliminary Findings Report

Summary of Public Meeting Work Session – (February 26, 1999)

Following are comments, recommendations and ideas from the participants at the February 26, 1999 public meeting to review the Preliminary Findings Report.

1. Stormwater and Riparian Area Management

Change "Flood Control" to "Flood Management".

Foster communication between municipal EACs to achieve watershed management.

Enforce legal designations of floodplain areas.

Remove rip-rap and replace/repair with less engineered solutions.

Develop alternatives to retaining walls.

"Daylight" streams using fewer culverts and conduits in new developments to underground and direct streams.

Enforce and monitor stormwater practices.

2. Future Development

Morrisville Waterworks adaptive reuse project needs to address traffic problem, and need for public restroom facilities.

Levittown Shopping Center project is too large and too costly.

3. Planning and Zoning

Need a zoning ordinance model to lessen expense and work for zoning ordinance review and upgrade.

Need to address the compatibility of recommended BMPs with zoning regulations.

EACs need to be actively involved in development proposal review to integrate progressive development techniques.

Select specific projects to promote overlapping the projects between municipalities to lay the foundation for regional planning.

4. Best Management Practices (BMPs) and Education

Need to identify funding sources.

Stress natural resource protection ordinances.

Improve coordination and cooperation between civic, environmental, watershed groups.

Utilize vegetative buffer strips.

Develop stormwater utility assessments to determine allowable impervious areas and fund mitigation.

5. Land Acquisition and Preservation Strategies

Need to develop bike paths (Roelofs Village, Brock Creek, Stony Hill Area).

New development catch basins not adequate in Morrisville near Falls border.

No river access available below Yardley on PA side of the Delaware River.

Lack of rest facilities.

Future preservation area - US Magnet Site.

Lower Delaware River Conservation Plan - Preliminary Findings Report

Summary of written public comments - (received by April 26, 1999)

Local Residents

"Excellent presentation...was clear and concise. Time was allotted for input from the audience. Follow up, with results, will be the key to the success of such well thought out information."

"It was impressive to see so many bright, energetic people lending their efforts to the clean up and preservation of our watersheds. It is a terrific effort in the right direction."

Recommendations:

- Make maps available to the public
- Need to provide specific guidance to private landowners for protecting waterways
- Need widespread education. Message needs to be brought to organizations, schools, senior centers.
- Walk the waterways to see the problem as well as the treasures they are.
- Avoid using "flood control". Use "flood management".
- Keeping floodplains sacrosanct is the only effective solution to flood damage and must be the thrust if any progress is to be expected.
- Older communities will need retrofitting of stormwater and riparian projects.
- We heard little mention of volunteerism. We all know that paid staff are needed, but properly directed volunteers can accomplish a great deal.
- Historic aspects fo the areas in question have, if not neglected, been under utilized.
- Check maps (open space). Many of the township owned green belts in Levittown were not listed.
- Work should be done to link the almost complete green belts through Levittown.
- Considerable work needs to be done with Township Zoning Ordinances.

Organizations

"The Silver Lake Nature Center, while not contiguous to the river, is centrally located within the study area. We are more than willing and able to assist with many of the recommendations and in particular, the educational components...Please keep us in mind as you work on implementation."

- I would not consider Betula papyrifera as characteristic of Coastal Plain Sweet Gum-Willow Oak Forest.

"The Delaware River Basin Commission (DRBC) appreciated the opportunity to attend the public workshop held in Falls Township, Pennsylvania on February 25, 1999 on the Preliminary Findings for the Lower Delaware River Conservation Plan. We feel that it is very important to approach water management from a regional perspective and any attempts to encourage municipalities to work together are admirable."

Lower Delaware River Conservation Plan – Draft Plan

Summary of Public Comments – (July 19, 1999)

Following are comments, recommendations and ideas following the June 9, 1999 public meeting to review the Draft Plan.

Yardley Borough

- All incorrect references and inconsistencies have been corrected.

Morrisville Borough

- All incorrect references and inconsistencies have been corrected.
- Specific recommendations listed in the Management Options for Morrisville Borough have been revised to be consistent with the completed Morrisville Borough Environmental Assessment.
- Historical references have been reviewed by HC Historic Preservation staff for clarification and accuracy.
- Description and reference to the significance of Gray Stones has been included in the report.
- Corrections to Base Map and Significant Resources Map have been made.
- Land Use Map (see discussion at end of list)

Bucks County Open Space Program

- References to the recently completed Natural Areas Inventory have been added. Specifically, recommendations have been included in the plan to protect coastal plain forest properties near Five Mile Woods in Falls Township.

Silver Lake Nature Center

- All incorrect references and inconsistencies have been corrected.
- Sub-basin, Floodplain, Hydric Soils and Wetland Tables have been revised to include percent coverage in study as well as total acreage.
- Edits to appendices have been made.
- Corrections to the Base Map have been made.
- Generalized Zoning Map and Land Use Map (see discussion at end of list)

Delaware River Keeper

- References for future watershed planning in Lower Makefield Twp, Bristol Twp and Bensalem Twp include cooperation with Middletown Twp and other headwater areas located outside the LDRCP study area. Please note that areas outside the LDRCP study are not a priority for DCNR when evaluating grant applications.
- A series of comments were added to sections of the Management Options (pp 58-71). Comments provided further emphasis of principles discussed in the text including; new ideas in stormwater management, enforcement of existing floodplain and wetland regulations, use of riparian buffer restoration and protection of natural greenway systems while developing public access and trails.

General Comments

- A number of comments were received regarding the Land Use and General Zoning maps, discussion and related statistics. The data sets used were provided by Bucks County Planning Commission and are the latest and best data available. While inconsistencies may exist in the data this planning study did not afford us the opportunity to generate a more detailed and updated database. We are not able to make changes to these data sets for this plan. The data is to be used for regional scale planning. We will include on the maps and in appropriate sections of the plan, clarification of the data source and its limitations for site-specific use.

LDRCP RESIDENT SURVEY SUMMARY
MAY 5, 1998

Current river usage:

Activity	Percentage of Total Responses
Sight Seeing	51.7
Nature Walks	48.9
Fishing	37.5
Biking/Hiking	29.5
Tubing	27
Boat Fishing	20.5
Canoeing	17

Should access be improved? yes - 62%

River usage if access improved:

Activity	Percentage of Total Responses
Nature Walks	45
Sight Seeing	42.6
Biking/Hiking	33
Fishing	32.4
Canoeing	24.4
Boat Fishing	24.4
Tubing	21.6

Three most important features of the Delaware River area:

Feature	Percentage of Total Responses
Natural and scenic resource	75
Home to many plant and animal species	58
Important cultural and historic resource	52.8

Preservation/Regulation within the watershed:

- An average of 86.9% of respondents favor preservation, including preservation of undeveloped land, farmland, forested land, historic resources, scenic character, and wildlife habitat.
- 72% support land use regulations within the entire watershed.
- 77% favor a conservation plan that focuses on the entire watershed.

HERITAGE
CONSERVANCY

Land Conservation • Historic Preservation
85 Old Dublin Pike, Doylestown, Pennsylvania 18901-2489 • (215) 345-7020 • Fax (215) 345-4328

February 13, 1998

Dear Resident,

The Delaware River is the last, free flowing river in the eastern U.S. Featuring outstandingly remarkable natural, cultural and recreational resources, the Lower Delaware River is currently the focus of two parallel studies which are designed to help preserve these significant resources.

The first study, conducted by the National Park Service, focuses on the Lower Delaware River being proposed for inclusion in the National Wild and Scenic Rivers Program. The Delaware is one of few rivers in the East that has portions already included in the program and another portion now being considered. The Wild and Scenic Rivers Act says that to be eligible, a river must be free flowing (that is, no impoundments), and the river corridor must also contain outstandingly remarkable resources. These resources can be natural, historic, scenic or recreational and of federal, state or regional importance.

The second study, which focuses on the Pennsylvania side of the river, is being conducted by a partnership of state, regional, and local organizations to develop a Lower Delaware River Conservation Plan (LDRCP). The communities directly involved in the plan are Bensalem, Bristol, Falls, and Lower Makefield townships, and the boroughs of Bristol, Morrisville, Tullytown, and Yardley. With the guidance and support of all partners, the plan is being prepared by Heritage Conservancy through a grant from the PA Department of Conservation and Natural Resources (DCNR). The need for such a plan has become increasingly clear as population and development in these eight municipalities have grown. Residential and commercial expansion, if left unrestricted, can threaten the environmental stability and beauty of the Delaware River and tributaries. Because of the commitment of the citizens and government leaders of these communities, this proposed plan will aid in protecting this vital resource, mitigate potential damage from development, and improve access to public sections of the river.

Both studies recognize the importance of serving the needs of the people who live in the region. Public workshops are being held, and the attached survey was created to seek the opinions of residents. Your input is critical in our attempt to identify assets that should be preserved and problems that should be corrected. Issues of primary importance include: developing a recreational and protective greenway, developing public education programs, implementing best management practices to control erosion and sedimentation, strengthening natural resource ordinances and regulations, and cleaning up the river corridor.

Please take the time to complete the survey and return it in the enclosed self-addressed, stamped envelope to Heritage Conservancy by April 1, 1998.

Respectfully,

Jeffrey L. Marshall
Director of Resource Protection

Printing Compliments of Xerographic Copy Center

HERITAGE CONSERVANCY

Land Conservation • Historic Preservation

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RESIDENTS' SURVEY FOR LOWER DELAWARE RIVER CONSERVATION PLAN AND LOWER DELAWARE RIVER WILD & SCENIC RIVER MANAGEMENT PLAN

Please return by April 1, 1998

1. Presently, do you or your family participate in any of the following activities in or along the Delaware River or major streams?

- ☐ Canoeing
- ☐ Fishing
- ☐ Boat Fishing
- ☐ Nature Walks
- ☐ Biking or Hiking
- ☐ Cross Country Skiing
- ☐ Sight Seeing
- ☐ Running or Jogging
- ☐ Tubing
- ☐ Horseback Riding
- ☐ Bird Watching
- ☐ River Views from Home
- ☐ Sailing
- ☐ Kayaking
- ☐ Jet Skiing
- ☐ Motor Boating

If yes, where do you usually access the river?_____

2. Generally, how often do you or your family participate in these activities?

- ☐ More than 10 times per month
- ☐ More than 5 times per month
- ☐ Less than 5 times per month
- ☐ Never

3. How do you or your family find accessibility to the Delaware River?

- ☐ Easily accessible
- ☐ Somewhat easily accessible
- ☐ Not easily accessible

4. In your opinion, should access to the Delaware River be improved?

☐ Yes ☐ No

4a. If yes, what improvements should be made? _____

4b. If yes, where should additional access sites be provided?_____

5. If access were improved, would you or your family be more inclined to use the Delaware River?

☐ Yes ☐ No

6. If access were improved, in which activities would you or your family participate?

- ☐ Canoeing
- ☐ Fishing
- ☐ Boat Fishing
- ☐ Nature Walks
- ☐ Biking or Hiking
- ☐ Cross Country Skiing
- ☐ Sight Seeing
- ☐ Running or Jogging
- ☐ Tubing
- ☐ Horseback Riding
- ☐ Bird Watching
- ☐ Sailing
- ☐ Kayaking
- ☐ Jet Skiing
- ☐ Motor Boating
- ☐ River Views from Home

7. Do you feel that local, state or the federal government should be responsible for providing increased access to the Delaware River?

☐ Yes ☐ No

7a. If yes, then who should be responsible?

☐ Municipality ☐ County Park System
☐ State ☐ Federal Government

7b. If no, then who should be responsible?

☐ Builders ☐ Residents ☐ Private enterprise ☐ Recreational Clubs/Users only

7c. Are local, state, and federal agencies meeting the need for river access, conservation and management of resources on the Delaware River?

☐ Yes ☐ No ☐ No opinion

If no, which issues are neglected _____

8. Would you be willing to financially support capital improvements to improve access and recreational opportunities along the Delaware River?

Municipal Bond	☐ Yes	☐ No
Increased Taxes	☐ Yes	☐ No
Permits and/or User Fees	☐ Yes	☐ No

9. What municipality do you live in? _____

10. Do you own waterfront property?

☐ Yes ☐ No

If yes, where? _____

11. Please describe the way that your property is used (check all that apply):

☐ Primary Residence ☐ Governmental/Municipal
☐ Seasonal Residence ☐ Industrial Use
☐ Agricultural Use ☐ Open Space
☐ Commercial Use ☐ Wetlands, Marsh
☐ Other _____

12. Please check the three qualities or characteristics of the Delaware River area that are most important to you:

☐ it is a good place to live
☐ it is home to many important plant and animal species
☐ it is an important commercial and industrial resource
☐ it is an important natural and scenic resource
☐ it is an important tourism and recreational resource
☐ it is an important cultural and historic resource
☐ it is relatively undeveloped
☐ other (please specify) _____

13. Please indicate whether you would recommend encouraging or discouraging each of the following activities in the Delaware River Watershed:

	Encourage	Discourage
Preservation of undeveloped land	☐	☐
Residential development	☐	☐
Shopping centers and retail development	☐	☐
Other commercial development	☐	☐
Industrial development	☐	☐
Preservation of farmland and farming	☐	☐
Tourism	☐	☐
River-based recreational opportunities	☐	☐
Land-based recreational opportunities	☐	☐
Preservation of forested land	☐	☐
Preservation of historic resources	☐	☐
Maintain/improve water quality	☐	☐
Fishing opportunities	☐	☐
Preservation of scenic character	☐	☐
Protection of land owner rights	☐	☐
Protection of wildlife habitat	☐	☐
Maintain biodiversity	☐	☐

14. What concerns/issues do you have about recreational use of the Delaware River?
☐ safety ☐ noise ☐ water quality ☐ access ☐ trash ☐ other _____

15. I would support stronger land use regulations for the entire Delaware River watershed, not just for land with waterfront.
☐ strongly agree ☐ agree ☐ no opinion ☐ disagree ☐ strongly disagree

16. I would support stronger land use regulations only for properties with waterfront on the Delaware River and its main tributaries.
☐ strongly agree ☐ agree ☐ no opinion ☐ disagree ☐ strongly disagree

17. I would support stronger land use regulations only for properties with waterfront on the Delaware River.
☐ strongly agree ☐ agree ☐ no opinion ☐ disagree ☐ strongly disagree

18. I would support stronger land use regulations and programs that may be necessary to conserve and protect creek corridors.
☐ strongly agree ☐ agree ☐ no opinion ☐ disagree ☐ strongly disagree

19. I would support stronger land use regulations and programs as long as they did not affect the value or maintenance of my property in a negative way.
☐ strongly agree ☐ agree ☐ no opinion ☐ disagree ☐ strongly disagree

20. I do not support stronger land use regulation in any way.
☐ strongly agree ☐ agree ☐ no opinion ☐ disagree ☐ strongly disagree

21. I would support a conservation plan only for properties with waterfront on the Delaware River.
☐ strongly agree ☐agree ☐no opinion ☐disagree ☐strongly disagree

22. I would support a conservation plan only for properties with waterfront on the Delaware River and its main tributaries.
☐ strongly agree ☐agree ☐no opinion ☐disagree ☐strongly disagree

23. I would support a conservation plan for the entire Delaware River watershed, not just for land with waterfront.
☐ strongly agree ☐agree ☐no opinion ☐disagree ☐strongly disagree

24. I would support an overall conservation plan for creek corridors.
☐ strongly agree ☐agree ☐no opinion ☐disagree ☐strongly disagree

25. I would support a conservation plan and its programs as long as they did not affect the value or maintenance of my property in a negative way.
☐ strongly agree ☐agree ☐no opinion ☐disagree ☐strongly disagree

26. I do not support a conservation plan in any way.
☐ strongly agree ☐agree ☐no opinion ☐disagree ☐strongly disagree

27. If a conservation plan is favored, who should pay for it?
☐ Municipality ☐ County
☐ State ☐ Federal Government

28. Prior to receiving this questionnaire, had you heard about any conservation efforts along the Delaware River?
☐Yes ☐ No

28a. If yes, which efforts?
☐ Delaware River Greenway Partnership Program
☐ Delaware River Wild & Scenic River Study
☐ Lower Delaware River Management Plan currently being conducted by the National Park Service and the Delaware River Greenway Partnership
☐ Lower Delaware River Conservation Plan currently being conducted by Heritage Conservancy
☐ Other _____

28b. If yes, where did you receive your information?
☐ Newsletter (__Heritage Conservancy __Delaware River Greenway __other)
☐ Newspaper
☐ Attended a meeting
☐ Told by a friend
☐ Other _____

29. Do you have any additional comments regarding the future of river access?

STUDY AREA

ZONING CODE	ACRES	PERCENT
M-1 - MIXED USES	12037	21
R-4 - RES - >4 DU/AC	9438	16
R-3 - RES - 2 DU/AC TO 4 DU/AC	8884	15
R-2 - RES - 1 DU/AC TO 2 DU/AC	6743	12
R-1 - RESIDENTIAL - <1 DU/AC	6316	11
C-3 - COMMERCIAL COMBINED	3564	6
I-2 - HEAVY INDUSTRIAL	2815	5
I-3 - EXTRACTION	1632	3
OPS - OPEN SPACE	1288	2
IST - INSTITUTIONAL	1005	2
I-1 - LIGHT INDUSTRIAL	904	2
C-1 - RETAIL	92	0
C-2 - OFFICE	30	0

BENSALEM TOWNSHIP

ZONING CODE	ACRES	PERCENT
RES - 2 DU/AC TO 4 DU/AC	5198	39
COMMERCIAL COMBINED	1589	12
MIXED USES	1262	9
RESIDENTIAL - <1 DU/AC	1014	8
INSTITUTIONAL	1002	7
RES - >4 DU/AC	924	7
HEAVY INDUSTRIAL	804	6
OPEN SPACE	688	5
RES - 1 DU/AC TO 2 DU/AC	101	1
RETAIL	91	1
OFFICE	13	0

BRISTOL BOROUGH

ZONING CODE	ACRES	PERCENT
RES - >4 DU/AC	492	39
COMMERCIAL COMBINED	267	21
LIGHT INDUSTRIAL	160	13
HEAVY INDUSTRIAL	141	11
OPEN SPACE	20	2

BRISTOL TOWNSHIP

ZONING CODE	ACRES	PERCENT
RES - >4 DU/AC	5560	51
HEAVY INDUSTRIAL	1331	12
RES - 2 DU/AC TO 4 DU/AC	901	8
MIXED USES	784	7
LIGHT INDUSTRIAL	739	7
COMMERCIAL COMBINED	564	5
OPEN SPACE	470	4

FALLS TOWNSHIP

ZONING CODE	ACRES	PERCENT
MIXED USES	8276	49
RES - 2 DU/AC TO 4 DU/AC	2589	15
EXTRACTION	1643	10
RES - >4 DU/AC	1167	7
RES - 1 DU/AC TO 2 DU/AC	985	6
COMMERCIAL COMBINED	930	5
HEAVY INDUSTRIAL	453	3
OPEN SPACE	122	1
OFFICE	12	0
RESIDENTIAL - <1 DU/AC	10	0

LOWER MAKEFIELD TOWNSHIP

ZONING CODE	ACRES	PERCENT
RES - 1 DU/AC TO 2 DU/AC	5604	48
RESIDENTIAL - <1 DU/AC	5173	44
MIXED USES	551	5
COMMERCIAL COMBINED	77	1
RES - 2 DU/AC TO 4 DU/AC	35	0
RES - >4 DU/AC	21	0
OFFICE	6	0
OPEN SPACE	2	0

MORRISVILLE BOROUGH

ZONING CODE	ACRES	PERCENT
RES - >4 DU/AC	835	66
MIXED USES	249	20
COMMERCIAL COMBINED	61	5

TULLYTOWN BOROUGH

ZONING CODE	ACRES	PERCENT
MIXED USES	1046	78
RES - >4 DU/AC	190	14
COMMERCIAL COMBINED	48	4
RES - 2 DU/AC TO 4 DU/AC	6	0
HEAVY INDUSTRIAL	0	0

YARDLEY BOROUGH

ZONING CODE	ACRES	PERCENT
RES - >4 DU/AC	237	37
RES - 2 DU/AC TO 4 DU/AC	133	21
RESIDENTIAL - <1 DU/AC	99	15
RES - 1 DU/AC TO 2 DU/AC	52	8
MIXED USES	44	7
HEAVY INDUSTRIAL	41	6
COMMERCIAL COMBINED	5	1

STUDY AREA

LAND USE CODE	ACRES	PERCENT
AGRICULTURAL	3146	5
COMMERCIAL	3430	6
GOVERNMENT & INSITUTIONAL	3118	5
MINING & MANUFACTURING	7227	13
MULTI-FAMILY RESIDENTIAL	1484	3
PARKS,REC, & PROTECTED OPEN	3486	6
RURAL RESIDENTIAL	1214	2
SINGLE-FAMILY RESIDENTIAL	16948	29
TRANSPORTATION & UTILITIES	4279	7
VACANT	7765	14
WATER	2552	4
NO DATA	47	0

BENSALEM TOWNSHIP

LAND USE CODE	ACRES	PERCENT
SINGLE-FAMILY RESIDENTIAL	4327	32
VACANT	1619	12
GOVERNMENT & INSITUTIONAL	1540	11
COMMERCIAL	1508	11
MINING & MANUFACTURING	954	7
PARKS,REC, & PROTECTED OPEN	796	6
TRANSPORTATION & UTILITIES	756	6
MULTI-FAMILY RESIDENTIAL	690	5
RURAL RESIDENTIAL	243	2
AGRICULTURAL	206	2

BRISTOL BOROUGH

LAND USE CODE	ACRES	PERCENT
SINGLE-FAMILY RESIDENTIAL	235	19
COMMERCIAL	195	16
VACANT	163	13
MINING & MANUFACTURING	145	12
GOVERNMENT & INSITUTIONAL	121	10
TRANSPORTATION & UTILITIES	89	7
MULTI-FAMILY RESIDENTIAL	77	6
PARKS,REC, & PROTECTED OPEN	66	5
WATER	4	0

BRISTOL TOWNSHIP

LAND USE CODE	ACRES	PERCENT
SINGLE-FAMILY RESIDENTIAL	4380	40
VACANT	1234	11
MINING & MANUFACTURING	1190	11
TRANSPORTATION & UTILITIES	1053	10
GOVERNMENT & INSITUTIONAL	719	7
PARKS,REC, & PROTECTED OPEN	708	6
COMMERCIAL	686	6
MULTI-FAMILY RESIDENTIAL	236	2
WATER	112	1
RURAL RESIDENTIAL	51	0

FALLS TOWNSHIP

LAND USE CODE	ACRES	PERCENT
MINING & MANUFACTURING	4772	28
VACANT	2715	16
SINGLE-FAMILY RESIDENTIAL	2659	16
WATER	2178	13
TRANSPORTATION & UTILITIES	1376	8
PARKS,REC, & PROTECTED OPEN	903	5
COMMERCIAL	691	4
GOVERNMENT & INSITUTIONAL	382	2
AGRICULTURAL	228	1
MULTI-FAMILY RESIDENTIAL	144	1
RURAL RESIDENTIAL	11	0

LOWER MAKEFIELD TOWNSHIP

LAND USE CODE	ACRES	PERCENT
SINGLE-FAMILY RESIDENTIAL	4385	37
AGRICULTURAL	2712	23
VACANT	1784	15
PARKS,REC, & PROTECTED OPEN	718	6
RURAL RESIDENTIAL	616	5
TRANSPORTATION & UTILITIES	421	4
GOVERNMENT & INSITUTIONAL	222	2
MULTI-FAMILY RESIDENTIAL	213	2
COMMERCIAL	76	1
NO DATA	14	0
WATER	8	0
MINING & MANUFACTURING	3	0

MORRISVILLE BOROUGH

LAND USE CODE	ACRES	PERCENT
SINGLE-FAMILY RESIDENTIAL	583	46
COMMERCIAL	102	8
VACANT	99	8
TRANSPORTATION & UTILITIES	90	7
GOVERNMENT & INSITUTIONAL	74	6
MULTI-FAMILY RESIDENTIAL	69	5
MINING & MANUFACTURING	66	5
NO DATA	33	3
PARKS,REC, & PROTECTED OPEN	18	1
WATER	2	0

TULLYTOWN BOROUGH

LAND USE CODE	ACRES	PERCENT
TRANSPORTATION & UTILITIES	469	35
WATER	248	19
SINGLE-FAMILY RESIDENTIAL	146	11
COMMERCIAL	125	9
VACANT	69	5
MINING & MANUFACTURING	63	5
GOVERNMENT & INSITUTIONAL	39	3
PARKS,REC, & PROTECTED OPEN	26	2
MULTI-FAMILY RESIDENTIAL	10	1

YARDLEY BOROUGH

LAND USE CODE	ACRES	PERCENT
SINGLE-FAMILY RESIDENTIAL	233	36
PARKS,REC, & PROTECTED OPEN	125	19
VACANT	83	13
COMMERCIAL	46	7
MULTI-FAMILY RESIDENTIAL	45	7
MINING & MANUFACTURING	34	5
TRANSPORTATION & UTILITIES	23	3
GOVERNMENT & INSITUTIONAL	22	3
NO DATA	1	0

STUDY AREA

SOIL TYPE	ACRES	PERCENT
HATBORO SILT LOAM	1661	3
OTHELLO SILT LOAM	1372	2
DOYLESTOWN SILT LOAM, 0 TO 3 PERCENT SLOPES	1274	2
NANTICOKE-HATBORO SILT LOAMS	698	1
BOWMANSVILLE-KNAUERS SILT LOAMS	424	1
URBAN LAND-OTHELLO COMPLEX	169	0
DOYLESTOWN SILT LOAM, 3 TO 8 PERCENT SLOPES	53	0
FLUVAQUENTS	40	0
TOWHEE SILT LOAM, 0 TO 3 PERCENT SLOPES	32	0
Total	5721	10

BENSALEM TOWNSHIP

SOIL TYPE	ACRES	PERCENT
DOYLESTOWN SILT LOAM, 0 TO 3 PERCENT SLOPES	885	7
HATBORO SILT LOAM	562	4
OTHELLO SILT LOAM	295	2
TOWHEE SILT LOAM, 0 TO 3 PERCENT SLOPES	32	0
NANTICOKE-HATBORO SILT LOAMS	27	0
Total	1801	13

BRISTOL BOROUGH

SOIL TYPE	ACRES	PERCENT
HATBORO SILT LOAM	24	2
Total	24	2

BRISTOL TOWNSHIP

SOIL TYPE	ACRES	PERCENT
OTHELLO SILT LOAM	493	5
HATBORO SILT LOAM	437	4
NANTICOKE-HATBORO SILT LOAMS	74	1
Total	1004	9

FALLS TOWNSHIP

SOIL TYPE	ACRES	PERCENT
HATBORO SILT LOAM	518	3
OTHELLO SILT LOAM	516	3
NANTICOKE-HATBORO SILT LOAMS	438	3
DOYLESTOWN SILT LOAM, 0 TO 3 PERCENT SLOPES	85	1
Total	1557	9

LOWER MAKEFIELD TOWNSHIP

SOIL TYPE	ACRES	PERCENT
BOWMANSVILLE-KNAUERS SILT LOAMS	399	3
DOYLESTOWN SILT LOAM, 0 TO 3 PERCENT SLOPES	304	3
URBAN LAND-OTHELLO COMPLEX	169	1
NANTICOKE-HATBORO SILT LOAMS	111	1
HATBORO SILT LOAM	89	1
OTHELLO SILT LOAM	68	1
DOYLESTOWN SILT LOAM, 3 TO 8 PERCENT SLOPES	53	0
FLUVAQUENTS	40	0
Total	1232	11

MORRISVILLE BOROUGH

SOIL TYPE	ACRES	PERCENT
NANTICOKE-HATBORO SILT LOAMS	34	3
Total	34	3

TULLYTOWN BOROUGH

SOIL TYPE	ACRES	PERCENT
HATBORO SILT LOAM	31	2
NANTICOKE-HATBORO SILT LOAMS	14	1
Total	44	3

YARDLEY BOROUGH

SOIL TYPE	ACRES	PERCENT
BOWMANSVILLE-KNAUERS SILT LOAMS	25	4
Total	25	4

Element Ranking for the Pennsylvania Natural Diversity Inventory, 1992

Global Element Ranks:

G1 Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.

G2 Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.

G3 Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single western state, a physiographic region in the East) or because of other factors making it vulnerable to extinction throughout its range; in terms of occurrences, in the range of 21 to 100.

G4 Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.

G5 Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.

GH Of historical occurrence throughout its range, i.e., formerly part of the established biota, with the expectation that it may be rediscovered (e.g., Bachman's Warbler).

GU Possibly in peril range-wide but status uncertain; need more information.

GX Believed to be extinct throughout range (e.g., Passenger Pigeon).

State Element Ranks:

S1 Critically imperiled instate because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation from the state.

S2 Imperiled in state because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from the state.

S3 Rare or uncommon in state (on the order of 21 to 100 occurrences).

S4 Apparently secure in state.

S5 Demonstrably secure in state.

SA Accidental in state, including species recorded once or twice or only at very great intervals, hundreds or even thousands of miles outside their usual range or species which only sporadically breed in state.

SE An exotic established in state; may be native elsewhere in North America (e.g., house finch or catalpa in eastern states).

SH Of historical occurrence in the state, perhaps having not been verified in the past 20 years, and suspected to be still extant.

SN Regularly occurring, usually migratory and typically nonbreeding species for which no significant or effective habitat conservation measures can be taken in the state.

SR Reported from the state, but without persuasive documentation which would provide a basis for either accepting or rejecting (e.g., misidentified specimen) the report.

SRF Reported falsely (in error) from state but this error persisting in the literature.

SU Possibly in peril in state but status uncertain; need more information.

SX Apparently extirpated from state.

The Nature Conservancy
Arlington, Virginia
Natural Heritage Program Operations Manual
April 1982

Lower Delaware River Conservation Plan

Open Space Inventory

Township/Borough	Park Name	Acreage	Description
Bensalem	Delaware River Access Area	103.13	County Park
Bensalem Twp	Municipal Parks	139.50	total of 22 parks
Bensalem Twp	School District Recreational Open Space	307.00	leased by township for active and passive recreation
Bensalem Twp	Municipal Open Space	138.00	undeveloped open space
Bensalem, Bristol Twp	Neshaminy State Park	330.00	picknicking, boating, fishing, swimming
Total		**1017.63**	
Bristol Boro	Memorial Fields	15.00	sporting complex
Bristol Boro	Lions Riverfront Park	20.00	scenic open space
Bristol Boro	Jefferson Avenue Playground	5.00	playground, basketball, street hockey
Bristol Boro	Grundy Park	5.00	play equipment, pathways
Bristol Boro	RIRA Site	2.50	path to Delaware Canal
Bristol Boro	Pond Street Playground	1.00	
Bristol Boro	Grundy Ice Rink	7.00	
Bristol Boro	Maple & Otter Street Playground	3.00	
Bristol Boro	Spurline Park		2-mile trail
Bristol Boro	Bristol Marsh Preserve	25.00	Nature Conservancy
Bristol Boro	Delaware Canal		2-mile trail
Total		**83.50**	
Bristol Twp & Boro	Silver Lake	283.62	County Park
Bristol Twp	Black Ditch	116.95	County Park
Bristol Twp	Silver Lake (Delhaas Woods)	109.24	County Park
Bristol Twp, Middletown	Queene Anne	147.11	County Park
Bristol Twp, Middletown Twp	Frosty Hollow	98.34	County Park
Total		**755.26**	
Falls Twp	Fallsington Park	16.58	County Park
Falls Twp	Biles Island Preserve Lot #13-51-87	74.78	Falls Twp/Biles Island Wildlife Preserve
Falls Twp	Three Arches	1.53	Historic Home
Falls Twp	Von Hoffman Park	3.53	Lighted basketball courts, softball field/mini soccer field, playground equipment, tot lot, walking path
Falls Twp	Children's Corner	0.66	playground equipment, tot lot
Falls Twp	Penns Grant park	2.35	Playground equipment, tot lot, tennis courts
Falls Twp	Franklin Kirby Park	36.26	Lighted basketball courts, playground equipment, tot lot

Falls Twp	New Pond Park	8.84	Basketball courts, playground equipment, tot lot
Falls Twp	Mill Creek Manor Park	0.90	Playground equipment, picnic tables on Delaware Canal
Falls Twp	Valley Day Park	0.50	Tot lot
Falls Twp	Mill Creek Sports Complex	14.60	6 lighted ballfields including a handicap field, concession stand, 3 mini soccer fields
Falls Twp	William's Tract	2.00	Soccer field
Falls Twp	Austin Drive Athetic Fields	4.00	3 baseball fields, concession stand
Falls Twp	Quaker Penn Park Lot #13-50-1.2	32.15	Pavilion, picnic tables & grills, walking paths and 3 soccer fields adjacent Pennsbury Manor
Falls Twp	Trenton Road Park Lot #13-16-341, 13-19-625	37.27	wooded nature trails near Vermilion Hill
Falls Twp	Fallsington Commemorative Park Lot #13-32-15	2.68	Gazebo, gardens, walkways near Fallsington
Falls Twp	Lot #13-15-1	72.20	adjacent Oxford Valley Park
Falls Twp	Community Park Lot #13-40-9	228.00	9 athletic fields, 70 acre lake, bike/pedestrian paths, picnic pavilion, concession stand, to open Fall of 1999
Falls Twp	Pennsbury Manor	44.00	historic site, state park
Falls, Middletown Twp	Oxford Valley	220.46	County Park
Falls, Tullytown	Walt Disney School	19.99	rec equipment and facilities
Falls, Tullytown	Levittown Lakes	30.73	boating, fishing
Total		**854.01**	
Lower Makefield	Falls of the Delaware	125.71	County Park
Lower Makefield Twp	Macclesfield Park	91.90	Township park adjacent Delaware Canal
Lower Makefield Twp	Oxford Valley-Roelofs Road	22.00	recreation
Lower Makefield Twp	Vargo Tract	62.00	Township park with farm structures
Lower Makefield Twp	Delaware Canal State Park	36.50	along the canal and river
Lower Makefield, Falls Twp	Five Mile Woods	335.00	forest preserve
Total		**673.11**	
Morrisville Boro	Gray Stones	6.10	woodland
Morrisville Boro	Williamson Park	35.00	riverfront park
Total		**41.10**	
Tullytown	Borough Park	2.00	adjacent Municipal Building
Total		**2.00**	
Yardley Boro	Buttonwood Park	< 2	walkways, gardens, gazebo
Yardley Boro	Delaware Canal State Park	< 9	canoeing, fishing, hiking
Total		**< 11**	
	Total Acreage	**3427**	

E. Animals of Silver Lake Nature Center:

Since no faunal studies have been made of the area, the following lists are based on known geographic ranges and habitat preferences. Where specific identifications have been made, an asterisk so indicates. Subspecies epithets are used only where more than one subspecies occurs in PA.

1. Class Mammalia (Phylum Chordata, Subphylum Vertebrata)

Identifications occur through accidental encounters, or individuals found dead. Tracks, scats, nests, trails, tunnels and evidence of feeding may give clues to mammalian activity and identity. Most mammals are nocturnal but Cottontail Rabbits, Woodchucks and Gray Squirrels are frequently encountered on trails or attracted to bird feeders. Opossums, Raccoons and Norway Rats have been observed raiding feeders at night. Deer are attracted to fallen apples in the old orchards and have ventured from Delhaas Woods. Bats are often observed but are difficult to identify in the field (even dead in the hand).They tend to migrate and wander far from breeding areas, so any eastern species might occur. Mist netting (of bats) and systematic trapping are needed to determine the status of those species not confirmed.

a. Order Marsupialia Family Didelphidae

*Virginia Opossum (*Didelphis virginiana*) - Common omnivorous scavenger; raids bird feeders; woods close to water but visits all other habitats.

b. Order Insectivora Family Soricidae

Masked Shrew (*Sorex cinerius*) - prefers moist woodland; old fields with good ground cover.

Maryland Shrew (*Sorex fontinalis*) - only recently recognized as district species. Moist habitats, sedge-grass meadows, woodlands, hedgerows, where Japanese Honeysuckle grows.

*Northern Short-tailed Shrew (*Blarina brevicauda talpoides*) - common all habitats; often found dead; feeds on spilled seed at bird feeders.

Least Shrew (*Cryptotis parva*) - populations widely scattered; dryer, old fields, meadows, abandoned fields.

Family Talpidae

*Eastern Mole (*Scalopus aquaticus*) - common in dryer areas; feeds on earthworms under bird feeders.

*Star-nosed Mole (*Condylura cristata*) - common in wet soils; water.

c. Order Chiroptera Family Vespertilionidae - frequently seen at dusk.

*Little Brown Myotis (*Myotis lucifugus*) - Most common bat in PA., hunts and lives near water.

Keen's Myotis (*Myotis Keeni*) - uncommon; may be more upland; hunts over trees and ponds.

Small-footed Myotis (*Myotis leibii*) - Rare; forages over ponds and streams.

Silver-haired Bat (*Hasionycteris noctivagans*) - forests; forages near ponds and streams. May be here during migration.

Eastern Pipistrelle (*Pipistrellus subflavus*) - forages in forests, along edges of woods with ponds and streams.

*Big Brown Bat (*Eptesicus fuscus*) - common; most often seen.

*Red Bat (*Lasiurus borealis*) - forest edges, orchards, old fields; attracted to lights (to feed on insects); observed on tree at S. L.

*Hoary Bat (*Lasiurus cinereus*) - Similar to Red Bat; may be here only on migration; collected within 3 miles of S. L. (dead).

Evening Bat (*Nycticeius humeralis*) - known from Bucks Co., general feeder, usually above trees.

d. Order Lagomorpha Family Leporidae

*Eastern Cottontail (*Sylvilagus floridanus mearnsii*) - very common in almost all habitats where adequate ground cover; often seen on lawns.

e. Order Rodentia Family Sciuridae

*Woodchuck (*Marmota Monax Monax*) - Common; lawns, fields, old fields, young woods; attracted to bird feeders.

*Gray Squirrel (*Sciurus carolinensis*) - Common; woods, lawns, bird feeders.

Southern Flying Squirrel (*Glaucomys volans*) - woods; bird houses, hollow trees.

Family Cricetidae

*White-footed Mouse (*Peromyscus leucopus*) - Common; woods, old fields, field edges; invades buildings; bird feeders

*Meadow Vole (*Microtus pennsylvanicus*) - Common; old fields, meadows, marsh, woods edges.

Woodland or Pine Vole (*Microtus pinetorum*) - woods with thick humas, herb layer, loose sandy soil of old fields; thickets; edges of agricultural land, old orchards.

Southern Bog Lemming (*Synaptomys cooperi stonei*) - old fields of poverty grass, timothy, broomsedge, woody plants; ground pine and mosses.

*Muskrat (*Ondatra zibethicus zibethicus*) - Houses, tunnels at pond edges; marshes; occasionally observed daytime.

Family Muridae

*Norway Rat (*Rattus norvegieus*) - attracted to spilled bird seed, open fields

House Mouse (*Mus musculus*) - usually in buildings; wild colonies may occur in woods, fields.

Family Zapodidae

*Meadow Jumping Mouse (*Zapus hudsonius*) - meadow/marsh; hibernates.

f. Order Carnivora Family Canidae

*Red Fox (*Vulpes vulpes*) - old fields, borders of pastural farmlands.

*Gray Fox (*Urocyon cinereoargenteus*) - forests; hunts a variety of habitats.

Family Procyonidae

*Racoon (*Procyon lotor*) - scavenges; eats bird feed; tracks frequent in wet areas, woods; hunts a variety of habitats.

Family Mustelidae

Ermine (*Mustela erminea*) - open woods, thickets, hedge rows usually close to water.

Long-tailed Weasel (*Mustela frenata*) - forest edges, thickets; near water.

*Mink (*Mustela vison vison*) - formerly trapped (C. King); observed once; marshy shorelines of ponds.

*Striped Skunk (*Mephitis mephitis*) - all habitats often close to humans; usually disturbed habitats.

g. Order Artiodactyla

*White-tailed Deer (*Odocoileus virginianus*) - attracted to apples in old orchards; strays from Delhaas Woods to other areas of park.

h. References

1. Doutt, J. K. *et. al.* MAMMALS of PA, PA Game Commission, 1973
2. Genoways, H. H. and F. J. Brenner (eds) SPECIES OF SPECIAL CONCERN IN PA. Carnegie Museum of Natural History, 1985
3. Merritt, J. F. GUIDE TO MAMMALS OF PA. U. of Pittsburgh Press, 1987
4. Tuttle, M.D. AMERICAS NEIGHBORHOOD BATS. U. of Texas Press, 1988
5. Whitaker, J. O. THE AUDUBON SOCIETY FIELD GUIDE TO NORTH AMERICAN MAMMALS. Alfred A. Knopf, 1980

2. BIRDS (Phylum Chordata, Subphylum Vertebrata, CLASS AVES)

a. Birds are usually the most conspicuous and familiar animals and the best recorded group for the nature center (see Mercer, R.A. *et al*) but records need up-dating. Among the most mobile animals, the species populations shift not only from season to season and year to year, but are less confined to specific habitats. They are often opportunistic feeders (thus easily attracted by artificial feeding) and often observed out of expected habitat if a food source becomes available there. Despite this, each spp. is remarkebly predictable , both as to season and habitat.

b. Because of diverse feeding habits and abundance, birds interact with each other and virtually all other macroscopic (and many microscopic) biota (taxons). They exert population control on many animals and plants, aid plant dispersal, and occasionally pollination, transport aquatic organisms from wetland to wetland, provide food for predators and parasites, and play a considerable role in mineral recycling (through excretions and

physical dismembering of dead plant material). Birds' interactions with humans are well covered by Stefferud and Nelson's BIRDS IN OUR LIVES, U.S. Government Printing Office.

c. An asterisk indicates known or probable breeding in the nature center. Others are either temporary visitors from the area or seasonal migrants. Since common names have been standardized by the American Ornithological Union (A.O.U.), scientific names are not given. Over 170 spp. have been recorded within the nature center boundaries, so only the more common or conspicuous spp. will be mentioned. Kitson's compilation of Bucks County records gives some indication of possible and probable occurrance.

d. Open Wetlands: Birds feed as active predators on aquatic animals or, by filtering small aquatic plants, algae, and tiny organism from the water. They also consume seeds and tubers of aquatic plants. Small land birds utilize seeds/fruit of wetland plants and their insect populations. They may also nest or roost here. Hawks and owls prey on vertetrates in the course of their unting rounds. Typical spp. include the small diving Pied-billed Grebe, the wading herons: Great Blue Heron, and Great Egret (in late summer especially), and an occasional summer roost of immuture Black-crowned Night Herons. A summer resident is the small Green-backed Heron*. In recent years Double-crested Cormorant have become regular visitors. Water Fowl are always present (unfortunately mixed with abandoned domestic breeds with which they may hybridize). Canada Goose* increases in fall from migrants; Mallards* are residents as are the much less abundant Wood Duck* best seen from the observation platform. Many other spp. visit and may occasionally breed. The Ring-necked Pheasant* formerly was abundant in the grand marsh but as elsewhere, it's populations have dropped drastically. This is also a good area for the Red -tailed Hawk and other raptors such as Osprey in migration and probably a hunting ground for owls. Rails are scarce though the American Coot occasionally visits. American Woodcock* prefer swamps and wet meadows and may be heard in spring when they perform their mating rituals. Other shore birds, such as Solitary Sandpipers and Common Snipe may be seen in spring migrations, but the Spotted Sandpiper probably breeds here. Ring-billed Gulls are always abundant especially in fall and winter. Other spp. of gulls and terns have been recorded. The Belted Kingfisher is regular year round. 5 spp. of Swallows have been recorded and with the Chimney Swift are regularly seen feeding over open water. The following small birds are associated with wetlands (usually summer nesting). Eastern Phoebe*, Willow Flycatcher*, Yellow Warbler*, Northern Water Thrush (migrating through), Northern Yellowthroat*, Red-winged Blackbird*, Swamp Sparrow*, and Song Sparrows* (a variety of habitats).

e. Forest and Forest Edge (also scattered trees). The strata of forest where the spp. is usually found is indicated by c= canopy, u=understory, s=shrub,

h=herb/ground; see Ehrlich, *et al.* Note that much of the forest tends to be ecotone or Swamp Forest.

(1). Residents: Mourning Dove* (c,u,h, also fields, lawns)Great Horned Owl* (c,u), Eastern Screech Owl* (u), Northern Flicker (u,h), Red-bellied Woodpecker*(c,u), Downy Woodpecker*, Hairy Woodpecker* (c,u), Blue Jay* (c,u), AmericAn Crow* (c,u, open habitats), Tufted Titmouse* (c,u), Carolina Chickadee* (c,u), White-breasted Nuthatch* (c,u), Carolina Wren* (s,h), Cedar Waxwing (c.u.s), Northern Cardinal* (u,s,h), Rufous-sided Towhee* (s,h), Brown-headed Cowbird* (c,u,s,h - brood parasite of small birds), Common Grackle* (c,u,h - most migrate).

(2). Migrants: Yellow-billed Cuckoo* (c,u), Ruby-throated Hummingbird (c,u,s,h), Yellow-bellied Sapsucker (c,u), Great Crested Flycatcher* (c,u), Eastern Wood Peewee* (c,u), Brown Creeper (c,u,s), House Wren* (s), Golden-crowned/Ruby-crowned Kinglets (u,s), Blue-gray Gnatcatcher (c,u), Wood Thrush* (u,s,h), Veery* (s,h), Hermit Thrush (u,s), American Robin* (c,u,s,h, some prob. resident), Gray Catbird* (u,s), Brown Thrasher* (s), Red-eyed Vireo* (c,u), other Vireos migrating through (c,u,s), Yellow-rumped Warbler (u,s), Ovenbird* (s,h), other Wood Warblers migrating through (c,u,s), Rose-breasted Goosbeak* (u), American Tree Sparrow (s,h), Dark-eyed Junco (s,h), White-throated Sparrow (s,h), Fox Sparrow (s,h), Northern Oriole* (c,u), Scarlet Tanager (c,u).

f. Fields and Old Fields: Typically resident spp. such as Field Sparrow*, and American Gold Finch* are replaced as old fields develop by shrub and understory spp. from the forest (Catbird, Brown Thrasher, Cardinal, Song Sparrow) so there is considerable overlap with the forest. Grass and weed seeds, fruit, galls, egg cases and stem borers attract forest spp. to forage in winter, especially in this habitat. Raptors, such as American Kestrel, hunt for small mammals, birds, and large insects here, though they nest in trees. The Indigo Bunting* is an old field sp. To ensure the continued presence of true field spp. controlled cutting and mowing is necessary.

g. Human-made Structures/Environments: Many spp. take advantage of un-natural situations (buildings, bridges, poles, fences, artificial nest boxes, landscape plantings, specimen trees) to nest and some such as the European Starling*, House Sparrow* and Rock Dove have become virtual year-round commensals with humans. Unfortunately the first two spp. also compete with native spp. for nesting holes. Barn Swallow*, House Wren*, House Finch*, and Chipping Sparrow* are nature center examples. The House Finch, a resident sp., was introduced from the west, the others are summer migrants. The Northern Mockingb ird might also be cited because of its relationship to, it not dependence on human-altered habitats.

h. References

Ehrlich, P. R. *et al* , THE BIRDER'S HANDBOOK: A FIELD

GUIDE TO THE NATURAL HISTORY OF NORTH AMERICAN BIRDS, Simon and Schuster, 1988

Kitson, K. (Compiler), BUCKS COUNTY BIRD DATA, Silver Lake Nature Center, 1991

McElroy, T.P. THE HABITAT GUIDE TO BIRDING, Alfred A. Knopf, 1974

Mercer, R.A. *et al*, BIRDS OF SILVER LAKE (check list), Silver Lake Nature Center, no date.

3. Class Reptilia (Phylum Chordata, Subphylum Vertebrata)

This group of animals tends to be secretive and, even when abundant, may be seldom seen. The species record for Silver Lake is incomplete requiring much more study. Monitoring of Redbelly Turtles (19 81-1988) has produced a good record of the aquatic turtles, but the apparent discovery of an Eastern Mud Turtle may indicate that the trapping methods used may still have been inadequate. Exotics (as in the case of the Red-eared Slider) may have been introduced.

a. Order Testudines

(1) Family Kinosternidae

?Eastern Mud Turtle (*Kinosternon subrubrum*)

Habitat - ponds, streams with mud bottoms, grasslands or open woods; endangered in PA; less aquatic than Stinkpot.

Food - invertebrates, small fish, tadpoles, carrion.

*Common Musk Turtle (*Sternotherus odoratus*)

Habitat - streams, ditches, ponds; almost any permanent body of water; nocternal but basks occasionally.

Food - mostly animal matter; invert. and vert.; some plants; carrion.

(2) Family Chelydridae

*Common Snapping Turtle (*Chelydra serpentina*)

Habitat - still or slow-moving water with muddy bottom and ample vegetation.

Food - about 1/3 plants; remainder fish and aquatic vertebrates and invertebrates; carrion.

(3) Family Emydidae

Spotted Turtle (*Clemmys guttata*)

Habitat - has not been found here but known from drainage system/area; semi-aquatic.

Food - insects, small invertebrates, occasionally frogs, carrion; rarely plants, berries.

Wood Turtle (*Clemmys insculpta*)

Habitat - as above; semi-aquatic to terrestrial (mostly).

Food - omnivorous; fruit, berries, tender leaves; invertebrates, carrion.

Bog Turtle (*Clemmys muhlenbergii*)

Habitat - has not been found here but known from drainage system/area semiaquatic; endangered in PA; bogs, marshes, swamps.

Food - berries, insects, worms, prob. carrion.

*Eastern Box Turtle (*Terrapene carolina*)

Habitat - terrestrial; diurnal; open woods; aestivates; hibernates on land.

Food - omnivorous: fruit, carrion, vegetables, flowers, insects, worms, small vertebrates.

*Painted Turtle (*Chrysemys picta*) - At Silver Lake apparently all *C. p. picta* or hybrids with *C. picta marginata* but other subspecies may have been introduced and hybrids may occur.

Habitat - basks; permanent ponds, slow streams.

Food - 65% plants, algae; 20% insects including mosquito larvae; occasionally other invertebrates and carrion.

*Red-eared Slider (*Trachemys scripta*) - Pet Store *T. s. elegans* (Red-eared) have been introduced.

Habitat - basks; introduced in drainage; known from Magnolia Lake; aquatic.

Food - omnivorous: insects, mollusks, aquatic invertebrates; water plants; carrion.

*Redbelly Turtle (*Pseudemys rubriventris*)

Habitat - PA endangered; Silver Lake/Magnolia Lake; largely aquatic; basks.

Food - omnivorous: invertebrates, small aquatic animals, carrion, plants.

b. Order Squamata

(1) Suborder Lacertilia

Five-lined Skink (*Eumeces faciatus*)

Habitat - terrestrial, burrows; area record; humid woodlands; diurnal.

Food - insects, larvae, earthworms, spiders, small mice.

Northern Fence Lizard (*Scaloporus undulatus*)

Habitat - open woodlands; sunny situations; diurnal; mostly arboreal.

Food - insects, spiders, centipeds, esp. beetles.

(2) Suborder Serpentes - Family Colubridae

Eastern Ribbon Snake (*Thamnophis sauritus sauritus*)

Habitat - marshy meadows; pond edges

Food - fish, frogs, salamanders.

*Eastern Garter Snake (*Thamnophis sirtalis*)

Habitat - almost all habitats usually near water.

Food - small mammals, birds, fish, frogs, toads, salamanders, earthworms.

Eastern Smooth Earth Snake (*Virginia valeriae*)

Habitat - damp deciduous forest, wooded residential areas, secretive.
Food - earthworms, slugs, snails, small frogs.

*Northern Water Snake (*Nerodia sipedon*)
Habitat - all aquatic situations.
Food - fish, frogs, salamanders, small mammals, cray fish, young turtles.

Queen Snake (*Regina septemvittata*)
Habitat - streams (sandy bottomed) ; proper habitat probably lacking here.
Food - crayfish.

Brown Snake (*Storeria dekayi*)
Habitat - found in area; moist woodland, marshes, swamps, vacant lots, almost anywhere.
Food - slugs, earthworms, snails.

Redbelly Snake (*Storeria occipitomaculata*)
Habitat - sphagnum bogs, hilly uplands; unlikely here; rare in PA.
Food - slugs, earthworms.

Northern Ringneck Snake (*Diadophis punctatus*)
Habitat - damp woods, grasslands.
Food - salamanders, small frogs, earthworms, insects, slugs, newborn snakes.

Eastern Worm Snake (*Carphophis amoenus*)
Habitat - damp woodlands; near streams; secretive, burrows
Food - earthworms, grubs.

Eastern Hognose Snake (*Heterodon platirhinos*)
Habitat - open, sandy soil areas, woodland meadows.
Food - toads, small frogs, salamanders.

Eastern Milk Snake (*Lampropeittis triangulum*)
Habitat - found in area; varied habitat open woodland, suburban areas.
Food - small mammals; rodents, shrews, moles; other snakes, small verbebrates.

*Northern Black Racer (*Coluber constrictor*)
Habitat - old fields, open woodland fields; diurnal
Food - small rodents, shrews, frogs, toads, fish, birds, other snakes.

4. Class Amphibia

Much dependent on water for breeding. The destruction of wetlands, especially the small, fishless often temporarily wet areas have restricted populations in our area to protected parkland, such as the Mill Creek Valley Park System. All are carnivorus as adults; tadpoles mostly vegetarian.

a. Order Caudata Family Ambystomatidae

Spotted Salamander (*Ambystoma maculatum*)

Habitat - Known from Bristol Twp; secretive, breeds early, often in temporary pools; burrows;woods.

Food - carnivorous at all stages.

Family Salamandridae

Red-spotted Newt (*Notophthalmus viridescens*)

Habitat - Red Eft stage missing on coastal plain; requires permanent water, pond or slow stream; dense aquatic vegetation.

Food - worms, crustacians, molluscs, amphibian eggs, larvae, fish eggs.

Family Plethodontidae

Northern Dusky Salamander (*Desmognathus fuscus*)

Habitat - common in Mill Creek drainage; suitable flowing stream; not in Nature Center; land edge of streams, springs.

Food - insect larvae, sowbugs, earthworms; nocturnal.

Northern Two-lined Salamander (*Eurycea bislineata*)

Habitat - common in Mill Creek drainage; suitable stream habitat not in Nature Center; at stream edges; possibly springs, swamps.

Food - this sp. and all the following eat tiny invertebrates; nocturnal.

Long-tailed Salamander (*Eurycea longicauda*)

Habitat - moist land areas near springs; suitable habitat may be missing here; possible floodplains (wooded).

Food - as above.

*Northern Red Salamander (*Pseudotriton ruber*)

Habitat - common in Mill Creek drainage; associated with springs in Delhaas Woods; also cool, clear brooks and adjacent woods.

Food - as above; fond of earthworms.

*Redback Salamander (*Plethodon cinereus*)

Habitat - terrestrial (even for breeding) in woods.

Food - as above.

Four-toed Salamander (*Hemidactylium scutatum*)

Habitat - terrestrial, associated with sphagnum; bogs; streams, possible flood plains in adjacent forests.

Food - as above.

b. Order Salientia Family Bufonidae

*American Toad (*Bufo americanus*)

Habitat - nocturnal; woods but wanders to open areas.

Food - insects; small invertebrates.

*Fowler's Toad (*Bufo woodhousii fowleri*)

Habitat - mostly nocturnal; sandy areas, more open areas.

Food - insects, small invertebrates.

Family Hylidae

Northern Cricket Frog (*Acris crepitans*)

Habitat - known in area; terrestrial except when breeding; marshes; fishless pools, ditches, often temporary water.

Food - insects, small invertibrates

Greater and Lesser Gray Treefrog (*Hyla versicolor or Hyla chrysoscelis*)

Habitat - woody areas, arboreal; breeds in fishless, often temporary pools.

Food - insects; small invertebrates.

*Northern Spring Peeper (*Pseudacris crucifer*)

Habitat - terrestrial except when breeding; small fishless pools, marshes, ditches, often temporary water.

Food - insects, small invertebrates.

New Jersey Chorus Frog (*Pseudacris triseriata kalmi*)

Habitat - endangered in PA (possibly extirpated) fishless pools, ditches usually temporary; terrestrial except when breeding; woods

Food - insects; small invertebrates.

Family Ranidae

*Wood Frog (*Rana sylvatica*)

Habitat - known from area; slow streams, ditches, ponds (often temporary) near woods, terrestrial except breeding.

Food - any live animal small enough to swallow.

*Bullf rog (*Rana catesbaiana*)

Habitat - aquatic; permanent water: lakes, ponds, slow streams, occasionally wanders but usually in or close to water; nocturnal.

Food - any live animal small enough to swallow, cannibalistic.

*Green Frog (*Rana clamitans*)

Habitat - aquatic; lakes, ponds, slow streams ; mostly nocturnal; stays close to water.

Food - any live animal small enough to swallow, cannibalistic.

*Southern Leopard Frog (*Rana utricularia*)

Habitat - endangered in PA; marshes, ditches, small ponds without fish; wanders from water.

Food - any live animal small enough to swallow, cannibalistic.

Pickerel Frog (*Rana palustris*)

Habitat - abundant in area; slow-moving water, swamps, meadows; wanders away from water.

Food - any live animal small enough to swallow, cannibalistic.

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FISHES: The variety of aquatic habitats in the Mill Creek drainage is <u>not</u> repeated within the S. L. N. C. boundaries, thus the diversity is reduced somewhat. This list is based on limited information and probability of occurance by range and habitat. Obviously not all will occur. Stocking and careless or accidental introductions may account for some of these or others not listed.

5. Class Agnatha (Jawless Fishes) Family Petromyzontidae
   Sea Lamprey (*Petromyzon marinus*)

6. Class Osteichthyes (Bony Fishes)
   a. Family Anguillidae
      American Eel (*Anguilla rostrata*)
   b. Family Umbridae
      Eastern Mud Minnow (*Umbra pygmaea*)
   c. Family Esocidae
      *Grass or Redfin Pickerel (*Esox americanus*)
      Chain Pickerel (*Esox niger*)
   d. Family Cyprinidae
      Goldfish (*Carassius auratus*) hybidizes with Carp
      *Common Carp (*Cyprinus carpio*)
      Golden Shiner (*Notemigonus crysoleucas*)
      Fallfish (*Semotilus corporalis*)
      Cutlips Minnow (*Exoglossum maxillingua*)
      Eastern Silvery Minnow (*Hybognathus regius*)
      Spotfin Shiner (*Cyprinella spiloptera*)
      Fathead Minnow (*Pimephales promelas*)
      Bluntnose Minnow (*Pimephales notatus*)

Bridle Shiner (*Notropis bifrenatus*)
Spittail Shiner (*Notropis hudsonius*)

e. Family Catostomidae
Quillback (*Carpiodes cyprinus*)

f. Family Ictaluridae
*Channel Catfish (*Ictalurus punctatus*)
White Catfish (*Ameiurus catus*)
Yellow Bullhead (*Ameiurus natalis*)
Brown Bullhead (*Ameiurus nebulosus*)
Tadpole Madtom (*Noturus gyrinus*)

g. Family Aphredoderidae
Pirate Perch (*Aphredoderus sayanus*) - considered extinct in PA; last records in Mill Creek; apparently suitable habitat still exists.

h. Family Fundulidae
Banded Killifish (*Fundulus diaphanus*)

i. Family Poeciliidae
Mosquitofish (*Gambusia affinis*)

j. Family Centrarchidae
Black Crappie (*Pomoxis nigromaculatus*)
White Crappie (*Pomoxis annularis*)
Mud Sunfish (*Acantharchus pomotis*)
Banded Sunfish (*Enneacanthus abesus*)
Bluespotted Sunfish (*Enneacanthus gloriosus*)
Blackbanded Sunfish (*Enneacanthus chaetodon*)
*Largemouth Bass (*Micropterus salmoides*)
Smallmouth Bass (*Micropterus dolomieu*)
Green Sunfish (*Lepomis cyanellus*)
*Bluegill (*Lepomis macrochirus*)
Redear Sunfish (*Lepomis microlophus*)
*Pumpkinseed (*Lepomis gibbosus*)
Orangespotted Sunfish (*Lepomis humilis*)

k. Family Percidae
Yellow Perch (*Perca flavescens*)
Johnny Darter (*Etheostoma nigrum*)
Tesselated Darter (*Etheostoma olmstedi*)
Swamp Darter (*Etheostoma fusiforme*)

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F. Invertebrates

The almost total lack of specific data for our area prescribes, at best, a general survey of the vast majority and probably most important groups of animals found at Silver

Lake/Delhaas Woods. Butterflies, some moths, and dragonflies are conspicuous and colorful and sufficient detailed literature exists to give us more information which has been utilized in the following account. The old term, "invertebrate", has lost its scientific significance in classification but is still widely used as a handy catch-all for the forms of animate life out-numbering, in species and individuals, all the scaly, furry and feathered groups combined by factors of 100,000 or more. Even in our limited area of concern, the insect species, alone, numbers in the thousands. This is a fertile field for study for amateurs and scientists which could encompass several lifetimes. These organisms, in their daily activities, ensure much of our food supply not only through pollination and recycling of nutrients but by providing the stability of our environment, the so-called "balance of nature", through a fascinating web of interconnecting relationships involving cooperation, predation, parasitism, commensalism and mutualism. Much of the fun and learning provided by the Silver Lake Nature Center staff revolves around these abundant life forms.

1. Phylum Anthropoda, Class Crustacea - Best represented in saline waters and tropical land areas.

a. Crayfish and Freshwater Prawns (*Order Decapoda*) 5-10 species in PA of genera *Procambarus, Cambarus, Orconectes, Paloemonetes* (Freshwater Prawns). Exoskeleton is a favorable habitat for microorganisms, algae and sessile Protozoa; Branchiobdlellida (oligochaete worms), parasitic or commensal on gills, and various surfaces and appendage bases; for intermediate hosts of parasitic lung fluke (man, other carnivores) transmitted by eating raw or poorly cooked crayfish; important food for vertebrates esp. fishes, frogs, turtles, wading birds, raccoons, mink may help control water weeds; fish bait. Omnivorous, seldom predaceous, scavengers.

b. Order Amphipoda (Scuds, sideswimmers) many species probably including *Hyalella azteca, Gammaridae (Gammarus, Crangonyx).* Omnivorous, general scavengers, rarely attack living animals; nocturnal; cling to objects, hide under rocks, debris, most common in unpolluted shallow water (*Hyalella* may go below 1m depth); intolerent of high temperatures or extreme changes. Food for fishes, birds, amphibians and predaceous aquatic insects; support sessile protozoa, algae on exoskeleton; intermediate hosts for parasites such as tape worms (water fowl, fishes), nematodes, trematodes, acanthocephala (birds, fishes, amphibians).

c. Order Isopoda (Sow Bugs, Pill Bugs, Roly-poly's) - probably one sp. for each aquatic habitat, (genera *Lirceus, Asellus* and one sp. parasitic on Freshwater Prawns);Scavengers, dead and live vegetation; under rocks and debris; in shallow water; nocturnal; freshwater forms indicator of pollution; many occasionally do damage to plants. Aquatic forms intermediate hosts for parasitic nematodes, acanthocephala of birds, fishes and amphibians; most are terrestial: Trichoniscids found in wet spots; Family Armadillidiiad (Pill Bugs) can roll into ball; Sow Bugs (Family Oniscidae) generally cannot. All are sensitive to humidity

seeking moist places under rocks, debris; nocturnal. Food similar to aquatic forms; important humus makers; bad tasting to many predators.

d. Order Ostracoda (Seed Shrimps) Many spp. occupying all aquatic (shallow) habitats; some can survive in dried mud; found on algae, living and dead vegetation, mud and gravel. Many are diurnal seeking light. Some are commensal on crayfish gills; may be intermediate hosts for parasites of fish and water fowl; often seasonal in occurance; feed on bacteria, molds, algae, fine detritus, occasionaly living on dead animals; omnivorous scavangers; eaten by fish and other aquatic animals; trapped by bladderworts.

e. Order Eubranchiopoda (Fairy Shrimp) appear in spring in temporary, small pools; eggs survive in substrate; eat algae, bacteria, Protozoa, rotifers and bits of detritus; eaten by amphibians, insect larvae.

f. Order Cladocera (Water Fleas) often seasonal; many species (genus *Daphnia* best known) may be found here; filter feed on algae, Protozoa, organic detritus, bacteria. Found in still water, shallow or part of zooplankton; important food for all aquatic predators including fishes.

g. Order Copepods: genus *Cyclops* best know; found in all slow-moving or still water at all depths; many possible species; feed on organic detritus from bottom; plankton filter-feeders; some parasitic on body, fins or gills of fish; important food, to some extent, for other aquatic animals. Some are intermediate hosts for fish tapeworm; may be seasonal in occurance; form drought resistant eggs or cysts dispersed by wind.

2. Phylum Arthropoda Class Arachnida, Order Araneae (spiders). All spiders feed upon other live organisms mostly insects; some are cannibalistic. They vary in size, method of prey capture and choice of habitat. All of ours have poison fangs to kill or paralyze prey and produce silk (but not all build webs). The most prominent of families in the nature center are listed here:

a. Dictynidae; sticky irregular mesh net at edges of woods, fields in crevices, under leaves and tips of plant stems.

b. Theridiidae (Cobweb Weavers) : *House Spiders, Black Widows* examples. Irregular webs in dark sheltered places including buildings. Eaten by birds, small mammals, amphibians, reptiles, fishes, wasps, mantids, parasitic nematodes, insects, fungi.

c. Araneidae (Orb Weavers): a large family; builds spiraling orb webs with radiating support lines in all habitats. *Araneus* spp often utilize eves of buildings building a new web every night; tall grasses and shrubbery. Black and Yellow Argiope (*Argiope aurantia*) among shrubbery, tall plants in meadows, gardens; makes white zig-zag band in center of web. *Micrathena* spp. with spiny abdomens common in woods.

d. Tetragnathidae (Large-jawed Orb Weavers); Elongate Long-jawed Orb weaver, (*Tetragnatha elongata*)* common; web often built over water tilted with central hole; fold legs close and parallel to body esp. when disturbed.

e. Agelenidae (Grass Spiders/Funnel Web Weavers); non-sticky sheet webs in grass and shrubs with a funnel leading off from center conspicuous when dew-covered; quick running; numerous.

f. Pisauridae (Nursery Web Spiders); large, run and pounce on prey (web for eggs and young only); may be seen carrying egg sac in fangs; one of largest (*Dolomedes* sp.) often seen running over water; can capture tadpoles, small fish.

g. Lycosidae (Wolf Spiders); usually do not build webs; run down prey or lie in wait in burrow in ground or under rocks; nocturnal; eyes reflect flashlight beam; common in meadows & leaf litter.

h. Oxyopidae (Lynx Spiders) similar habits and habitat to Wolf Spiders but diurnal.

i. Clubionidae (Sac Spiders); build sac like tubular resting sites inside a rolled leaf or under bark or stones. Some may be ant mimics; hunters instead of web weavers; nocturnal

j. Thomisidae and Philodromidae (Crab Spiders). Camouflaged; flattened, crab-like in movements; lie in ambush on tree bark, foliage, in litter, especially on flowers for insect prey; usually diurnal.

k. Salticidae (Jumping Spiders); jump on prey from some distance trailing silk dragline; some ant mimics; usually diurnal; make silken shelters in crevices, under bark and stones.

l. Gnaphosidae; nocturnal hunters similar to Sac Spiders; found under bark, stones often in silken sac during the day.

m. Linyphiidae (Dwarf Spiders and Sheet-web Weavers); a huge family of mostly tiny spiders. Dwarf Spiders, very abundant, prefer shade; hide under litter and natural debris on ground or beneath leaves of living trees; Sheet-web Weavers build flat or dome-shaped horizontal webs, often two-layered, in grass or between limbs.

3. Class Arachnida, Order Pseudoscorpiones (False Scorpions) tiny; common everwhere in leaf litter, moss, under loose bark/stones; sometimes hitch-hike on flies and beetles; capture small insects with poisonous pincers.

4. Class Arachnida, Order Opiliones (Harvestmen or Daddy-long-legs); feed on living insects, dead animals, plant juices. Mite Harvestmen: tiny, in leaf litter; Many species.

5. Class Arachnida, Order Acarina

a. Mites exist in tremendous numbers; parasitic on plants/animals; some free-living predators; often plant pests; may transmit disease; aquatic spp. common in nature center; most predators but some parasitize clams, insects esp. Odonata. Oribatid Mites (moss or beetle mites) important in breakdown of litter to form humus; often seen in rotten wood.

b. Ticks (Ixodides): usually larger than other mites; all are external parasites; may transmit disease; most drop off host after feeding. Deer Tick (*Ioxidides dammini*) not common (recent collecting yielded one tick which was not infected with Lyme Disease Spirochaete)

6. Phylum Arthropoda, Class Pauropoda: tiny, multi-legged (usually 9 pairs); live in decaying logs, forest litter, humus, under stones; feed on fungi and dead animals

7. Phylum Arthropoda, Class Symphyla: tiny, multi legged (usually 12 pairs); pair of spinnerets; live in moist, rotting wood, soil, litter; feed on decaying vegetation; may eat living plants and become pests in gardens, greenhouses.

8. Phylum Arthropoda, Class Chilopoda (Centipedes): mostly nocturnal insect/arthropod predators; find prey mostly by smell; all poisonous; *Scutigera* found in buildings (outside in summer). *Lithobiomorpha* (Stone Centipedes) common under rocks, debris, under bark, leaves. *Geophilomorpha* (Soil Centipedes): mostly tiny; burrow in soil for insect larvae, worms; eyeless.

9. Phylum Arthropoda, Class Diplopoda (Millipedes): under stones, moist soil, leaf litter; avoid light; feed on plant materials mostly soft, decomposing tissue; discharge strong smelling secretions as repellent but eaten by birds, toads and other animals; two subclasses, several spp.; common in nature center.

10. Phylum Arthropoda, Class Insecta - In the absence of any systematic surveys, the following, mostly general descriptions of the thousands of insect spp. present in our area emphasizes habitat and food relationships.

a. Order Protura: tiny wingless inhabitants of damp, humusy soil; feed on fungi.

b. Order Collembola: tiny, wingless; live in almost any habitat, some spp. on surface film of water; but most in soil, litter, under bark; eat fungi, algae, decaying vegetation; capable of great (relatively) leaps by catapulting leaping organ under abdomen; may be active on snow (springtails)

c. Order Entotrophi (Diplura): tiny, wingless; inhabit soil, under debris, stones, bark litter, logs; nocturnal; some eat vegetable matter, others, spingtails, mites, other soil arthropods.

d. Order Microcoryphia: small, wingless; in rubble, litter; eat algae.

e. Order Thysanura (Bristle tails): under forest debris, litter; feed on decayed vegetable matter, algae, lichens; nocturnal.

f. Order Ephemeroptera (May flies): aquatic naids live up to 4 years; ours feed on algae, organic particles; nocturnal. Adults do not feed. Naids eaten by fish, aquatic predators; adults by birds. Naids may be climbers, bottom sprawlers or burrowers, in still water.

g. Order Odonata (Dragonflies and Damselflies) - These insects are conspicuous and often colorful. Most active on warm sunny days, many of the most common can be easily identified. They feed mainly on Diptera (flies) from tiny Black Flies to large Deer Flies. Some may land and feed on plant aphids but mostly they trap flying insects in a basket formed from their long legs. Small ones may fall prey to larger species. In turn, Odonates are important food for fish, frogs and birds. Dependent upon water for their immature stages, their presence often reflects the quality of the aquatic environment.

Suborder Zygoptera Family Calopterygidae

* Black-winged Damsel fly (*Calopteryx maculata*) - along shady wooded slow-moving streams, common.

Family Lestidae - Spread-winged Damselflies should be common, especially in Delhaas. Easy to recognize as a group, several of the 10 or 11 spp. recorded from PA should be found within the Nature Center area. *Lestes disjunctus, Lestes eurinus, Lestes vigilax, Lestes rectangularis* could be looked for.

Family Coenagrionidae - This group characteristically fold their wings above the body. Violet Dancer (*Argia fumipennis*), Civil Bluet (*Enallagma civile*), Common Forktail (*Ischnura verticalis*) have been identified but many more species should be found of the 37 recorded from PA.

Suborder Anisoptera, Family Aeshnidae (Darners) - of 15 species recorded from PA, *Aeshna umbrosa*), one of the Blue Darners, which prefers shady areas and the abundant, conspicuous Green Darners (*Anax junius*) are known from Silver Lake. The large Hero Darner (*Epiaeschna heros*) has been collected in the area. Several others should be recorded.

Family Gomphidae - The so-called Clubtails usually require clear, running water so only a very few are likely to be found here.

Family Cordulegastridae and Macromiidae: Probably poorly represented but should be looked for, despite general lack of proper habitat.

Family Corduliidae - The Green-eyed Skimmers are probably represented by *Epitheca cynosura* and *Epitheca princeps*, the Water Prince, which has been recorded for our area, though not in the Nature Center.

Family Libellulidae - These are the most conspicuous and easily identified dragon flies: Slaty Skimmer (*Libellula incesta*) is consistant along the edge of Silver Lake; Whitetails (*Libellula lydia*) often rests flat on board walks; Painted Skimmer (*Libellula semifasciata*) has been recorded at Delhaas Woods; Great Blue Skimmer (*Libellula vibrans*) at Silver Lake edge;The Widow (*Libellula luctuosa*) occasional along Lake edge; 10-Spot (*Libellula pulchella*) is common all over; *Libellula cyanea* and *Libellula quadrimaculata* have been recorded for the area. At least 5 others are possible. Amberwings (*Perithemis tenera*) is consistantly common along the lake edge, as is the Blue Pirate (*Pachydiplex longipennis*). At the same locale, also seen resting flat on the boardwalks, the Green jacket (*Erythemis simplicicollis*) is frequent. The little red Topers (*Sympetrum rubicundulum, Sympetrum semicinctum* and, late into the fall, *Sympetrum vicinum* are common. *Sympetrum internum* should be looked for. At least

one Whiteface Skimmer (prob. *Leucorrhinia intacta*) could be expected. The Spot-winged Skimmers or Pennants (3 spp. in PA) should be here, or at Magnolia Lake. (*Celithemis elisa, Celithemis eponina, Celithemis martha*) having been recorded for Southern Bucks County. The Globe trotter (*Pantala flavescens*) occurs frequently in feeding swarms, with an occasional *Pantala hymenea* mixed in. The Black Saddlebags (*Tremea lacerata*) is recorded (frequently) but *Tremea carolina* should occur

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h. Order Hemiptera: sucking mouth parts; feed on plant juices or animal blood; common on plants in all habitats; aquatic forms include: predatory Marsh Treaders (*Hydrometra*) and Water Striders (*Gerris*) on surface film; predatory Back Swimmers (*Notonectidae*), Pygmy Back Swimmers (*Neoplea striola*) and Water Scorpion (*Ranatra*) hanging from water film. The Giant Water Bug (*Lethocerus americanus*) preys on all aquatic life including small vertebrates. Water Boatman (*Corixidae*) feed on algae, protozoa, microscopic metazoa. Terrestrial forms may be encountered in all habitats. Some more common and conspicuous forms include predatory Assassin and Thread-legged Bugs (*Reduviidae*), many of the Miridae (Plant Bugs); some of the Stink Bugs (*Pentatomidae*), Ambush Bugs (*Phymatidae*) camouflaged, hide in flowers to pounce on nectar seekers. Damsel Bugs (*Nabidae*), even thin tiny Flower Bugs (*Anthocoridae*), many are important plant eaters: the odiforous Stink Bugs, and Squash Bugs (*Coreidae*), tiny Lace Bugs (*Tiongidae*) mainly broad-leaved trees and shrubs; and Chinch Bugs (*Lygaeidae*) grasses. Box Elder Bugs are colorful, attract attention by congregating in fall. Orange and black Milkweed Bugs (*Lygaeus* and *Ochrimnus*) feed on seeds. The Cimidae and related groups are extoparasites on birds, mammals. All bugs are parasitized by other insects such as Tachinid Flies and eaten, even bad-smelling ones, by birds.

i. Order Homoptera: sucking mouth parts feed on plant juices wherever plants are found; often camouflaged to resemble thorns, plant growths and non-living material; many agile jumpers; may spread plant diseases.

Cicadas "Locusts" (*Cicadidae*) feed on tree roots as nymphs, often for years, before maturing. Adults familiar sound-makers on hot summer days; adults may injure limbs and twigs esp. depositing eggs; die after reproducing. Spittle Bugs, Frog Hoppers (*Cercopidae*): nymphs make familiar masses of protective froth on plant stems; feed on grasses, legumes esp. Tree Hoppers (*Membracidae*); often bizarrely shaped; in all habitats. Leaf hoppers (*Cicadellidae*): large family in all habitats, some like, *Graphocephals coccinea*, brightly colored. Plant hoppers (*Fulgoridae*) feed on all plants, esp. grasses. Moth-like (in flight) *Acanolonia brevittata* common. Jumping Plant Lice (*Psyllidae*); may induce galls; produce honey dew excretion encouraging fungus growth. Bark, Gall Aphids (*Phylloxeridae*); may also induce galls on grapes. Aphids, Plant Lice (*Aphididae*) tiny, usually wingless, often in tremendous numbers on all kinds of plants and plant parts; excrete honey dew which encourages ants to protect them (sometimes bringing them into nests); sexual generations produced in fall and eggs laid; can carry plant diseases. Soft Scales, Armored Scales, Mealy Bugs (*Coccoidea*) small, but often numerous, most fixed in place; esp. on trees and shrubs; some, as mealy bugs, produce protective wax.

j. Order Psocoptera (Book Lice and Bark Lice) eat algae, lichens, organic debris;

k. Order Mallophaga (Chewing Lice) scavengers in nests and ectoparasites, co-evolved with birds and some mammals feeding on feathers and hair. Sucking Lice (*Anoplura*) wood-sucking ectoparasites, on placental mammals.

l. Order Phantasmodea - Walking Sticks (*Diapheromera femorata*) resemble twigs feed at night on leaves of Oaks, Black Locust, and Wild Cherry. Order Dermaptera (Earwigs) live in humid places, under bark, in soil, cracks etc; omnivorous. Order Dictyoptera, Praying Mantids (*Mantidae*) two common spp. in area: Chinese Mantis (*Tenodera aridifolia sinensis*), Narrow-winged Mantis (*Tenodera angustipennis*). European Mantis (*Mantis religiosa*) and Carolina Mantis (*Stegmomantis Carolina*) may also occur. All feed on anything (including each other) they can over power, day or night. Overwinter in egg stage. Egg cases often parasitized; broken open by birds. Wood Cockroaches (*Dictyoptera blatteria*) common in woods, litter, rotten logs; omnivorous scavengers; nocturnal. Order Isoptera (termites) eat and recycle wood nutrients (digestion of cellulose initiated by symbiotic bacteria and protozoa in gut); live in organized colonies with distinct castes in soil and wood; do not forage outside.

m. Order Orthoptera, Pygmy or Grouse Locust (*Tettrigidae*) , Short-horned Grasshoppers (*Acrididae*) Long-horned Grasshoppers, Katydids, Cone-headed, Meadow Grasshoppers (*Tettigoniidae*) sound producers esp. at night in late summer and fall. The preceding 3 groups most common in field, marshes; feed on vegetation. Over-winter as eggs or nymphs (*Acrididae*). Crickets (*Gryllidae*) two typical and common spp.

House Cricket (*Acheta domestica*) and Field Cricket (*Acheta assimilis*) omnivorous, under debris; may invade building; chirping stridulators; nocturnal. Tree or Bush Crickets (*Oecanthus spp.*) incessant chirpers; rate depends on temperature; eat fruit. Ground Crickets (*Nemobius spp.*) sing (males) from July until frost; eat plants. Burrowing like name sake, Mole Cricket (*Gryllotalpa spp.*) and semi aquatic Pygmy Mole Cricket (*Tridactylus minutus*) all feed on larvae, worms, roots. Evolved limbs and body reminiscent of moles; not often seen. Camel, Cave Crickets (*Gryllacrididae*) nocternal predators, hide under debris (*Ceuthophilus* spp. probaby here); prayed upon by Digger Wasp spp.

n. Order Trichoptera (Caddisflies): adults moth-like, do not feed; aquatic larvae build characterists cases of various materials (usually dead plant) held together by silk; most live on algae, water plants, tiny invertebrates.

o. Order Neuroptera (may be divided into more than one order): biting mouth parts. Lacewings (*Chrysopa* spp.) both adult and larva prey on aphids, mealy bugs. Antlions (*Hesperoleon, Myrmeleon* spp.) dig pit traps for (mainly) ants; parasitised by Bee Flies. Suborder Megaloptera (Alder flies and Fish flies): aquatic larvae. Fish flies, larvae and adults prey on other insects (*Chauliodes* spp.). Alderflies (*Sialis* spp.), adults crepuscular, do not eat or live long; larvae predaceous. Spongilla fly (*Climocia areolaris*), larvae prey on fresh water sponges.

p. Order Coleoptera (Beetles): Not only the largest order of insects but, in terms of identified species, exceeds all other organisms together worldwide. They occupy every habitat (except oceans) and niche as predators, herbivores, parasites, and scavengers. Despite the diversity, most can be recognized as such, the larvae (grubs) often exhibiting more variation in form that the adults. R. White in A FIELD GUIDE TO THE BEETLES OF NORTH AMERICA has included a handy chart of "characters of beetle families including habitats. A few, commonly encountered, families and spp. are mentioned here: Ground Beetles (*Carabidae*) usually black are important predators of other insects, occasionally invading buildings. Crawling Water Beetles (*Haliplidae*) often very common , collected when studying water organisms. Predaceous Diving Beetles (*Dytiscidae*) also frequently collected along with Water Scavenger Beetles (*Hydrophilidae*) and Whirligig Beetles (*Gyrinidae*) on the water surface. All the Larvae swim actively and are predaceous. Rove Beetles (*Staphylindae*) with short wings, are common in woods as ground predators or scavengers. Scarab Beetles (*Scarabaeidae*): Dung Beetles, lay eggs in dung. June "Bugs" (*Phyllophagafusca, ets.*) are plant eaters; larvae are "white grubs" in soil; Japanese Beetle (*Popillia japonica*),Spotted Pelidnota (*Pellidnota punctata*), Fig Eater (*Cotinus nitida*) are examples ; Metallic Wood-boring Beetles (*Buprestidae*) bright colors attract attention; larvae bore into trees, dead wood. Click Beetles (*Elateridae*) trigger mechanism for righting themselves makes them familiar; larvae eat roots, under ground parts of

plants; called wireworms. Soldier Beetles (*Cantharidae*) often met with on flowers such as goldenrods; larvae and adults predaceous; adults also eat pollen, nectar. Net-winged Beetles (*Lycidae*) characteristic of forests, are carnivorous as larvae, adults may also feed on decaying vegetation. Lightning bugs, Fire flies (*Lampyridae*) esp. common near water; larvae predaceous, adults mostly do not feed. Ladybird Beetles, Lady bugs (*Coccinellidae*): most predaceous esp. on aphids; some, such as Mexican Bean Beetle, eat leaves. Long-horned Beetles (*Cerambycidae*) extremely long antennae, bright colors call attention to this large group; larvae bore into plants, damage trees; adults either do not eat or visit flowers (important pollinators) for nectar, pollen. Milkweed Beetles (*Tetraopes* spp.) and Locust Borer (*Megacyllene robiniae*) are familiar examples. Leaf Beetles (*Chrysomelidae*) a large family; adults eat leaves, larvae roots; most somewhat host specific. Spottled Cucumber Beetle (*Diabrotica undecimpunctata*) will eat over 200 spp. of plants. The Dogbane Beetle (*Chrysochus auratus*) with its brilliant metallic green is a favorite with nature center naturalists; feeds on Dogbane and Milkweeds; larvae on roots. Tortoise Beetles (*Cassidinae*): strange extended margins and metallic colors attract attention. The 2nd largest family in U. S., Snout Beetles (*Curculionidae*), are all plant-feeders; some cause root galls; no part or condition of plants misses attention by some species. Adults may feed on different plant or part of plant than larvae. Holes in acorns are evidence of nut weevils (*Curculionae*). Pinhole Borers or Ambrosia Beetles (*Platypodidae*) and Bark and Ambrosia Beetles (*Scolytidae*) are best known by their activities (adults and larvae); bore into living and dying trees. Shot holes and sawdust and (Scolytids) engraving-like tunnels under bark are evidence. Ambrosia beetles feed on fungus which grows in tunnels, a mutualism symbiosis beneficial both to fungus and beetle.

Reference: White, R. E. A FIELD GUIDE TO THE BEETLES OF NORTH AMERICA Houghton Mifflin Co., 1983.

q.Order Hymenoptera (Wasps, Bees, Ants) a very large and important order. Many are parasites of other arthropods, efficient pollinators and honey producers and predators. A few damage plants. They are often important food for birds and other insect-eating animals. Some of the more important families:

(1.) TENTHREDINIDAE (Saw flies): Many species; use saw-like ovipositors to insert eggs into stems or leaves; sometimes cause galls; larvae feed on plant tissues; often larvae gregarious; larvae eaten by birds.

(2.) SIRICIDAE (Horntails): abdominal spine; female ovipositer used to insert eggs into wood or bark of trees; example: Pigeon Tremex (*Tremex columba*) conspicuous; known in area; larva parasitized by the Ichneumon Wasp (*Megarhyssa macrurus*); bore into heartwood of Maple, Elm, Beech.

(3.) ICHNEUMONIDAE (Ichneumon Wasps): some largest Hymonopterans: all parasitic; ovipositers often much longer than body, deposit eggs near, on or in body of host which is usually paralyzed or killed by stinging; host usually larva of other insects, spiders; adults may visit flowers (see preceding)

(4.) BRACONIDAE (Braconid Wasps): small but important parasites of other insects (larvae or pupae) and aphids.

(5.) CYNIPIDAE (Gall Wasps): deposit eggs in leaves and twigs of oaks, roses, thistles causing galls; not usually very harmful; honeydew-like substance produced by galls eaten by ants; galls eaten by squirrels.

(6.) CHALCIDIDAE: tiny; larvae parasites of other insects, sometimes hyperparasites on tachinid fly and ichneumon parasites.

(7.) TORYMIDAE: tiny, metallic green; parasites on larvae of wasps, flies living in stems, seeds leaves, and mantid eggs. Some (larvae) infest seeds of variety of plants.

(8.) EURYTOMIDAE: tiny, metallic black; parasitic similar to preceding; some (larvae) attack clover, seeds and grasses; some hyperparasites; one eats eggs of Snowy Tree Cricket.

(9.) TRICHOGIAMMATIDAE and SCELIONIDAE: tiny; all egg parasites of other insects.

(10.) PELECINIDAE (*Pelecinus polyturator*): female usually seen; grotesquely long abdoman; lay eggs on rotten wood and root-feeding larvae of scarab beetles; woods.

(11.) CHRYSIDIDAE (Cuckoo Wasps): metallic green or blue inquilines or cleptoparasites (kill host larvae so own can utilize stored food in nests of solitary bees and wasps for its own larvae)

(12.) MUTILLIDAE (Velvet Ants): hairy, colorful, wingless (females) wasps parasitic on wasps, bees; sandy areas esp. where hosts burrow; not common.

(13.) FORMICIDAE (Ants): social with castes (Most wingless, nonreproductive female workers). Reproductive females and males swarm for nuptial flight, shed wings, males die; burrow in soil, wood or under stones, debris; may be predatory, scavengers, harvest seeds, herbivorous; some attend aphids for excretions; some make "slaves" of other spp. Carpenter ants (*Camponotus* spp.) are our largest; burrow in rotted wood. Ants are important soil builders and aerators. Winged forms important food for fish, birds, dragon flies. All eaten by a great variety of other animal; a number of insects, spiders

superficially resemble ants (mimicry); benefit in some way by relating with ants.

(14.) VESPIDAE (True Wasps): large family; often social; build nests of paper, mud, or plant materials glued together. Adults often visit flowers for nectar. Potter wasps (*Eumeninae*) lay eggs in mud nests attached to twigs, rocks, or in burrows; some partition hollow twigs; collect larvae for each cell, usually Lepidoptera; lay single egg in each cell. Some use old Mud Dauber nests. *Eumenes fraternus* is probably most common; constructs nests in form of a clay pot. Hornets, Yellow Jeckets (*Vespinae*): construct paper cells for eggs in the ground or above ground (Hornets); only fertilized queen hibernates (others die); new nest built each spring. Giant Hornet (*Vespa crabro germanica*),Yellow Jacket (*Vespula* spp.), Baldfaced or Whitefaced Hornet (*Dolichovespula* spp.) are common. Paper Wasps (*Polistinae*) *Polistes* spp.; nests lack outer paper covering with one comb attached by a pedicel to support (often eaves of building). All feed young lepidopterous Larvae, masticated insects; adults eat mostly nectar, fruit, insect bits.

(15.) POMPILIDAE (Spider Wasps); burrow in ground; egg attached to each paralyzed spider (larval food); some parasitize other spider wasps and usurp prey.

(16.) SPHECIDAE (Digger Wasps, Mud Daubers, Cicada Killer, Sand Wasps): solitary, some colonial (living close together); tunnel in soil or wood; utilize hollow (grass) and pithy stems or build cells of mud (singly or in groups) on buildings, trees, rocks. Stock cells with spiders, orthopterans, caterpillers, aphids, bugs, flies; egg laid upon each victim; usually sealed but some feed young partially chewed prey. Adults eat nectar, host blood. Mud Dauber nests are familiar. *Sphecius speciosus*, Giant Cicada Killer often conspicuous in summer when its prey is active; burrows.

(17.) APOIDEAS (Bees): much modified to gather nectar and pollen; all most important pollinators as they tend to consistantly gather pollen from a single sp. or group of related spp. at any given time. Some are social with well-developed castes, while others are solitary or congregations (no division of labor). APIDAE (Bumble Bees, Honey Bees) are social; *Apis mellifera* (Honey Bee) introduced; is regularly seen at flowers; most efficient pollinators. *Bombus* spp. (Bumble bees) nest in ground in small hives; only fertile queens hibernate to start new colonies in spring; a few are (*Psithyrus* spp.) obligate parasites in *Bombus* nests. HALICTIDAE, Sweat Bees (*Halictus* spp.) usually noticed for those spp. attracted to perspiring humans; show tendency toward social behavior. MEGACHILIDAE (Leafcutting Bees) cut large discs from leaves of plants (esp. roses) to line and divide burrows

provisioned with pollen and nectar for larvae. Some parasitize other Leafcutting Bees. COLLETIDAE (Yellow-faced and Plasterer Bees) and ANDRENIDAE (Mining Bees) have similar habits. ANTHOPHORIDAE (Cuckoo Bee, Digger Bee, Carpenter Bee) some are cleptoparasites on other bees; or similar habits to Mining Bees. Carpenter Bee (*Xylocopa virginica*) resembles Bumble Bees and Little Carpenter Bee (*Ceratina dupla*) bore into sound dead wood to make nests; visit flowers for nectar, pollen.

r. Order Diptera (Flies, Mosquitoes, Gnats, Midges) next in number of spp. to the Hymenoptera, the two-winged flies are the most important vectors of disease, may be serious plant "pests" while also important natural control of other insects and snails, pollinators, and scavengers of dead animals/plant wastes. Their mouthparts are modified, depending on source of food, for bloodsucking, sponging, stabbing, sucking nectar or are non-functional. They have fascinating reproductive cycles. While most lay eggs, some deposit larvae (maggots); some are parthenogenetic and these can produce larvae from larvae or (rarely) from pupae. Parasitized; eaten by other insects, and spiders, birds, bats, herptiles, fishes. Following is much abbreviated listing.

(1.) SUBORDER NEMATOCERA:

Group	Larvae	Adult
TIPULIDAE (Crane Flies)	aquatic, moist soil, humus	various habitats, do not feed, generally.
CULICIDAE (Mosquitoes)	eat plants, organic matter, aquatic; bacteria, algae	female: animal blood both sexes plant juices
CERATOPOGONIDAE (No-see-ums, punkies, etc.)	aquatic; moist places; scavengers	both nectar from flowers female blood, various animals
CHIRONOMIDAE (Midges)	mainly aquatic (often polluted), predaceous; some plants	do not feed; often seen "dancing" swarms.
CECIDOMYIIDAE (Gall Midges)	Fungi, decaying organic matter, a few already damaged plants, roots, inquilines, parasites, gall inducers, predaceous, some reproduce as larvae	
BIBIONIDAE (March Flies)	most eat decaying roots, logs, excretment; some roots	flowers; fields
PSYCHODIDAE (Moth Flies)	decaying matter; in water	moth-like small

A number of other families such as CHAOBARIDAE (Phantom Midges - are aquatic; predaceous larvae) may be found in the nature center.

(2) SUBORDER BRACHYCERA: most spp.; more "typical" flies

TABANIDAE (Horse, Deer Flies)	water (Horse Flies) damp soil near water predaceous	female; blood; both nectar, plant juices; forests (Deer Flies); various habitats. May transmit diseases.
STRATIOMYIDAE (Soldier Flies)	terrestrial or aquatic, feed on algae, micro-organisims, decaying matter; some carn-ivorous	forested areas; also sedge meadows; visit flowers (nectar, pollen)
RHAGIONIDAE (Snipe	terrestrial; predaceous	long grass, woods; preda-ceous (esp. other flies); a few bite (blood)
THEREVIDAE (Stilletto Flies)	terrestrial in soil, decaying vegetation, rotten wood; preda-ceous, often cannibal-istic	shrubs, flowers
ASILIDAE (Robber Flies)	similar to above; important predator on white grubs	predaceous on other insects, various, esp. sunny, habitats; some mimic bees
BOMBYLIIDAE (Bee Flies)	predaceous on larvae, eggs of insects	flower nectar; pollen; mimic bees
DOLICHOPODIDAE (Long-legged Flies) and EMPIDIDAE (Dance Flies)	predaceous, many aquatic; damp soil, under bark; a few leaf miners	predaceous; male may pre-sent prey to female but may not eat; wet meadows
PHORIDAE (Hump-backed Flies)	mostly scavengers; Fungi; some parasites of Mollusks, milli-pedes, other insects, bees, wasps	around decaying vegetation
SYRPHIDAE (Flower Flies)	feces, decaying mat-ter, carcasses, pre-daceous on aphids, mealy bugs; rat-tail maggots one type larvae	important pollinators; nectar, tree sap, fruit; some bee mimics; conspicous
CONOPIDAE (Thick-headed Flies)	internal parasites of bees, wasps	flowers; oviposit on hosts in flight; brushy areas
OTITIDAE (Picture-winged Flies)	decaying plant, animal matter; a few invade plant roots	attract attention by active "display" of marked wings; sunny spots
TEPHRITIDAE (Fruit Flies)	fruit; some stem/root gall inducers (golden-	various habitats

	rods), mine leaves	
MUSCIDAE (House, Stable Flies)	dung, excrement, decaying animal matter; a few on flesh/blood	liquid organic material, foods; a few, blood; may carry disease; attacked by fungus
DROSOPHILIDAE (Vinegar Flies)	yeasts, bacteria in decaying vegetable matter; fungi	decaying fruit, sap, nectar, fungi

A number of families, esp. "Tachina" flies are important parasites of other insects. Wingless Louse Flies are extoparasites on bats, birds. Blow, Screw-worm, Bottle, Flesh Flies (to name a few) attack various terrestrial vertebrates. Others attack plants; many are leaf miners. Larvae do most of the direct damage.

s. Order Lepidoptera (Butterflies, Skippers, Moths)

(1). Ropalocera Super Family Papilionoidea. These insects are colorful and attract attention. Many popular field guides are available and "Butterfly Gardening" is becoming popular. Since much material has been published, a reasonable list of known and probable species, with detailed ecology, is included. Unusual or rare species may occur in our area either in the form of strays or because the particular larval food plant or habitat exists in the park (or at a nearby location). The Delhaas Bog may be one of those unusual and critical habitats. Butterflies are important pollinators, contribute to the food chains and only occasionally impact seriously on plant populations (such as is the case with the introduced Cabbage White on members of the Cabbage clan). Most important, they are sensitive indicators of the ecological quality of our environment. Its habitat, whether or not it visits flowers, larval food given in order in the following:

Family Satyridae

*Eyed Brown (*Satyrodes eurydice*)

- moist meadows, marshes
- no
- marsh grasses, sedges

Little Wood Satyr (*Megisto cymela*)

- open woods, woods edges, occasionally brushy meadows
- no
- grasses, possibly sedges

*Common Wood Nymph (*Cercyonis pegala*)

- as above - shade
- occasionally
- grasses (Poaceae)

Family Danaidae

*Monarch (*Danaus plexippus*)

- meadows, weedy fields; anywhere in migration

- yes
- milkweeds (except Butterfly weed), dogbanes (Apocynum)

Family Nyphalidae

Variegated Fritillary (*Euptoieta claudia*)
- open fields, roadsides; probably only as stray
- yes; Centaurea thistle, composites
- Violets, Plantego

*Great Spangled Fritillar (*Speyeria cybele*)
- wood edges, open country
- yes, esp. milkweeds
- Violets

Silver-bordered Fritillary (*Clossiana selene*)
- wet meadows, marshes
- yes
- Violets

Meadow Fritillary (*Clossiana bellona*)
- damp meadows
- yes; prefers Verbena
- Violets

*Baltimore
- moist meadows; open marshes in woodlands
- yes
- Turtlehead (Chelone), Gerardia; Plantego; White ash.

*Pearl Crescent (*Phyciodes tharos*)
- open country, dry weedy fields, attracted to puddles
- yes, esp. composites
- Asters

Silvery Crescent (*Charidryas nycteos*)
- damp areas, stream edges, in open country (Mainly Piedmont); open deciduous woods
- yes, esp. Red Clover
- Helianthus, Asters, Rudbeckia laciniata, Actinomeris alternifolia

Tawny Crescent (*Phyciodes batesii*)
- dry weedy fields; old pastures where Andropogon grows; rare
- yes
- Asters esp. A. undulatus

Question Mark (*Polygonia interrogationis*)
- woods, openings in woods, orchards, stream sides; hibernates
- yes, also sap, rotting fruit
- Elm, Nettle, False Nettle, Hackberry

Comma (*Polygonia comma*)
- woodlands, openings; hibernates
- yes
- Elm, Nettle, False Nettle, Hops

*Mourning Cloak (*Nymphalis antiopa*)
- woods; various habitats: hibernates
- Yes, esp. milkweeds
- mostly Willows; Elm, Hackberry, Blackberry; communal, may defoliate small trees

*Red Admiral (*Vanessa atalanta*)
- woods, strays to margins, fields, shorelines, roadsides; hibernates; tame
- yes; also rotting fruit
- Nettle, False Nettle

*American Painted Lady (*Vanessa virginiensis*)
- open country; may hibernate
- yes
- Composites esp. Gnaphalium, Antennaria, Anaphalis, Artemisia, Burdock, Ironweed

*Painted Lady (*Vanessa cardui*)
- open country (worldwide); migrates
- yes
- thistles, Cirsium, other composites

*Buckeye (*Junonia coenia*)
- open areas; mostly Coastal Plain; migrates
- yes
- Plantego (except P. major), figworts, vervains

*Red-spotted Purple (*Basilarchia astyanax*)
- woodlands, open scrubby areas where wild cherry grows
- yes, but more often at puddles, rotten fruit; carrion
- Wild Cherries, Willows, Poplars, Aspens, Hawthorns, Apples, Hornbeam

*Viceroy (*Basilarchia archippus*) - mimics Monarch
- marshes, streamsides, lakes, meadows, roadsides
-yes - Button bush, etc.
- as above

Gray Emperor (*Asterocampa celtis*) - uncommon
- damp woods; strays; may alight on buildings, people
- uncertain
- Hackberry (Celtis)

Tawny Emperor (*Asterocampa clyton*) - uncommon
- as above
- as above; rotten fruit
- as above

Family Lycaenidae

Snout Butterfly (*Libytheana bachmanni*) - uncommon

- wooded streams
- yes, esp. thistles; puddles
- Hackberry

*Red-banded Hairstreak (*Calycopis cecrops*) - uncommon
-woods open fields
- yes
- Dwarf Sumac

*Gray Hairstreak (*Strymon melinus*)
- open fields, woods, roadsides
- yes
- Knotweeds, beans, Tick-trefoil, Bush Clover, St. John's Wort, Mallows, Hops

*Banded Hairstreak (*Satyrium calanus*)
- oak forest, strays to open areas
- yes, esp. mildweed, sumac, sweet clovers, mints
- White Oaks, esp Q. prinus; possibly hickories, butternut

Striped Hairstreak (*Satyrium liparops*) - uncommon
- mixed deciduous forest, wet areas (Bristol record)
- yes, Swamp Milkweed
- not known

Several other Hairstreaks may occur and should be looked for.

Bronze Copper (*Hyllolycaena hyllus*) - rare
- low, damp meadows, marshes
- yes, esp. clover
- Docks (Rumex)

American Copper (*Lycaena phlaeas*)
- meadows, waste places
- yes, esp. tall flowers (Daisies, Yarrow, Queen Ann's Lace)
- sheep sorrel (Rumex acetosella)

*Tailed Blue (*Everes comyntas*)
- open situations
- yes
- Clovers, Sweet Clovers, Tick-trefoil, Bush Clover

*Spring Azure (*Celastrina laden*)
- woods, brushy fields
- yes; Spicebush, Dogwood, Mints, Thistles, Clover
- Dogwoods, Viburnums, Ceanothus, blueberries, Black Snake root (Cimicifuga), Spiraea

Family Liphyridae

Harvester (*Feniseca tarquinius*)
- woodland streams, damp woods
- rarely; mud puddles
- Carnivorous on wooly aphids on Alder and Beech

Family Pieridae

Falcate Orange Tip (*Anthocharis midea*)

- deciduous woodlands, may stray into our area; early spring
- early mustards
- Cruciferae (Arabis, Barbarea, Capsella)

*Alfalfa or Orange Sulphur (*Colias eurytheme*)
- open country
- yes
- Alfalfa, Clovers, Sweet Clovers, False Indigo, Crown Vetch, other Legumes

*Yellow or Common Sulphur (*Colias philodice*)
- open country
- yes
- Clovers, other Legumes

Cloudless Sulphur (*Phoebis sennae*)
- open country; migrates, may wander into our area
- yes; Rose, Mallow esp.
- Senna (Cassia)

Sleepy Orange (*Eurema nicippe*)
- open country, Coastal Plain; migrates; wanders into area
- yes
- Senna (Cassia)

Little Sulphur (*Eurema lisa*)
- dry, sandy fields, roadsides
- seldom
- Senna (Cassia)

*Checkered White (*Pontia protodice*)
- meadows; formerly very common at Silver Lake
- yes
- Cruciferae (Lepidium, Capsella)

*Cabbage White (*Artogeia rapae*)
- woods in spring; everywhere
- yes
- Cruciferae (Barbarea and cultivated forms)

Family Papilionidae

Pipevine Swallowtail (*Battus philenor*) bad tasting; often mimicked by Redspotted Purple, Female Tiger Swallowtail, Black and Spicebush Swallowtail
- open country; strays into our area
- yes
- Dutchman's Pipe; Morning Glories

*Black Swallowtail (*Papilio polyxnes*)
_____- open country, dryfields, marshes
- yes
- Umbellifera (Queen Ann's Lace, dill, parseley, carrot)

*Tiger Swallowtail (*Pterourus glaucus*) - dark female common
- open country, marshes; very common

- yes - Joe Pye Weed esp.
- Wild Cherries, Tulip tree, occas. Birches, Ashes

*Spice bush Swallowtail (*Pterourus troilus*)
- open woods to open fields
- yes, esp. honeysuckle
- Spicebush, Sassafras

(2.) Superfamily Hesperoidea

*Silver-spotted Skipper (*Epargyreus clarus*)
- open areas, marshes, brushy areas; very common
- yes
- Robinia pseudo-acacia, Desmodium

Long-tailed Skipper (*Urbanus proteus*)
- Coastal Plain migrant from South
- yes
- Desmodium, Beans, Wisteria

Northern Cloudy Wing (*Thorybes pylades*)
- open woods, wood edges, occas. roadsides, open fields
- yes
- Legumes

Checkered Skipper (*Pyrgus communis*)
- open fields, roadsides
- yes, es. mints, Centaurea
- Malvaceae

Sooty Wing (*Pholisora catullus*)
- disturbed areas, roadsides
- rarely
- Chenopodium album, Amaranthus, Ambrosia, possibly Monarda and mints.

Dreamy Dusky Wing (*Erynnis icelus*)
- open woods
- seldom; mud puddles
- Poplars, Birches, poss. Willows

Common Dusky Wing (*Erynnis juvenalis*)
- woods but strays widely
- seldom
- Oaks

*Least Skipper (*Ancyloxipha numitor*)
- grassy open areas, wet meadows, along streams
- seldom
- grasses (Poa esp.)

*Fiery Skipper (*Hylephila phylaeus*)
- dry fields, meadows, roadsides, lawns
- yes (esp. Thistles, Ironweed, Knapweed)
- grasses (esp. Crab Grass)

*The Sachem (*Atalopedes campestris*)
- mainly Coastal Plain, open fields, roadsides

- yes (esp. yellow composites)
- grasses (esp. Crab and Gorse)

Glassy Wing (*Pompeius verna*)
- meadows, open woods (where Honeysuckle, Poison Ivy, Milkweed are common); often with Broken Dash and Dun Skippers
- yes (esp. Milkweed)
- Tridens flavus (Bunch grass)

Tawny-edged Skipper (*Polites themistocles*)
- damp meadows, marshes, lawns, vacant lots
- yes (chicory, thistles, clovers etc.)
- grasses (smaller Panicum spp.)

*Yellow-spotted Skipper (*Polites coras*)
- damp meadows, roadsides, lawns, vacant lots
- yes (esp. Joe Pye weed)
- grasses in general

Whirlabout (*Polites vibex*)
- migrant into our area; open fields, roadsides
- yes
- does not breed here

Broken Dash (*Wallengrenia egeremet*)
- meadows, open woods, old fields (often with Glassy Wing)
- yes (esp. thistles)
- grasses (larger Panicum spp.)

Mulberry Wing (*Poanes massasoit*)
- boggy meadows, marshes; where sedge tussocks
- yes
- Sedges (Carex spp.)

Broad-winged Skipper (*Poanes viator*)
- marshes; esp. tidal marshes (Bristol Marsh), sedge bogs
- yes; Spatterdock verbena, etc.
- Wild Rice, Panicum, Carex, perhaps Phragmites

Northern Golden Skipper (*Poanes hobomok*)
- damp country at woodedges, woods, along streams; ranges widely
- occasionally (Blackberry)
- grasses (Panicum, Poa, etc.)

*Zabulon Skipper (*Poanes zabulon*)
- similar to above; also dry meadows, roadsides (usually with Dun Skipper)
- yes (pink & purple composites)
- grasses (Tridens, Eragrostis)

*Dun Skipper (*Euphyes ruricola*)
- prefers more shade than Zabulon but often found with it
- yes (esp. thistles, mints, Prunella)
- grasses, esp. Redtop (Tridens flavus)

Black Dash (*Euphyes conspicua*)

- boggy meadows, slightly acidic marshes; rare but reported from Bristol
- yes, swamp thistle, jewelweed especially
- Sedge (Carex spp.)

Delaware Skipper (*Atrytone delaware*)

- dry and damp meadows, roadsides, marshes, old fields
- yes, dogbane, milkweed, less often thistle
- grasses, (Andropogon, Erianthus, Panicum virgatum)

Clouded Skipper (*Lerema accius*)

- immigrant to our area; Coastal Plain, damp meadows, marshes
- yes, esp. Buttonbush, Verbena
- *Erianthus*

Swarthy Skipper (*Nastra I'herminieri*)

- dry meadows, roadsides, burn areas, waste places; occ. woods clearings, along streams
- yes, esp. thistles, Prunella
- Andropogon scoparius

Long-winged Skipper (*Panoguina ocola*)

- immigrant; low, damp meadows on Coastal Plain
- yes
- marsh grasses

Skippers are often difficult to identify even "in-the-hand". Species additional to these may occur at Silver Lake while some of the above may not be found. Only systematic collecting over several years can resolve the problem._____

_____ (3). Heterocera (Moths)

While modern technical classification does not recognize this convenient separation, it is still useful. Lepidoptera other than Hesperioidea (Skippers) and Papilionoidea (Butterflies): The huge number of spp. (probably over 15 times the number of Butterfly spp.) probably present at some time or another within the nature center boundaries precludes more than a superficial listing. Fortunately, C. V. Covell's FIELD GUIDE TO THE MOTHS OF EASTERN NORTH AMERICA is recent and readily available. Moths are nocturnal (some exceptions), and mostly less colorful than Butterflies. The White-striped Black (*Trichodezia albovittata*), the Forester Moths (*Alypia* spp.), Ctenucha Moths, Hummingbird Moths (*Nemaris* spp.) flower visitors, are diurnal and often attract attention. The Giant Silkworm Moths (*Saturniidae* esp. *Antheraea polyphemus, Actias luna*, and *Hyalophora cecropis*), Noctuidae (genus *Catocala*, underwings) and Sphingidae (Sphinx or Hawk Moths) are attractive and even spectacular. The "inchworm" larvae of Geometridae are well-known, even to youngsters, as are the Wooly

Bears (*Pyrrhgarctia isabella*). Also the tree webs and hairy larvae of spring Eastern Tent Caterpillers (*Malacosoma americanum*) and bizarre larvae of Tussock Moths, Lymantriidae. While almost all moths (larvae) are plant-eaters, none has become a problem within the nature center area. A few are predators or parasites on other insects. The adults feed on nectars, honeydew, rotten fruit, or not at all, and are important pollinators. They provide at all stages food for almost every group of insect eating animals through parasitism to direct predation beetles, wasps, flies, spiders, birds and bats are among the most obvious. The following charts are taken from Arnett's AMERICAN INSECTS.

(4.) References

Arnett, R. H., Jr. AMERICAN INSECTS: A HANDBOOK OF THE INSECTS OF AMERICA NORTH OF MEXICO, Van Nostrand Reinhold Co., 1985

Covel, C. V., Jr. A FIELD GUIDE TO THE MOTHS OF EASTERN NORTH AMERICA, Houghton Mifflin Co., 1984

Klots, A. B. A FIELD GUIDE TO THE BUTTERFLIES OF NORTH AMERICA, EAST OF THE GREAT PLAINS, Houghton Mifflin Co., 1951

Pyle, R. M. THE AUDUBON SOCIETY FIELD GUIDE TO NORTH AMERICAN BUTTERFLIES, Alfred A. Knopf, 1981

Shapiro, A. M. BUTTERFLIES OF THE DELAWARE VALLEY, American Entomological Society, 1966

11. Phylum Porifera (Sponges), Family Spongillidae: take the form of encrusting growth on twigs and other objects in water. Nothing is known about them at Silver Lake Nature Center but they probably occur in all our permanent waters. They tend to be rare on mud bottoms or silty water preferring dim light. pH influences what spp. are found. The reproductive and dispersing gemmule form often contain zoochlorellae (algae) symbiosis. The gemmules may disperse through currents or overland by wind, insects and birds. They feed by filtering particles from the water including algae which may persist and multiply in their tissue. These zoochlorellae apparently contribute to sponge growth and are very slowly digested. Larvae of Sisyridae (neuroptera) feed exclusively on sponges.

12. Phylum Coelenterata (Hydroids, Jellyfish): Few spp. are found in fresh water but usually abundant. The Chlorahydra spp. contain zoochlorellae thus appearing green. The Hydra spp. may be brown or nearly transparent taking on the color of their food. Using stinging and adhesive cells and tentacles, they capture almost any suitably-sized (tiny) metazoon (not Ostracods). One of the two spp. of free-swimming, jelly-fish-like, medusae (Craspedacusta sp.) has been collected from the small pond adjacent to Delhaas Woods. Certain Commensal or parasitic ciliates are common on the surface of hydras where they feed on bits of food without discharging the stinging cells (nematocysts). They may be eaten by certain flatworms, nemertines, crustaceans and aquatic insects or parasitized by an ameba.

13. Class Turbellaria (Flatworms, Planaria) Found in all waters usually on or close to substrate; range from microscopic to 30 mm or more; nocturnal or avoid light. Food, detected chemically, may be living or dead, and is sucked in by a tube-like pharynx extended from the ventral body surface. Diatoms are eaten but animal tissue is generally preferred. Some actively capture prey with the aid of a sucker-like structure, or trapped in slime. May be eaten occasionally by Odonata nymphs, nematodes, annelids, a few crustaceans, and aquatic insects; parasitised by ciliates, gregarines and (rarely) larval nematodes. May live as commensals in brood pouches of isopods and amphipods.

14. Phylum Nemertinea (Proboscis worms) one sp (Prostoma graecense); possibly others introduced; found in algae mats, underside of lily pads, on weeds; usually overlooked; spotty in distribution; up to 30 mm long. Stabs prey (any small metazoon) with extendible, poisonous proboscis; may eat dead animals; take in organic debris; preyed upon by larger worms, carnivorous insects, crustaceans.

15. Phylum Gastrotricha: microscopic browsers ingesting smaller organisms and organic material on the substrate often drawn into mouth by cilia-induced currents. Cilia aid in locomotion. Typical of puddles, marshes, wet bogs and pond edges, can withstand low oxygen content. Probably eaten by all carnivorous organisms.

16. Phylum Rotatoria (Rotifers) mostly microscopic (40 microns to 2.5 mm) but universal in all aquatic and semiaquatic habitats (damp soil, mosses) of any size. Many spp., sessile or free-swimming; feed on other rotifers, all kinds of tiny metazoans, plankton, algal cells, depending on sp. A few are parasitic on worms, protists; many are commensals or epizoics on a wide variety of fresh-water invertebrates. May have zoochlorellae in stomach wall. Attacked by fungi; eaten by other carnivous invertebrates. Many can withstand desiccation for months or years.

17. Phylum Nematoda (Round worms) mostly microscopic; probably universal in all habitats esp. soil and damp or aquatic habits; considered the most adaptable organisms; many live as parasites in almost all other plants and animals; feed on dead plant material, detritus, dead animal material, live plants, other animals. Probably eaten by other carnivorous organisms.

18. Phylum Nematomorpha (Horsehair worms, Gordian worms); long, tangled clumsy-swimming aquatic (in all types of aquatic habitats). Free swimming larvae encyst on vegetation at or near waters edge. Cysts eaten by orthopterans, beetles and aquatic insects; cysts hatch inside hosts and digest and absorb host tissues. Adults emerge; become free-living; do not feed.

19. Phylum Tardigrada (Water Bears) microscopic (50-1200 microns) in droplets, water film on terrestial mosses, liverworts, angiosperm rosettes; also between sand grains at waters very edge and filimentous algae. Can withstand drying. Feed mostly on plant cells; some carnivorous on nemotodes; rotifers.

20. Phyla Bryozoa (Moss Animalcules) and Entroprocta: mostly sessile, colonial, tentacle-bearing; surrounded by jelly-like layer. Found in most quiet waters with sunken logs, twigs, rocks and aquatic vegetation. Prefer unpolluted, unsilted water. Feed on algae, protozoans, micrometazoa, and detritus. Eaten by many invertebrates (snails, planarians, oligochaetes, water mites, crustaceans, caddis-worms) and small fish. The colony forms an excellent substrate for a variety of commensals and browsers, esp. ciliates, rotifers. The only spp. so far identified here is Pectinatella magnifica which attracts attention because of the huge size of the gelatinous colonial mass.

21. Phylum Annelida (Segmented worms) Range from microscopic to over 1 foot.
    (a) Class Oligochaeta (Earthworms) found in moist soil (esp. humusy), mud, debris in stagnant pools and ponds; in mosses of filimentous algae; ingest substrate digesting organic components. Chaetogaster spp. feed on entomostracans, insect larvae, other oligochaetes. Aeolosoma spp sweep debris and microorganisms into mouth. Tubifex spp. usually build tubes, wave tails in water, head down; tolerate low oxygen levels. Dero spp. found underside of Duckweeds. Eaten by fishes, turtles, birds, predaceous invertebrates. Enchytraeidae, white or pinkish, common in humus-rich, moist terrestrial soils, as are earthworms Lumbricidae: All are burrowers, (some feeding on the surface at night); often in tremendous numbers; acid soils unfavorable; migrate deeper in winter, dry periods; activites

important in soil mixing (formation of A Horizons), aeration, drainage, fertility and breakdown of organic matter. Eaten by moles, shrews, other mammals, birds, reptiles, amphibians and predaceous soil larvae/adult invertebrates.

(b) Class Branchiobdella: commensals of crayfishes; feed on diatoms, algae, organic debris; possibly parasitic on host's blood (gills, intersegmental membranes)

(c) Class Hirudinea (Leeches) ectoparasites ("blood suckers"), predators, scavengers; 5mm to 45 cm (extended); often brightly colored, patterned; looping locomotion utilizing suckers, or swim. Feed on dead animal matter or snails, insects, oligochaetes, small invertebrates; a few temporary, semi-permanent or permanent ectoparasites on wide variety of vertebrates, crustaceans; chiefly nocturnal, under stones, debris during day. No strong habitat preferences (aquatic). Some may wander on land at night feeding on living/dead invertebrates esp. earthworms. Definitely known to be transported by ducks, shore birds.

22. Phylum Mollusca

(a) Class Gastropoda (Snails, Limpets): found in all aquatic habitats, on all submerged surfaces. Besides gliding on slime track, "hunching" (muscular contractions), "spinning" (decreases specific gravity); moves upward attached by mucous fastened to substrate); eat plants (algae) and dead plant and animal material, incidentally, tiny animals caught in mucous. Eaten by fishes (esp.` sucker, perch, pumpkinseed), some ducks, shore birds, turtles, occasionally amphibians, Invertebrates (leeches, beetle larvae, Hemiptera, Odonata nymphs, Ostracods); intermediate hosts of trematodes. Pouch Snails, Physa spp. (Physidae) where moderate amount of vegetation, organic debris. Hydrobia spp. may occur (in springs). Orb of Wheel Snails (Planorbidae) common as are Lymnaeidae (pond snails). Introduced Viviparidae (mystery snails) apparently competitive with Lymnaea. Terrestrial forms here are usually tiny except for introduced forms which seldom invade natural areas; eat decaying vegetation in which small fungi mycelia are found; (a few are predators on worms, other mollusks). Mostly in woods, sometimes open areas; many families and spp. possible in our area (see references). Land Slugs are pulmonate snails with shells buried internally; feed on dead and live vegetation, animals (omnivorous) serve as food for birds, salamanders, turtles, small mammals, predaceous invertebrates.

(b) Class Pelecypoda (Clams, Mussels); all aquatic; move by extension of foot, "hunching". Filter feed by trapping zoo-and phyto-plankton, organic detritus; draw water into mantle cavity and trap food in mucous; burrow. Unionidae (Mussels); usually in moving water, larvae must be picked up on fishes gills where they live parasitically for several weeks; drop off and transform to adults. Sphaeridae (Fingernail clams) most common in still water. Some can burrow into substrate and tolerate several months drying; may be carried overland in mud debris on feet of birds. Eaten by fish,

muskrats, occasionally by other mammals, trutles. Often heavily infested by parasitic larval flukes, commensal mites.

(c) Reference: Emerson, W. K. and M. K. Jacobson. THE AMERICAN MUSEUM OF NATURAL HISTORY GUIDE TO SHELLS: LAND, FRESHWATER, AND MARINE, FROM NOVA SCOTIA TO FLORIDA. Alfred A. Knopf, 1976.

Visual Stream Assessment Report

prepared with
Environmental Advisory Councils

in
Falls Township
Rock Run and Martins Creek

Yardley Borough
Brock and Silver Creeks

Lower Makefield Township
Brock Creek and Rock Run

Martins Creek - Falls Township

Rock Run - Lower Makefield Township

Brock Creek - Yardley Borough

prepared in support of the
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"Preserving our Natural and Historic Heritage"

Introduction
In support of the Lower Delaware River Conservation Plan (LDRCP), Pennsylvania Environmental Council (PEC) has funded visual stream assessment projects for major tributaries within the study area. In cooperation with local EAC groups, Heritage Conservancy has completed projects in the following municipalities.

Falls Township - *Rock Run and Martins Creek*

Yardley Borough - *Brock, Buck, and Silver Creeks*

Lower Makefield Township - *Brock Creek and Rock Run*

Heritage Conservancy provided information sheets and one field session at the municipality to review stream assessment procedures. EAC members then walked the streams using the checklist and provided a detailed inventory of conditions along streams in their municipality. With this information, Heritage Conservancy mapped and photographed the conditions using the latest technology in GPS, GIS and digital photography and scanning. Using this data, recommendations were developed for restoring stream buffers in the region. The recommendations will be included in the LDRCP and a working map produced and provided to each EAC.

Falls Township - Martins Creek
Much of the length of Martins Creek has an intact, if narrow, riparian buffer. The buffer includes dense herbaceous vegetation, understory and overstory woody growth. Common species include Sweet Gum, Willow, Cherry, Grape, Poison Ivy, Cottonwood, River Birch, and Ash. The history of the creek is significant in that a considerable length of it passes through active or abandoned sand and gravel quarrying operations. The stream bed has been altered by these activities and does not appear to have a natural meandering course. Many areas are virtually inaccessible due to dense vegetative growth and steep slopes. Buffers range to 50 feet in width. Problems do exist where adjacent property owners are mowing along the creek and dumping yard debris into the stream channel. In addition, inappropriate land uses located adjacent to the creek are potential sources of non-point source pollution.

The Falls Township Community Park which includes 10 sports fields and numerous other large active recreation facilities is being constructed adjacent to Martins Creek. Approximately one mile of the creek flows through the 228 acre park site. The property was previously a quarry site and the stream bed appears to be altered. The banks are 15-20 feet high in areas, steep and covered with dense brush. A number of drainage and bridge structures cross the creek for equipment access. North of the park are continuing quarrying operations. Flooding has appeared to cause disturbance in some existing woodland areas, killing the overstory canopy and allowing exotics to invade (purple loosestrife). Specifically noted land uses adjacent the creek include, a salt house and paving for commercial areas infringing on the stream buffer. The stream does have points where flow is restricted which cause flooding due to jams of trash and debris during major storm events.

A possibility may exist for the community to create a greenway along this stream corridor. The land is not divided into small parcels, but owned by large quarrying operations. The park land could extend further north and include .5 to 1 mile of the stream. Also, the Delaware Canal is adjacent the existing park property and is a resource to be linked to a greenway in the future.

Following are field notes collected by Greg Giles of the Falls Township EAC.

Rock Run headwaters are located in Lower Makefield Township in the vicinity of Stony Hill Rd. This stream flows in a east/southeasterly direction through wooded and residential areas where it enters Falls Township in the vicinity of Louise Drive and Valley Drive. From this point the flow direction becomes more southerly and a tributary coming from the north is added. From this point the stream flow is primarily through a wooded region until crossing under Route 1 near Snipes Nursery. From Route 1, Rock Run flows south, roughly parallel to Route 13. South of Tyburn Road a tributary from the east is added and the stream becomes Martins Creek. As the stream flows south it goes through the new Falls Township Park, crosses Bristol Pike and flows into Tullytown Borough where it discharges into a cove of the Delaware River.

Rock Run flows out of Lower Makefield Township in Falls Township through residential neighborhoods. In this area, the stream bed is entrenched, wide and flat but carries little water, showing the characteristic shape of a flood-controlled stream channel. The base of the stream is composed of large gravel and boulders. Average water depth is 2 inches in depth. Stream banks contain little plant growth and show signs of ongoing erosion.

South of Route 1, a property owner on the west side of the stream is piling up tree pruning debris along the western bank of the stream **(photo 1)**. Additionally, a large tree has fallen across the stream at this location. The pruning debris and the large tree both have the potential to inhibit stream flow at times of high flow. Water depth in this area averages 6 inches to one foot in depth. Downstream from this point the stream appears to disappear as it is channeled underneath a road for a distance of approximately 300 feet **(photo 2)**. The overlying road goes through three large tunnels that allow traffic to cross under the Conrail railroad yard. Where the stream is directed under the road (at the northern side of the tunnel complex), there is little additional room under the road to allow for additional water flow or debris to move downstream. This location represents a stream pinch point where water can back up and debris can be caught during periods of high stream flow. At this location, the stream bed consists of coarse sand and gravel.

As Rock Run nears Tyburn Road, it flows by a sand/salt house **(photo 3)**. At Tyburn Road, a significant amount of debris (wood pallets, tires, etc.) can be seen in the water on the south side of the bridge **(photo 4)**. The stream channel on the north side of Tyburn road appears to have been straightened. As Rock Run flows south it appears to frequently overflow its banks as evidenced by the appearance of a large area of dead trees. While this area was obviously once

largely a forest, it is now dominated by invasive wetland plants including Phragmites and Purple Loosestrife **(photo 5)**.

Between Tyburn Road and Penn Valley Road, Rock Run joins an unnamed stream to form Martins Creek. South of Penn Valley Road, martins Creek flows through abandoned quarry property now being developed for the Falls Township Community Park **(photo 6)**. Continuing through the new park, numerous trees have fallen across the creek resulting in significant blockage of the creek **(photo 7)**. The trees appear to have fallen due to erosion of the base of the trees during periods of high stream flow. Large carp and some smaller fish were observed in this section.

As the creek flows south nearing the Delaware Canal, it is channeled through three large culverts laid side by side. This location appears to restrict flow at times of high stream flow, resulting in the accumulation of trash and debris. From this location north to Lower Morrisville Road the stream channel is soft and largely composed of a clayey silt.

Martins Creek flows out of the community park as it is piped under the Delaware Canal **(photos 8-9)**. The creek appears to end as it disappears under the embankment of the Delaware Canal. This point represents a location of severe flow restriction at high stream flow conditions. Significant amounts of trash and debris were observed at this location and appear to get trapped here. The creek flows south from this point paralleling the canal. Along this stretch of the creek a Delaware Canal flood gate discharges water from the canal into Martins Creek. Accordingly, this point represents the potential for significant flow input into Martins Creek from the Delaware Canal.

As Martins Creek nears Mill Creek Road, adjacent properties have encroached into the buffer area **(photo 10)**. South of Mill Creek Road, the stream consists of a meandering channel that flows through forest. The creek bed in this area is covered by coarse sand and gravel. Abundant clams exist in this area. This was the only area in which abundant benthic organisms were observed. Water depth ranges from several inches in areas where the channel widened to greater than two feet in slower moving spots. Several small tributaries discharge into the creek in this area but add little additional flow. Assorted railroad ties and tires were observed in the stream.

Yardley Borough - Brock and Silver Creeks

Brock Creek flows through Lower Makefield Township into Yardley Borough before emptying into the Delaware River **(photo 1)**. Much of the Brock Creek watershed has been developed for residential homes and the creek receives tremendous amounts of storm water runoff and sediment. The effects of runoff during major storm events heavily impacts the creek as it flows through Yardley Borough.

Starting at the river the first section of the creek passes by the Yardley Inn. The left bank (looking upstream) is stabilized using large riprap rock. The paved parking area of the Inn extends to the edge of the stream bank. On the right side, a retaining wall protecting residen-

tial properties is collapsing into the creek **(photo 2)**. The rip rap continues on the left bank up to the Delaware Canal crossing **(photo 3)**. Paved parking areas extend to the edge of the bank and no vegetative buffer exists **(photo 4)**. Debris blocks the creek in several places where large limbs have been caught in rip rap. Stands of Purple Loosestrife are growing on the right bank.

Brock Creek passes underneath the Delaware Canal **(photo 5)**. The opening is slowly being filled with sediment and during major storm events, the opening traps debris and restricts water flow. This backup of water has severely eroded the left bank and exposed the foundation of the mill building adjacent to the creek. Moving upstream, a narrow canopy buffer exists in pieces **(photo 6)**. Many of the adjacent homeowners have mowed to the edge of the stream. These areas are experiencing severe bank erosion. As the creek nears the Main Street bridge crossing, a 300 foot retaining wall is failing and falling into the creek **(photo 7)**. The opposite bank is experiencing severe erosion due to high velocity storm water flowing in the creek. Multiflora Rose has invaded several disturbed areas along the creek.

Debris becomes trapped underneath the bridge at Main Street. Evidence of stream bank erosion continues on the right bank until reaching the dam at Lake Afton **(photos 8-9)**. The study continues to the confluence of Buck and Brock Creek. Again, debris continues to restrict water flows and sediments are building up on the right bank. On the left bank, two open drainage pipes empty into the creek and a paved parking area abuts the stream for approximately 300 feet. Brock creek joins Brock Creek from the south. Upstream along Brock Creek, paved parking continues to intrude into the riparian corridor for another 200 feet **(photos 10-13)**. Multiflora rose has invaded some areas. Further upstream the riparian buffer has been destroyed and stream bank erosion is evident on both sides of the Creek. Debris from flooding is causing damage and diverting stream flows. Multiflora Rose is prevalent along both sides of the creek and adjacent property owners are mowing along the stream in numerous places.

Buck Creek flows from the west for approximately 450 yards. The stream channel is primarily narrow and shallow widening in a few placing. The left bank has a moderate to steep slope. A woodland canopy remains intact for much of the length, with mown lawns beginning to intrude into the riparian zone. Erosion is becoming a problem along much of this bank.

The right bank is a low-lying floodplain area primarily covered with a woodland canopy. Wetlands do exist in some areas. Primarily, the bank is stabilized by existing vegetation. There is evidence of former industrial uses along this side of the creek. A settling pond provides habitat for populations of fish and turtles.

Important to note, a dam and settling pond occur along this segment of the creek. The dam has created a large pool and extended wetland area. Water seepage and erosion are evident around the dam presenting some danger.

Silver Creek runs through the south portion of Yardley Borough. The headwaters are in Lower Makefield Township with a large private lake just outside Yardley Borough. As the stream enters the borough it passes through the Yardley Country Club golf course **(photo 4)**. Both sides of the creek are mown to the edge of the streambank. No riparian vegetation exists. Riprap has been used where a pedestrian bridge crosses the creek **(photo 3)**. Continuing downstream to the Main Street crossing moderate erosion occurs along both banks. Several properties continue to mow to the edge of the stream and Multiflora Rose has invaded in some areas **(photo 2)**. Below Main Street, Silver Creek is experiencing severe bank erosion **(photo 1)**. Rocks and debris from flood events are restricting creek flows. Properties encroach into the riparian area as the creek continues until emptying into the Delaware Canal.

The headwaters and a majority of the watersheds for Brock, Buck, and Silver Creek are outside of Yardley Borough and lie in Lower Makefield Township. It is important that projects along the creeks include both municipalities.

Lower Makefield Township - Brock Creek and Rock Run

Brock Creek flows from the southwest corner of Lower Makefield Township northeast into Yardley Borough where it joins Buck Creek and then empties into the Delaware River. The township has recently completed a streambank restoration on a portion of Brock Creek and continues to work to improve this stream.

Rock Run begins in the area of Stoney Hill Road and flows east/southeast through wooded areas and residential developments before entering Falls Township where it joins an unnamed stream to form Martins Creek. Martins Creek flows south through Falls Township and Tullytown Borough before emptying into Franklin Cove and the Delaware River.

The Lower Makefield Township EAC under the direction of John Ryder conducted the following inventories along Brock Creek and Rock Run.

Brock Creek

Near Sandy Run, Brock Creek flows out of Lower Makefield Township and into Yardley Borough. Adjacent properties have mown down to the edge of the creek leaving no buffer vegetation **(photo 1)**. Recently disturbed areas are being colonized with dense pioneer vegetation. Erosion occurs intermittently along the stream banks while pools and riffles with large rocks characterize the stream bottom. Storm drain outlets are visible emptying directly into the creek **(photo 2)**.

Continuing upstream, the creek flows through a wooded area with a dense canopy cover **(photo 3)**. Dwellings are not placed near the stream bank. The vegetation includes a dense understory with established pioneer shrubs. Erosion is evident in areas caused during high flows. The silty deposits are visible opposite the cut banks.

Nearing Stony Hill Road, the riparian vegetation has been moderately impacted by clearing and motor bike paths.

A dense understory remains intact in many areas. Stream flows have cut vertical banks up to 4 feet high undercutting some trees **(photo 4)**. Sediment deposits are visible. Upstream from Stony Hill Road, the riparian area is covered with a slightly impacted mature forest canopy with specimen trees **(photo 5)**. Mature trees are threatened by severe undercutting along the creek. One side of the creek is impacted by adjacent swim club activities which include a playground in forested areas along the creek.

Continuing upstream, Brock Creek flows through a relatively mature forest with a dense understory before flowing under the rail line **(photo 6)**. Creek flows have eroded vertical banks undercutting large trees. The bottom of the stream appears stable with small rocks. From this point Brock Creek flows under Heacock Road and through new residential areas. Here town house development has been placed within 50 feet of the stream channel. A narrow strip of vegetation remains with a diversity of wildflowers, understory, and canopy trees **(photo 7)**. Creek flows have severely eroded streambanks and significant deposits of sand and gravel are visible in some deep pools. Trash and debris is visible throughout this segment of the creek.

Rock Run

Near its headwaters, Rock Run remains forested except for a portion flowing through a residential development **(photo 1)**. The channel shows signs of heavy flows scouring stream banks and depositing sediment on the stream bottom. Downstream, Rock Run flows through an established residential development **(photo 2)**. Young trees are vegetating stream bank areas. Properties back up to the stream channel.

Crossing Derbyshire Road, the stream is characterized with a dense young forest cover. Near vertical banks are sloughing into the channel **(photo 3)**. Sedimentation is occurring while portions of the channel appear as a rectangular flume. From this point the stream exits the wooded area and flows through school parking areas and playing fields at Charles Boehm Middle School. No riparian vegetation exists along the stream channel and the channel is experiencing severe erosion **(photo 4)**. Banks are sloughing into the stream and erosion has exposed a buried pipe. The bottom is eroding due to heavy flows from stormwater runoff directed into the stream from parking areas. Trash is collecting at numerous points along the stream.

Leaving the school property, Rock run flows through a number of larger institutional properties. The existing buffer varies in width and vegetative cover. Segments range from densely wooded areas with scattered mature trees and numerous young saplings to only dense herbaceous growth **(photo 5).** Erosion is evident throughout with stream banks sloughing into channel. Invasive species have colonized including Purple Loosestrife, Multiflora Rose and Reed Canary Grass. Channel is relatively stable with small pools visible.

Continuing downstream, Rock Run has been channeled to flow beneath Big Oak Road. Limited overstory is present along the stream **(photo 6)**. Below Big Oak Road Rock Run flows through a mature buffer with forest canopy and

dense understory. On the Big Oak Road side of the stream, a parking lot has encroached into the riparian corridor. The stream is characterized by very large boulders and a towering tree canopy **(photo 7)**. Erosion is limited in the area but sedimentation is impacting pools in the stream bottom.

Near Falls Township Rock Run is heavily impacted by adjacent property owners mowing to the edge of the stream and dwellings built within 50 feet of the channel. Vertical streambanks are sloughing into the channel and adjacent residents are mowing to the stream edge and dumping yard waste into the channel **(photo 8)**.

Summary

The region's waterways are heavily impacted by stormwater runoff from continuing residential development and urbanization. Much of the riparian buffer area has been lost as adjacent property owners mow and maintain lawns to the stream bank. This loss reduces a stream's effectiveness to trap and filter out sediment and nutrients from stormwater runoff, provide wildlife habitat, and be a valuable recreational resource. Increasingly, streams are carrying heavy flows during major storm events which scour the stream bottom and erode stream banks. Pressures on downstream areas have required drastic measures (including the use of riprap and concrete retaining walls) to keep waters from flooding and destroying property. While these problems continue, areas of significant wildlife habitat and beauty do exist along many of the streams.

Point	Stream Channel	Left Corridor	Right Corridor	Left Streambank	Right Streambank	Erosion	Deposits	Notes
1	wide (12ft), shallow (3ft)	steep slope with shrub growth	moderate slope with 50% tree cover and 50% shrubs	narrow corridor encroached on by adjacent property owners	narrow corridor limited by adjacent road right-of-way	undercutting and scouring	gravel bottom with silt deposits	the adjacent property owner has dumped tree cuttings and lawn clippings along the creek
2	narrow (8ft), shallow (3ft)	steep banks with shrub growth	steep banks with shrub growth	little vegetative growth, no buffer	little vegetative growth, no buffer	undercutting	silt deposits	at this point Martins Creek flows underground beneath the rail crossing for approximately 500 ft.
3	wide and shallow	floodplain with 80% paved and 20% tree canopy	moderate slope with 80% tree canopy 20% shrubs	narrow corridor with little vegetation, adjacent land uses encroaching on corridor	dense vegetative growth with overstory	NA	NA	at this location a salt house has been located adjacent to Martins Creek with additional paved surface within the corridor area
4	wide (20ft), deep (8ft)	moderate slope with 40% tree cover and 60% shrubs	steep slopes with shrub cover	dense vegetative growth with some overstory	narrow band of vegetation, adjacent commercial business encroaching	right bank severely eroded by undercutting	gravel deposits	an adjacent commercial business has severely encroached into the riparian corridor
5	wide and shallow	floodplain	floodplain	wetland and floodplain forest vegetation	floodplain forest vegetation	NA	NA	at this point it appears that flooding has disturbed the existing hardwood vegetation, wetland invasive species are colonizing (Purple Loosestrife)
6	wide (20-30ft), shallow (2ft)	floodplain with 80% tree cover and 20% shrubs	floodplain with 80% tree cover and 20% shrubs	dense vegetative growth with overstory	dense vegetative growth with overstory	stable-vegetated, some scouring visible	silt deposits	at this point a healthy corridor remains intact and little disturbed by human activity
7	narrow (8ft), deep (8-10ft)	steep slope with 50% tree cover and 50% shrubs	steep slope with 50% tree cover and 50% shrubs	steep bank with heavy vegetation	steep bank with heavy vegetation	undercutting, moderately erosion occurring	gravel deposits	the stream bed appears to have been straightened with heavy flows eroding a deep but narrow channel
8	wide (15ft), deep (8-10ft)	moderate slope with 30% tree cover, 50% shrubs and 20% meadow	moderate slope with 80% tree cover and 20% shrubs	disturbed area with sparse vegetation and limited overstory	heavy vegetative growth with overstory	moderately eroded area	NA	at this point Martins Creek is submerging below the Delaware Canal, the canal levee has been reinforced with large concrete blocks, appears to back up heavy water flows during flooding events
9	wide (20ft), deep (8-10ft)	floodplain and moderate slopes with 60% tree cover and 40% shrubs	moderate slope with 70% tree cover and 30% shrubs	dense understory with overstory growth	heavy overstory growth, understory disturbed by footpaths	stable-vegetated 70-80% with some moderate erosion	NA	at this point Martins Creek emerges from under the Delaware Canal, a deep pool has formed, foot traffic has caused a moderate erosion problem
10	narrow (8ft), shallow (3ft)	moderate slope with 80% shrub cover and 20% lawn	floodplain and moderate slopes with 80% shrub cover and 20% lawn	dense vegetative growth, adjacent property encroaching on corridor, no overstory	disturbed areas being colonized by Purple Loosestrife, no overstory, some mowing to the edge of streambank	stable-vegetated 80-100%	gravel deposits	adjacent properties are encroaching on the riparian corridor, remaining area is only 20-30 feet wide

Point	Stream Channel	Left Corridor	Right Corridor	Left Streambank	Right Streambank	Erosion	Deposits	Notes
1	wide (12ft), shallow (3ft)	moderate slope with 60% tree cover, 10% shrubs, 30% lawn, dwelling with lawn down to bank	moderate slope with 90% tree cover, 6% shrubs, 2% lawn, 2% meadow, formerly disturbed area, revegetating with dense pioneer species	80% stable-vegetated, 20% moderately eroded, 5% bedrock	85% stable-vegetated, moderately eroded 15%	intermittent erosion throughout reach	pool and riffles with large rocks	limited access
2	wide (12ft), shallow (3ft)	moderate slope with 20% tree cover, 10% shrubs, 70% lawn	moderate slope with 20% tree cover, 15% shrubs, 65% lawn	60% stable-vegetated, 20% moderately erode, 20% channelized	60% stable-vegetated, 20% moderately erode, 20% channelized	intermittent erosion throughout reach	NA	lawns and dwellings adjacent to creek; invasive shrubs - Multiflora Rose, Pokeweed, some stream sections are channelized with retaining walls, footbridge over stream
3	wide (25ft), shallow (4ft)	floodplain 20% and moderate slope with 80% tree cover, 10% shrubs, 10% meadow	moderate slope with 90% tree cover, 5% shrubs, 5% meadow	40% stable-vegetated, 40% moderately eroded, 20% severely eroded	20% stable-vegetated, 20% moderately eroded, 60% severely eroded	3-4ft vertical sides of silty soil	deposits opposite erosion	forested with dense to sparse understory with pioneer shrubs, wetland delineation marks are set on property
4	wide (15ft), shallow (4ft)	moderate slope with 100% tree cover	moderate slope with 100% tree cover	10% stable vegetated, 30% moderately eroded, 60% severely eroded	10% stable-vegetated, 20% moderately eroded, 70% severely eroded	vertical banks up to 4ft high of silty soil, undercut banks and trees	some sediment deposits along reach	mature forest, moderately impacted by clearing and motor bike paths
5	wide (15ft), shallow (4ft)	moderate slope with 100% tree cover, mature forested area with specimen trees, little floodplain area, forest area slightly impacted	moderate slope with 80% tree cover, 20% lawn, mature forest with areas used by swim club as playground, moderately impacted by activities	10% moderately eroded, 90% severely eroded	10% moderately eroded, 90% severely eroded	mature trees threatened by severe erosion, undercutting	many pool riffle segments	healthy forested area on left bank
6	narrow (10ft), deep (3-5ft)	floodplain 10%, moderate slope 90% with 90% tree cover, 10% lawn	floodplain 10%, moderate slope 90% with 100% tree cover, relatively mature forest area with dense understory	20% stable-vegetated, 20% moderately eroded, 60% severely eroded	20% stable-vegetated, 20% moderately eroded, 60% severely eroded	near vertical stream banks, silty soil, undercutting large trees	bottom of stream is stable with small rocks, some pools up to 3ft deep	relatively mature forest area with dense understory, housing development and lawns
7	narrow (10ft), shallow (3ft)	floodplain 20%, moderate slope 80% with 90% tree cover, 10% shrubs, young forest, townhouses and lawns within 50ft of stream channel	floodplain 20%, moderate slope 80% with 100% tree cover, young forest with scattered large trees	10% stable-vegetated, 30% moderately eroded, 60% severely eroded	10% stable-vegetated, 30% moderately eroded, 60% severely eroded	bare streambanks with silty soil, trees on banks severely undercut at some locations	some deep pools with moderate to significant deposits of sand and gravel	adjacent property owner dumping wood waste from wood splitting operations, being carried several hundred feet downstream, debris scattered throughout stream channel

Point	Stream Channel	Left Corridor	Right Corridor	Left Streambank	Right Streambank	Erosion	Deposits	Notes
1	narrow (10ft), deep (6-8ft)	moderate slope with 95% tree cover 5% shrubs, drained forested wetland, housing development	moderate slope with 90% tree cover, 4% shrubs, 2% lawn, 2% driveway and dwelling, drained forested wetland, housing development	20% stable-vegetated, 78% moderately eroded, 2% channelized	20% stable-vegetated, 77% moderately eroded, 3% channelized	vertical sides of channel consisting of silty soil scoured by flood flows	stony relatively stable stream bottom, significant sedimentatio n	stream appears to be deepened and relocated
2	wide (15ft), shallow (4ft)	moderate slope with 15% tree cover, 15% shrubs, 50% lawn, 20% driveway and dwelling; stream channel vegetated with young trees through 20 year old residential development	moderate slope with 15% tree cover, 15% shrubs, 50% lawn, 20% driveway and dwelling; stream channel vegetated with young trees through 20 year old residential development	60% stable-vegetated, 40% moderately eroded	60% stable-vegetated, 40% moderately eroded	NA	NA	private property, limited access
3	wide (12ft), shallow (3-4ft)	moderate slope with 100% tree cover; dense young forested area	moderate slope with 100% tree cover; dense young forested area	30% stable-vegetated, 70% moderately eroded	10% stable-vegetated, 90% moderately eroded	near vertical banks of silty soil sloughing off into channel	significant sedimentatio n	channel appears as a rectangular flume
4	narrow (8-10ft), shallow (2-5ft)	moderate slope, 40% lawn, 60% paved, playing fields and parking area for middle school	95% lawn, 5% paved, playing fields for middle school	50% stable-vegetated, 40% severely eroded, 10% channelized	50% stable-vegetated, 105 channelized	vertical banks (3ft) sloughing off into channel; on right side buried pipe is exposed from erosion	unstable channel bottom	trash and debris in channel, storm flows piped through parking area behind school
5	narrow (10ft), shallow (3-4ft)	moderate slope with 85% tree cover, 5% shrubs, 10% lawn, dense forested area, scattered mature trees surrounded by young trees, sparse understory with little groundcover	20% tree cover, 15% shrubs, 65% lawn, dense forested area comprised of young pioneer trees, crab apple & black cherry, lawn area is mowed field	90% moderately eroded, 10% severely eroded	90% moderately eroded, 10% severely eroded	vertical banks and trees being undercut	some sections with pools, channel bottom relatively stable with small rocks up to 6in diameter	well worn path south side of channel
6	narrow (10ft), shallow (4 ft)	moderate slope with 10% tree cover, 105 shrubs, 80% lawn, channelized stream with adjacent lawn and driveways	moderate slope with 10% tree cover, 10% shrubs, 80% lawn	moderately eroded, channelized	moderately eroded, channelized	erosion throughout entire segment, vertical sidewalls sloughing off into channel	sediment deposits at several locations throughout segment; stream bottom stable in most locations and comprised of small rocks	invasive species throughout section, Purple Loosestrife, Reed Canary Grass, Multiflora Rose
7	wide (15-20ft), shallow (3ft)	moderate slope with 100% tree cover, mature forest with dense to moderate vegetation	floodplain and moderate slope with 40% tree cover, 10% lawn, 35% paved, 15% other, mature forest, parking for church and transformer yard	30% stable-vegetated, 555 moderately eroded, 15% severely eroded	40% stable-vegetated, 60% moderately eroded	erosion kept in control at some locations by very large rocks, erosion undercutting large rocks and trees throughout segment	channel bottom relatively stable comprised of rocks and boulders	pools in stream bottom being impacted by sedimentation
8	narrow (10-12ft), shallow (4ft)	moderate slope with 90% tree cover, 10% shrubs, young forested area with rocky soil	moderate slope with 50% tree cover, 50% lawn, lawns and landscaping up to stream bank, dwellings within 50ft of stream bank	85% stable-vegetated, 15% eroded	80% moderately eroded, 20% channelized	near vertical sidewalls sloughing off into channel	stream bottom relatively stable, composed of 6-12" diameter rocks	property owners dumping yard waste into channel

Point	Stream Channel	Left Corridor	Right Corridor	Left Streambank	Right Streambank	Erosion	Deposits	Notes
1	wide (30ft+), deep (20ft)	steep slope with 100% riprap cover	steep slope with 80% tree cover 20% shrubs	no vegetation, steep slope stabilized with riprap	steep slope with minimal vegetation	severe erosion occurring	sediment deposited in channel	stabilized slope supporting parking area for Yardley Inn
2	wide (30ft+), deep (20ft)	steep slope with 100% riprap cover	steep slope with 80% tree cover 20% shrubs	no vegetation, steep slope stabilized with riprap	steep slope with supporting retaining wall deteriorating	riprap and retaining wall protecting against erosion	sediment deposited in channel	nearby properties on right streambank protected by retaining wall
3	wide (30ft+), deep (20ft)	steep slope with 100% riprap cover	flood plain with 100% meadow cover	no vegetation, steep slope stabilized with riprap	floodplain area with herbaceous vegetation, Purple Loosestrife colonizing disturbed areas	moderate bank erosion occurring on right streambank	sediment deposited in channel	
4	wide (30ft+), deep (20ft)	steep slope with 100% riprap cover	flood plain with 100% meadow cover	no vegetation, steep slope stabilized with riprap	floodplain area with herbaceous vegetation, Purple Loosestrife colonizing disturbed areas	moderate erosion occurring on right streambank	sediment deposited in channel	
5	wide (30ft+) deep (20ft)	steep slope with 100% riprap cover	steep slope with minimal cover	no vegetation, steep slope stabilized with riprap	severely degraded bank with little vegetation	severely eroded (vertical) right streambank	sediment deposited in channel	nearing Delaware Canal crossing, stream flows under canal
6	wide (15ft), shallow (2ft)	moderate slope with 20% tree cover, 40% shrubs and 40% lawn	moderate slope with 50% shrub cover and 50% lawn	lush undergrowth along stream, buffer less than 20ft wide, some mowing to stream edge	dense shrub growth with mowing encroaching into buffer area.	moderate erosion	rocky bottom with some sedimentation	adjacent residential properties encroaching into corridor area
7	narrow (8ft), shallow (2ft)	moderate slope with 100% tree cover	moderate slope with 100% tree cover	forested buffer with Multiflora Rose	forested buffer with Multiflora Rose	moderate erosion along streambanks	minimal deposits	300ft deteriorating retaining wall protecting adjacent properties
8	narrow (6ft), shallow (1ft)	floodplain with 20% tree cover 30% shrubs and 50% lawn	moderate slope with 80% tree cover and 20% shrubs	minimal buffer area disturbed by mowing on adjacent property	forested buffer with Multiflora Rose	stable-vegetated	minimal deposits	adjacent property mowing and dumping yard waste in buffer area, debris under Main St bridge crossing
9	wide (30ft+), shallow (5ft)	floodplain with 100% meadow cover	moderate slope with 80% tree cover and 20% shrubs	no buffer and retention area stabilized with riprap	adjacent development encroaching into buffer	stable-vegetated	minimal deposits	near the Dam at Lake Afton, deep pool created at base of dam, drain pipes emptying into creek
10	narrow (10ft), shallow (2ft)	moderate slope with 50% tree cover and 50% paved	moderate slope with 100% tree cover	adjacent commercial parking encroaching into buffer area	forested buffer with Multiflora Rose	moderate erosion	sediment deposits	buffer width is minimal due to nearby commercial business, stormwater from paved area directed into creek
11	narrow (10ft), shallow (2ft)	moderate slope with 50% tree cover and 50% shrubs	moderate slope with 100% tree cover	buffer width limited by proximity of Afton Avenue	forested buffer with Multiflora Rose	moderate erosion	sediment deposits	narrow buffer area undisturbed but invasive species dominate some areas
12	narrow (10ft), shallow (2ft)	floodplain with 20% tree cover, 30% shrubs and 50% meadow	moderate slope with 50% tree cover and 50% shrubs	undisturbed buffer with limited overstory	forested buffer with Multiflora Rose	moderate erosion	gravel deposits	wide undisturbed buffer with diverse vegetation
13	narrow (8ft), shallow (2ft)	moderate slope with 50% shrub cover and 50% lawn	moderate slope with 50% shrub cover and 50% shrubs	limited buffer vegetation, adjacent properties mowing to stream edge	limited buffer vegetation, adjacent properties mowing to stream edge	severe erosion causing vertical banks to slough into stream channel	gravel deposits	adjacent property owners disturbing buffer along stream, mowing and dumping yard debris in buffer area

Point	Stream Channel	Left Corridor	Right Corridor	Left Streambank	Right Streambank	Erosion	Deposits	Notes
1	narrow (10ft), shallow (3ft)	steep slope with 50% tree cover and 50% paved	moderate slope with 100% tree cover	retaining wall supporting nearby structures	forested buffer with Norway Maple	severe erosion occurring between Main St and canal	silt sediments	adjacent properties encroaching into buffer area, debris in channel slowing creek flows
2	wide (15ft), deep (15ft)	moderate slope with 100% tree cover	steep slop with lawn cover	forested buffer with Norway Maple	no buffer vegetation	moderate erosion	silt deposits	Adjacent property mowing to stream edge
3	wide (30ft), deep (5ft)	floodplain with 100% lawn cover	moderate slope with 100% shrub cover	no buffer vegetation	shrubs colonizing slope areas	moderate erosion	silt deposits	country club maintaining lawn to stream edge, gabions used to support streambank near pedestrian bridge
4	wide (30ft+), deep (5ft)	floodplain with 100% lawn cover	floodplain with 100% lawn cover	no buffer vegetation	no buffer vegetation	severely eroded banks sloughing into stream	silt deposits	stream widened into pond with no buffer vegetation, country club maintaining lawn to waters edge

WATERWAY HABITAT SURVEY

DATE___/___/___ SURVEYORS_____

WATERWAY_____ WATERSHED_____

LOCATION_____ MUNICIP._____

SEGMENT LENGTH (yds.)_____ RECENT WEATHER _____

RELATIVE STREAM FLOW: HIGH____ MODERATE____ LOW____

Stream Channel:
NARROW, SHALLOW ___% WIDE, SHALLOW ___% NARROW, DEEP ___% WIDE, DEEP ___%

Stream Corridor Conditions: (slope percentage; ground cover type and percentage)
(LEFT SIDE - *FACING UPSTREAM*)
FLOODPLAIN____% MODERATE SLOPE____% STEEP SLOPE____%

TREES____% SHRUBS____% LAWN____% CROPLAND____%
PASTURE____% PAVED____% MEADOW____% OTHER____%
(DESCRIBE OTHER)_____

(RIGHT SIDE - *FACING UPSTREAM*)
FLOODPLAIN____% MODERATE SLOPE____% STEEP SLOPE____%

TREES____% SHRUBS____% LAWN____% CROPLAND____%
PASTURE____% PAVED____% MEADOW____% OTHER____%
(DESCRIBE OTHER)_____

Characterize Stream Corridor and Adjacent Area:
LEFT SIDE:

RIGHT SIDE:

Streambank Conditions:
(LEFT BANK - *FACING UPSTREAM*)
STABLE-VEGETATED____% MODERATELY ERODED____% SEVERELY ERODED____%
BEDROCK____% CHANNELIZED____% OTHER (describe below)____%

(RIGHT BANK - *FACING UPSTREAM*)
STABLE-VEGETATED____% MODERATELY ERODED____% SEVERELY ERODED____%
BEDROCK____% CHANNELIZED____% OTHER (describe below)____%

Describe Streambank Erosion (including approx. length and height in yards/feet):

Describe Sediment Deposits (gravel bars, silt etc.):

Additional Field Notes:

Field Observations for Lower Delaware River Conservation Plan

EAC Members
Complete the provided field observation forms and locate points of concern on the provided USGS Quad Map (enlarged to 1"=1000').

Step One - Complete the survey forms
Two forms have been provided for collecting general information regarding the character of the stream corridor and adjacent areas.

- Waterway Habitat Survey
- Windshield-Waterway Survey

Step Two - Mapping
When mapping, user the symbols below with a number inside to correspond with descriptive text. Estimate the area in a descriptive format. Label all points sequentially. Put your name/s on the sheet you worked on in case we later have questions. Observe land uses and general management of the riparian corridor, the 50' to 100' buffer on each side of the creek. Use the following symbols to map conditions:

- erosion: type, source, severity, cause if visible
- siltation or other deposition
- unvegetated banks: mowed, paved or other unnatural surfaces
- extensive invasive species: Multiflora Rose, Knotweed, Russian Olive...
- non-point pollution: large parking lot runoff
- visible pipes from stormwater, effluent, or culverts
- existing recreation access points - county or local parks
- other specific observations

All of your field information will be put directly on the provided USGS Quad, scaled to 1"=1000' as it will be the final product for submission to DCNR. Your observations and location area can only be general due to the loss of accuracy at the large scale of the USGS quads. Anything less than 500' can only be represented by a point. This will make it easier for the GIS coordinator to "digitize" or locate the information uniformly. If the numbered points are made on a copy of the USGS quads, then they can be entered into the GIS database. If you observe anything larger than 500' draw the estimated line and put the symbol associated with it.

-Use the scale and symbols provided for easy reference when mapping-

HERITAGE CONSERVANCY
85 OLD DUBLIN PIKE
DOYLESTOWN, PA 18901
TELE: 215.345.7020
FAX: 215.345.4328

Visual Stream Assessment

Rock Run & Martins Creek

Falls Township
Environmental Advisory Council
in support of the

Lower Delaware River Conservation Plan

Photo 1 - Looking downstream south of Route 1 crossing. Debris (leaves, tree cuttings, and lawn clippings) piled at the stream edge. No overstory tree cover and little undergrowth along the stream banks. Recommendation: Establish a buffer area. Clear debris and plant riparian buffer.

Photo 2 - Looking downstream towards the inlet where Martins Creek submerges below the railyard crossing. During storm events, debris collects and slows creek flow. The area is disturbed with sparse vegetation. Recommendation: Clear debris from channel and plant riparian buffer.

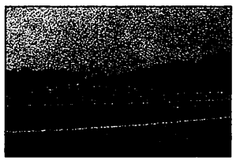


Photo 3 - Looking upstream near Tyburn Road. A sand/salt house is located adjacent to Martins Creek. No riparian buffer between the structure and the creek. Recommendation: Plant buffer vegetation to trap and filter runoff from the adjacent land uses. Look to relocate sand/salt house in the future.

Photo 4 - Looking downstream from Tyburn Road crossing. Adjacent commercial development encroaching in the riparian buffer. Paved area extending to the stream edge. No overstory riparian vegetation. Recommendation: Look to reestablish buffer area along the creek during future construction or renovations.

Photo 5 - View from the Tyburn Road Route 13 off-ramp. Looking across floodplain wetlands along Martins Creek. Overstory vegetation being replaced by Purple Loosestrife and Phragmites. Stormwater runoff from the Route 13 freeway flows directly into the area. Recommendation: Trap and filter stormwater flowing into the floodplain. Manage invasive species and restore native vegetation.

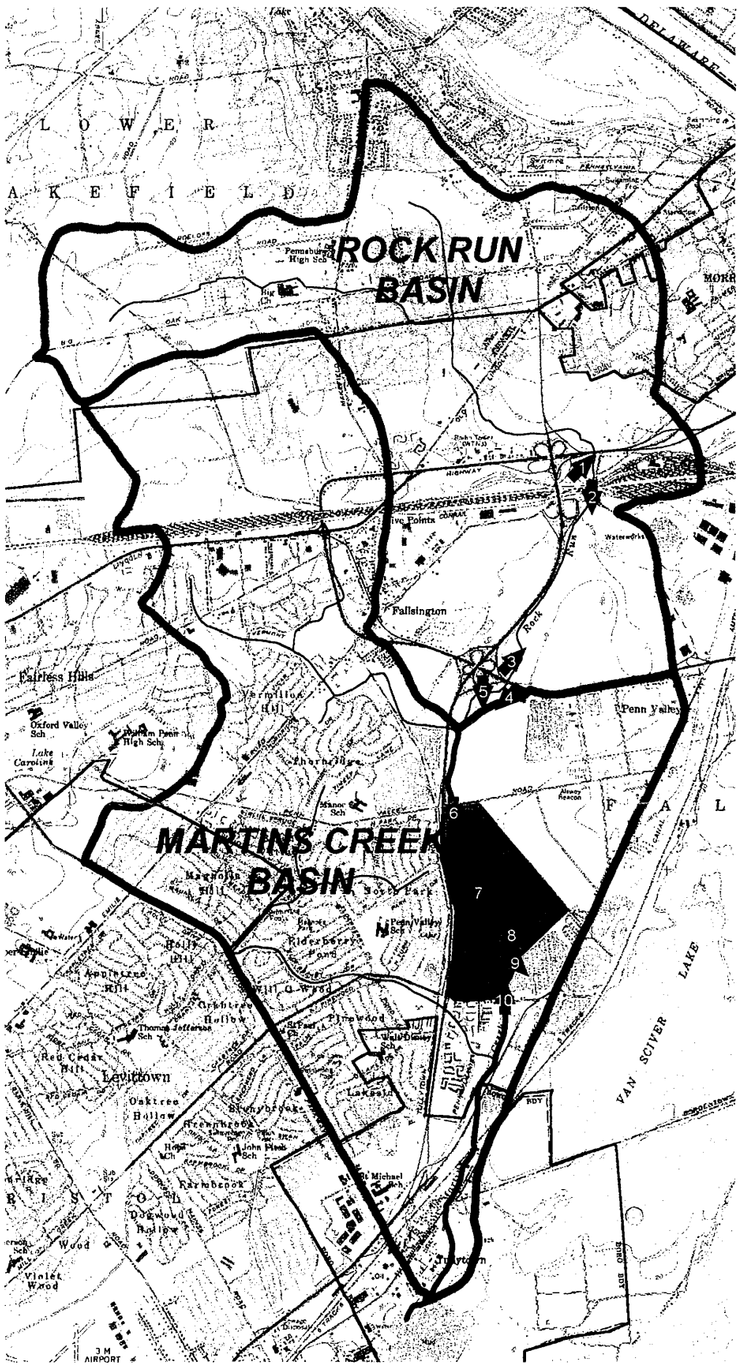
Photo 6 - Looking downstream from the Penn Valley Road crossing. A broad, shallow stream channel with an existing riparian buffer. Northern most portion of the Community Park property. Recommendation: Protect existing buffer.

Photo 7 - Narrow riparian buffer. Debris in channel slowing and diverting heavy stream flows. Past quarrying and ongoing park development activities have limited buffer width. Stream banks are steep and the creek base flows occur about 15-20 feet lower than the stream bank. Recommendation: Restore stream channel character and riparian buffer.

Photo 8 - Inlet where Martins Creek submerges below the Delaware Canal. Debris collects during storm events and slows creek flow. Concrete blocks have been used to protect the canal levee. Existing vegetation disturbed due to high water flows. Recommendation: Mitigate stormwater flows and plant buffer vegetation to stabilize banks.

Photo 9 - Looking downstream at a deep pool where Martins Creek emerges from under the Delaware Canal. Riparian buffer intact. Recommendation: Manage invasive vegetation and mitigate erosion from foot traffic.

Photo 10 - Looking upstream from Mill Creek Road crossing. Adjacent landuses encroaching in the riparian buffer. No overstory growth. Purple Loosestrife establishing disturbed areas. Recommendation: Stop mowing along the creek. Remove invasive vegetation and plant riparian buffer.

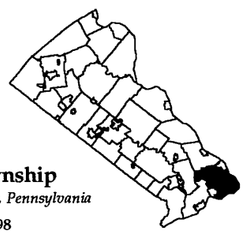


Legend

- Photographs
- Martins Creek
- Community Park
- Tributaries
- Watersheds

N

2000 0 2000 Feet



Falls Township
Bucks County, Pennsylvania
December 1998

Lower Delaware River Conservation Plan
developed through
Pennsylvania Department of Conservation and Natural Resources

Visual Stream Assessment
funding provided by

Projects and Mapping
prepared by

HERITAGE CONSERVANCY
85 Old Dublin Pike
Doylestown, PA 18901
(215) 345-7020
"Preserving our Natural and Historic Heritage"

Visual Stream Assessment

Brock & Silver Creeks

Yardley Borough
Environmental Advisory Council

in support of the

Lower Delaware River Conservation Plan

Brock Creek

Photo 1 - Looking towards the mouth of Brock Creek joining the Delaware River. Paved parking to the edge of the embankment. Steep slope stabilized using riprap. Recommendation: Use live staking to restore slope vegetation and provide additional stability.

Photo 2 - Looking upstream from the parking area. Failing retaining wall on opposite bank. Recommendation: Replace retaining wall with structural bioengineered solutions and restore slope vegetation.

Photo 3 - Looking downstream. Riprap used to stabilize steep embankment and support parking area at the top of the slope. Recommendation: Restore slope vegetation embankment using livestakes.

Photo 4 - Looking upstream towards commercial area along Afton Ave. Opposite bank severely eroded and stabilized using riprap. Recommendation: Use structural bioengineered techniques to stabilize slope and restore slope vegetation.

Photo 5 - Looking upstream at the Delaware Canal crossing. Riprap visible on opposite bank. Severely eroded near bank. Recommendation: Restore slope vegetation with live stakes. Utilize bioengineering techniques to stabilize near bank.

Photo 6 - Looking upstream near canal crossing. Adjacent property owners mowing to creek edge. Invasive plants colonizing in disturbed areas. Recommendation: Stop mowing along creek. Remove and manage invasive exotic plant species.

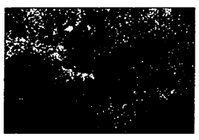


Photo 7 - Looking downstream from Main Street crossing. Healthy buffer vegetation. Deteriorating retaining wall visible at a bend in the creek. Recommendation: Replace wall using bioengineered techniques and restore vegetation where necessary.

Photo 8 - Looking upstream from Main Street crossing. Existing overstory vegetation with scattered understory. Overall a narrow buffer. Recommendation: Plant understory vegetation and work to widen an undisturbed buffer area.

Photo 9 - Looking upstream towards the dam near Lake Afton. Near bank stabilized with riprap. No buffer vegetation. Recommendation: Use live stakes to restore vegetation on the slope. Establish a buffer area and plant riparian vegetation.

Photo 10 - Looking upstream near Afton Ave. Moderate erosion with invasive species colonizing disturbed areas. Pavement from nearby commercial development encroaching into corridor. Recommendation: Remove and manage invasive vegetation. Look to reestablish buffer area by removing paving paving during future renovations.

Photo 11 - Looking downstream near Afton Ave. Dense riparian vegetation existing along the creek. Recommendation: Protect existing buffer and manage invasive vegetation.

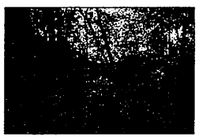


Photo 12 - Looking upstream from an undeveloped property parcel. Healthy buffer existing along creek. Recommendation: Protect buffer from impacts of any future development.

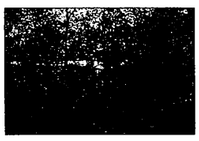
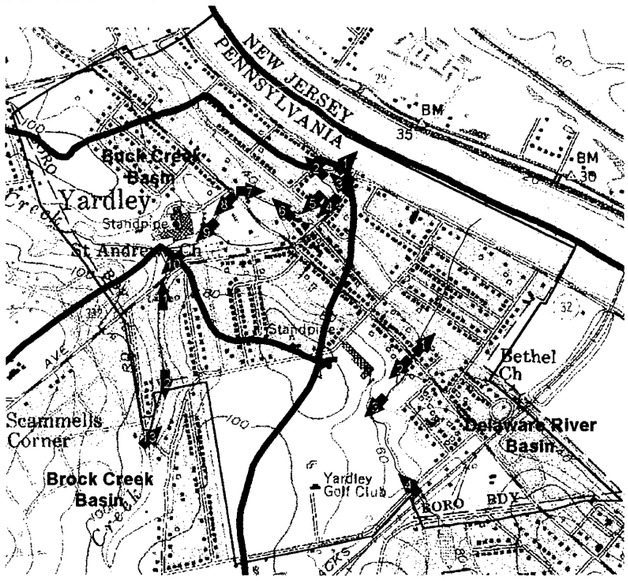


Photo 13 - Looking downstream from Sandy Run crossing. Invasive species colonizing creek banks. Adjacent property owners mowing to edge of creek. Recommendation: Stop mowing along the creek. Stabilize banks with buffer plantings.



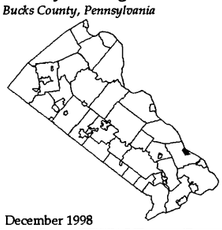
Legend

- Brock Creek Photos
- Silver Creek Photos
- Streams
- Municipal Boundary
- Watersheds

1 inch = 500 feet
500 0 500 Feet

N

Yardley Borough
Bucks County, Pennsylvania



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Silver Creek

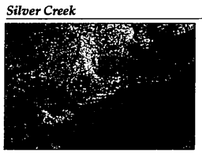

Photo 1 - Silver Creek looking downstream from Main Street crossing. Stream bank has been stabilized with a concrete retaining wall to protect nearby structures. The stream flows from this point into the canal. Recommendation: Manage invasive vegetation. Protect against further encroachment into the riparian buffer.

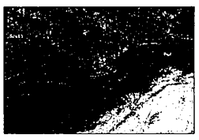

Photo 2 - Looking upstream along Silver Creek from Main Street crossing. Narrow buffer with adjacent property owners mowing to bank edge. Recommendation: Stop mowing to bank edge. Plant riparian vegetation.

Photo 3 - Looking upstream from the dam crossing Silver Creek at the north end of the Yardley Country Club. Gabions visible along banks near pedestrian bridge. Recommendation: Restore vegetation along creek banks using live staking and riparian plantings.

Photo 4 - Looking downstream along Silver Creek from Reading Ave. Stream has been widened into a pond on the Yardley Country Club property. Lawn is mown to stream edge with no existing buffer vegetation. Recommendation: Stop mowing to stream edge. Stabilize banks with riparian vegetation.

Photo 1 - Brock Creek looking downstream from Sandy Run bridge. Adjacent property owners mowing to edge of creek with some corridor vegetation remaining. Recommendation: Stop mowing along stream and plant riparian buffer.

Photo 2 - Sandy Run crossing Brock Creek Stormwater outlet visible draining directly into the stream. Recommendation: Stop mowing along stream edge and plant riparian buffer

Photo 3 - Looking upstream along Brock Creek. Dense vegetation existing along the stream. Recommendation. Protect existing riparian buffer

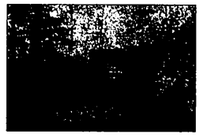

Photo 4 - Looking towards Stonyhill Road along Brock Creek. Streambanks sloughing into the channel, undercutting roots of mature trees. Recommendation. Protect existing buffer and stabilize streambanks using bioengineering techniques.

Photo 5 - Looking upstream along Brock Creek from Stony Hill Road. Dense riparian vegetation but adjacent properties/activities are encroaching into corridor area. Recommendation Prevent significant damage to buffer area and protect existing vegetation.

Photo 6 - Looking downstream along Brock Creek below the rail crossing. Existing vegetation in areas but severe erosion occurring along streambanks Residential development encroaching into buffer. Recommendation: Protect existing vegetation, restore and stabilize streambanks using bioengineering techniques.

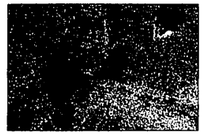

Photo 7 - Looking upstream along Brock Creek near Covington Road. Dense herbacuous vegetation existing along creek. Recommendation: Manage invasive exotics, protect against encroachment from new development.

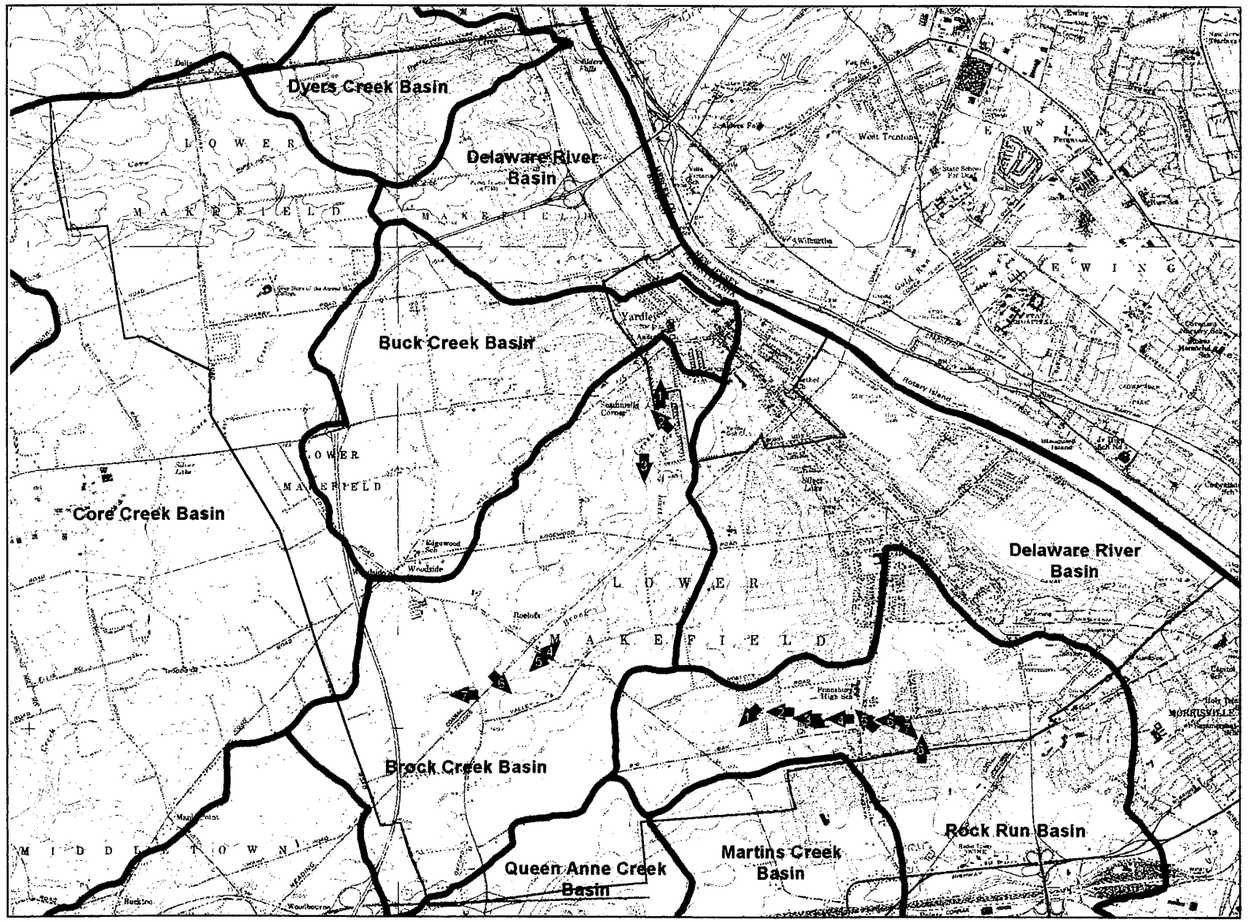

Photo 1 - Looking upstream along Rock Run from David Terrace. Narrow buffer existing with adjacent property owners mowing to edge of slope. Yard debris being dumped into channel. Recommendation: Stop mowing and dumping. Widen buffer with new plantings

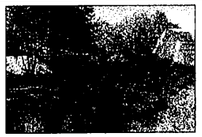

Photo 2 - Looking upstream along Rock Run from Derbyshire Road. No existing riparian buffer. Recommendation: Plant riparian buffer.

Photo 3 - Looking upstream along Rock Run towards Derbyshire Road Stream banks sloughing into channel in areas Debris visible in the channel. Recommendation Stabilize streambanks using bioengineering techniques.

Photo 4 - Looking upstream along Rock Run across Boehm School property. No existing buffer. Severely eroded streambanks along length of the creek. Recommendation. Restore stream channel with bioengineering techniques and plant riparian buffer.

Photo 5 - Looking upstream along Rock Run on the north side of Big Oak Road Dense herbaceous vegetation but no overstory growth. Recommendation: Plant riparian overstory species along the stream.

Photo 6 - Length of Rock Run as it flows parallel to Big Oak Road. Existing overstory vegetation and rocky channel. Recommendation: Mitigate stormwater drainage into stream.

Photo 7 - Looking downstream along Rock Run south of Big Oak Road Rocky stream channel with mature overstory and riparian buffer. Recommendation: Protect existing buffer from encroachment.

Photo 8 - Looking upstream along Rock Run from Kent Drive Adjacent property owners mowing to edge of stream. Streambanks sloughing into stream channel. Recommendation: Stop mowing and restore stream channel. Plant riparian buffer.

Visual Stream Assessment

Brock Creek & Rock Run

Lower Makefield Township
Environmental Advisory Council

in support of the

Lower Delaware River Conservation Plan

Legend

- Brock Creek Photographs
- Rock Run Photographs
- Municipal Boundary
- Basins

N

1 inch = 2000 feet

2000 0 2000 Feet

Lower Makefield Township
Bucks County, Pennsylvania

December 1998

Lower Delaware River Conservation Plan
developed through
Pennsylvania Department of Conservation and Natural Resources

DCNR

Visual Stream Assessment
funding provided by

Pennsylvania Environment Council

Projects and Mapping
prepared by

HERITAGE CONSERVANCY
85 Old Dublin Pike
Doylestown, PA 18901
(215) 345-7020

"Preserving our Natural and Historic Heritage"

Visual Stream Assessment and Viewshed Analysis Report

prepared for
Tullytown Borough
Martins Creek

Bristol Borough
Otter and Adams Hollow Creeks

Martins Creek in Tullytown Borough

Otter Creek in Bristol Borough

prepared in support of the
Lower Delaware River Conservation Plan
PA Department of Conservation and Natural Resources

funding for this project provided by
Pennsylvania Environmental Council

project prepared by

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Introduction
In support of the Lower Delaware River Conservation Plan (LDRCP), Pennsylvania Environmental Council (PEC) has funded visual stream assessment and viewshed analysis projects for two municipalities within the study area. Heritage Conservancy has completed projects in the following municipalities.

Tullytown Borough - *Martins Creek*

Bristol Borough - *Otter and Adams Hollow Creeks*

Heritage Conservancy photographed current conditions of the streams noting disturbed and undisturbed riparian buffer areas. Using field notes, Heritage Conservancy mapped conditions using the latest technology in GPS, GIS and digital scanning. The second step in the project was to assess significant visual impacts in public park and recreation areas. Using USGS Digital Elevation Model (DEM) data, Heritage Conservancy prepared a topographic analysis for each municipality and mapped viewsheds from key points in public areas. Through the inventory and analysis, recommendations were developed to illustrate the effectiveness of vegetative buffers to screen undesirable views. Recommendations from this study will be included in the LDRCP and working maps produced and provided to each EAC.

Tullytown Borough - Martins Creek
Tullytown Borough comprises approximately two square miles located along the Delaware River. A large extent of the borough is undeveloped containing several large bodies of water (Franklin Cove and Van Sciver Lake) created during past quarrying activities. Also located within the borough is the Tullytown Landfill operated by Waste Management Incorporated. Martins Creek flows north to south emptying into Franklin Cove along the Delaware River.

Martins Creek enters Tullytown Borough flowing south from Falls Township. The land adjacent to the stream is currently undeveloped and a dense buffer remains intact. Ownership and land uses nearest the creek are mostly industrial. The creek is about 15-20 feet wide at this point. The streambanks are stabilized by native vegetation. Trash in the creek is visible and a concern for health of the creek. As the creek continues, it flows alongside the commuter rail line and then passes behind a number of residences. Here a wall has been constructed to control flooding and prevent the stream from cutting into the residential properties. Where the wall ends gabions have been used to direct the stream under the bridge at Bordentown Road.

South of Bordentown Road, the creek passes through the community park and by the municipal offices. Tullytown has developed a park leaving the stream buffer intact wherever possible. Some areas are mown to the edge of the creek and buffer plantings would help to stabilize the banks. On the west bank, evidence of older stabilization projects is evident. Private properties abut the creek. Junked automobiles and buildings have been placed adjacent the creek leaving only a few feet to the edge of the creek with intermittent trees.

South of the park, no buffer exists. The property is being mowed to the edge of the creek. The land is privately owned by Lucisano Brothers. The creek remains about 10-15 feet wide. The streambanks remain intact due to a combination of older stabilization projects and naturalized plantings. Invasive species such as Purple Loosestrife and Crown Vetch are becoming established in disturbed areas. The creek continues and empties into the Cove near the Tullytown Marina. The creek widens at the mouth and tidal influences are evident. Mud flats spread out from the creek edge as it flows into the cove.

The Tullytown Landfill is very visible from the creek as it flows south of Bordentown Road through the community park and Lucisano Brothers properties. Existing trees and industrial buildings screen much of its existing height but operations will continue upward for at least another 60 feet. Strategically placed buffer plantings could better screen the landfill and industrial activities near the park.

Topographic Analysis

Tullytown Borough lies in the coastal plain province along the Delaware River. The land remains relatively flat (ranging from 1 to 7 meters mean sea level) gradually rising as you move away from the river. No dramatic changes naturally occur in the landscape. The most significant change in the topography of Tullytown Borough is the Tullytown Landfill. Rising 180 feet above the landscape, the landfill is a highly visible element on nearby properties. The continuing expansion of the landfill is expected to raise the height an additional 60 feet to a final 240 feet.

Visual Analysis

Tullytown Borough has developed a community park and constructed the Borough Hall on property south of Bordentown Road along Martins Creek. This location places the public facility within a half-mile of the landfill. Surrounding industrial facilities and the landfill are in full view of the community park and significantly impact views towards the river from within the park. Existing trees and vegetation along Martins Creek are an important amenity to the park. The trees provide shade and stabilize stream banks along the creek. The trees also provide a visual buffer, blocking views towards adjacent commercial and residential properties as well as major vehicular traffic areas.

Maintaining existing riparian buffer vegetation and restoring vegetation in areas along Martins Creek not only will improve the quality of the stream but provide visual screening of nearby industrial properties. In addition, strategic plantings to the south of the park will provide further screening of the landfill facility. Long vistas can be interrupted by planting a series of buffers to screen undesirable views and focus attention on areas of scenic value. For example, screening of industrial facilities and the landfill and focusing views on areas such as the Delaware River, Franklin Cove and Van Sciver Lake.

Bristol Borough -
Otter and Adams Hollow Creeks

Bristol Borough recently completed a supplement to the Park, Recreation, and Open Space Plan adopted in 1996. This "Municipal Open Space Plan" prepared by DePallo Design and Planning outlines priorities for open space and recreation within the borough. Recommendations from this plan are included in the following inventory.

Through the open space planning process, Bristol Borough has designated Otter and Adam's Hollow Creeks as areas suitable for consideration for preservation or improved management. These areas have been encroached upon by development over the years and the borough desires to preserve and manage the remaining open space and resources associated with these stream corridors that are currently unprotected.

Otter Creek

The Otter Creek is fed from the waters of Silver Lake in Bristol Township and its upstream waters. The creek proceeds from the lake, crosses under Route 13, follows the township-borough border, and flows through land owned by Rohm and Haas until it empties into the Bristol Marsh area. While the creek is located through some densely developed industrial land uses and piped underground for some length, it is still worth noting in this report. It remains a significant natural feature within the borough and a flood control facility for the local municipalities.

As mentioned previously, Otter Creek exists as an intermittent corridor that is disrupted by industrial uses and piped underground in numerous locations. Not withstanding these shortcomings, it still represents a potential link from Silver Lake, through Rohm and Haas to Bristol Marsh. This potential link may be worthy of further investigation.

Adams Hollow Creek

The Adams Hollow Creek is fed from Silver Lake. It originates at Silver Lake in Bristol Township crosses under Route 13, follows the township-borough border, connects with the canal under the AMTRAK line, and proceeds to the Delaware River through a residential neighborhood. It exists with open watered sections to the west and is primarily piped underground through the residential neighborhood area until it reaches the Delaware River.

Adams Hollow Creek also represents a potential link from Silver Lake Park to the Delaware River. Again, while it exists as a watered feature in some areas, other lengths are piped underground and traverse through residential neighborhoods. Crossing Route 13 remains a critical deterrent to this link.

In addition to Otter and Adams Hollow Creeks, a number of pockets of wetlands exist at various locations in and adjacent to the borough. Two privately-owned sites are adjacent to the canal and towpath and are considerable in size, while one site is owned by Bucks County and located adjacent to Silver Lake near Route 13. These pockets of wetlands are significant land parcels and worthy of protection. They remain difficult or even unbuildable and are protected through existing zoning and other preservation efforts.

Bristol Borough is a highly developed community so a majority of the wooded or open areas are presently preserved as public open space. The Nature Conservancy protects one of the borough's most sensitive areas, the Bristol Marsh Preserve due to its ownership and operational management. A number of existing public and privately owned wetlands have been identified in and adjacent to the borough. These areas are environmentally sensitive wetland areas and are worthy to be considered for acquisition and sound management/ preservation efforts.

Portions of the Delaware River, and its tributaries, Adam's Hollow Creek and Otter Creek, are environmentally sensitive water features that are in need of stream bank preservation and protection. The need to preserve open space for public access along the Delaware River and these streams is important for maintaining the character of the community.

Topographic Analysis

Bristol Borough lies along the Delaware River across from Burlington Island. The community is located in the Coastal Plain. This low-lying community consists of a relatively flat topography (ranging from 1-7 meters mean sea level) with marsh areas along the river and freshwater wetlands in interior areas.

The municipality has recognized unique resources related to the character of the topography in their plans for open space protection and are looking to protect marsh and wetland areas as significant natural areas for the community.

Visual Analysis

Views of the Delaware River define the character of the Borough. This historic community retains its identity as a river community embracing the river as a resource for its residents. Viewing areas in Riverfront Park and the Grundy Memorial Library are excellent examples of how the community looks to the river as an amenity. In the future, the borough is looking to provide additional public access to the river. The river provides a focal point for the downtown business community. Downtown businesses rise up from the river bank, sitting above the floodplain area. Businesses are beginning to take advantage of views to the river with outdoor patios and opening up the rear of their properties facing the river.

Future plans look to develop a recreational trail system connecting Silver Lake County Park, the Spurline Trail, the Delaware Canal Towpath Trail, Bristol Marsh and the river front. Obtaining public access along the river and natural greenways along Otter and Adams Hollow Creeks will be a long-term project. Important to future recreation development will be the protection of high quality views along the Delaware River.

Topographic Analysis

Martins Creek

Tullytown Borough
Environmental Advisory Council

in support of

Lower Delaware River Conservation Plan

LEGEND

- Municipal Boundary
- Martins Creek
- Water Features

Elevation in 5 Meter Intervals

- 0 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 30
- 31 - 35
- 36 - 40
- 41 - 45
- 46 - 50
- 51 - 55
- No Data

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1 inch = 2000 feet

2000 0 2000 4000 Feet

March 1999

funding for this project
provided by
Pennsylvania Environmental Council

Pennsylvania Environmental Council

prepared by:

HERITAGE CONSERVANCY
85 Old Dublin Pike
Doylestown, PA 18901
(215) 345-7020

Topographic Analysis

Otter & Adams Hollow Creeks

Bristol Borough
Environmental Advisory Council

in support of

Lower Delaware River Conservation Plan

Elevation in 5 Meter Intervals
- 0 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 30
- 31 - 35
- 36 - 40
- 41 - 45
- 46 - 50
- 51 - 55
- 56 - 60
- 61 - 65
- 66 - 71
- No Data

Municipal Boundary
Major Roads
Delaware River
Streams

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2000 0 2000 4000 Feet

Lower Delaware River Conservation Plan
developed through
Pennsylvania Department of Conservation and Natural Resources
DCNR

Visual Stream Assessment
funding provided by
Pennsylvania Environmental Council

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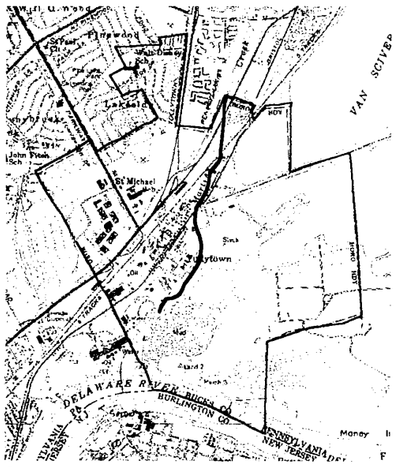

Context Map

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Tullytown Borough

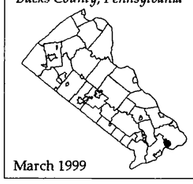
Martins Creek

Environmental Advisory Council
Topographic Analysis and Viewshed Mapping

in support of

Lower Delaware River Conservation Plan

Tullytown Borough
Bucks County, Pennsylvania



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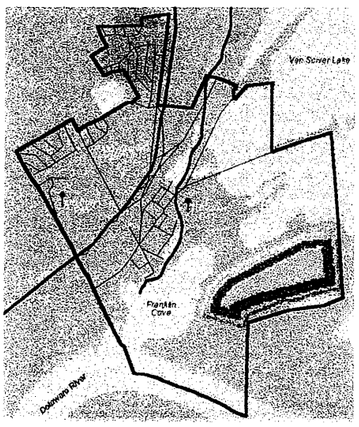
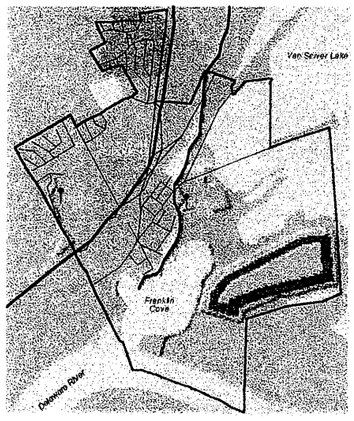


MAP 1 - Existing Topography

Viewpoints in Tullytown and Levittown Parks

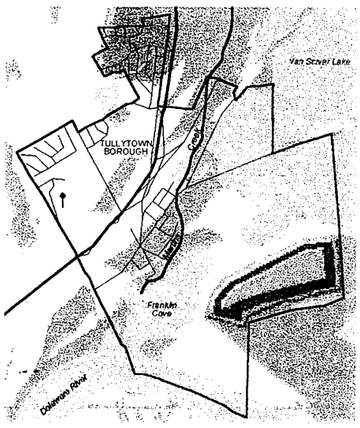
This map illustrates the topography of Tullytown Borough. The Tullytown Landfill is indicated at its current height of 180 feet. The topography is characteristically very flat as the area is located in the Coastal Plain along the Delaware River.



MAP 2 - Topography with 50 ft Buffer Vegetation

NOTE: Buffer areas indicated along Martins Creek and around Franklin Cove

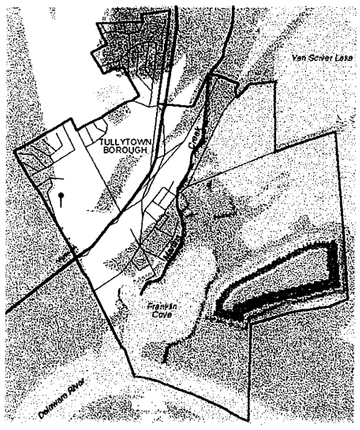
This topographic map indicates a vegetative buffer along Martins Creek and additional buffer vegetation south of the Tullytown Community Park.



MAP 3 - Views from Levittown Park

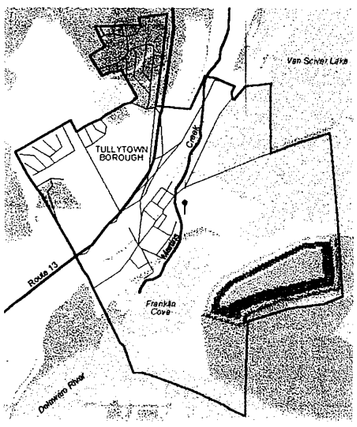
Visible Areas

This map identifies areas visible from Levittown Park (the athletic field located behind the Levittown Shopping Center). Note the visible areas of the Tullytown Landfill.



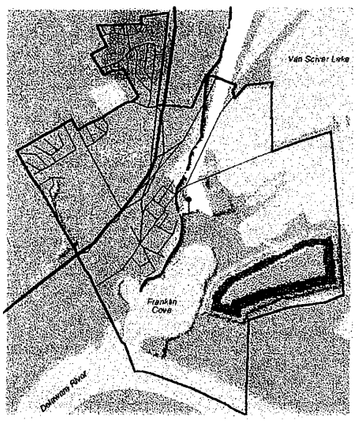
MAP 4 - Buffered Views from Levittown Park

This map indicates those areas still visible when the vegetative areas remain along Martins Creek and around the 'Cove'. Upper reaches of the Tullytown Landfill are remain visible from the park. Additional plantings closer to the park area would provide additional screening as the landfill height increases.



MAP 5 - Views from Tullytown Park

This map identifies areas visible from the Tullytown Community Park along Martins Creek south of Bordentown Road. Note the visible areas of the Tullytown Landfill.



MAP 6 - Buffered Views from Tullytown Park

Here views from the Tullytown Community Park have been buffered by vegetation along Martins Creek and an additional buffer planted south of the park (the buffer is located where an older planting once screened industrial properties near the park). Note how little of the landfill is visible from the park due to screening by the existing and proposed buffer plantings.

Visual Stream Assessment

Otter & Adams Hollow Creeks

Bristol Borough
Environmental Advisory Council

in support of the

Lower Delaware River Conservation Plan

Photo 1 - Looking upstream at the buffer along Adams Hollow Creek from Radcliffe St. Recommentation: In developed urban area, maintain minimum riparian buffer where possible.

Photo 2 - View downstream of existing concrete channel along Adams Hollow Creek from Radcliffe St. Recommendation: During future construction, reestablish naturalized stream channel, stabilized with bioengineering techniques.

Photo 3 - View of the Delaware River looking upstream from the Grundy Library Terrace. Important view to preserve along riverfront.

Photo 4 - Riverfront Park access to Delaware River. Important visual access point along the river. Provides recreation trail along riverfront.

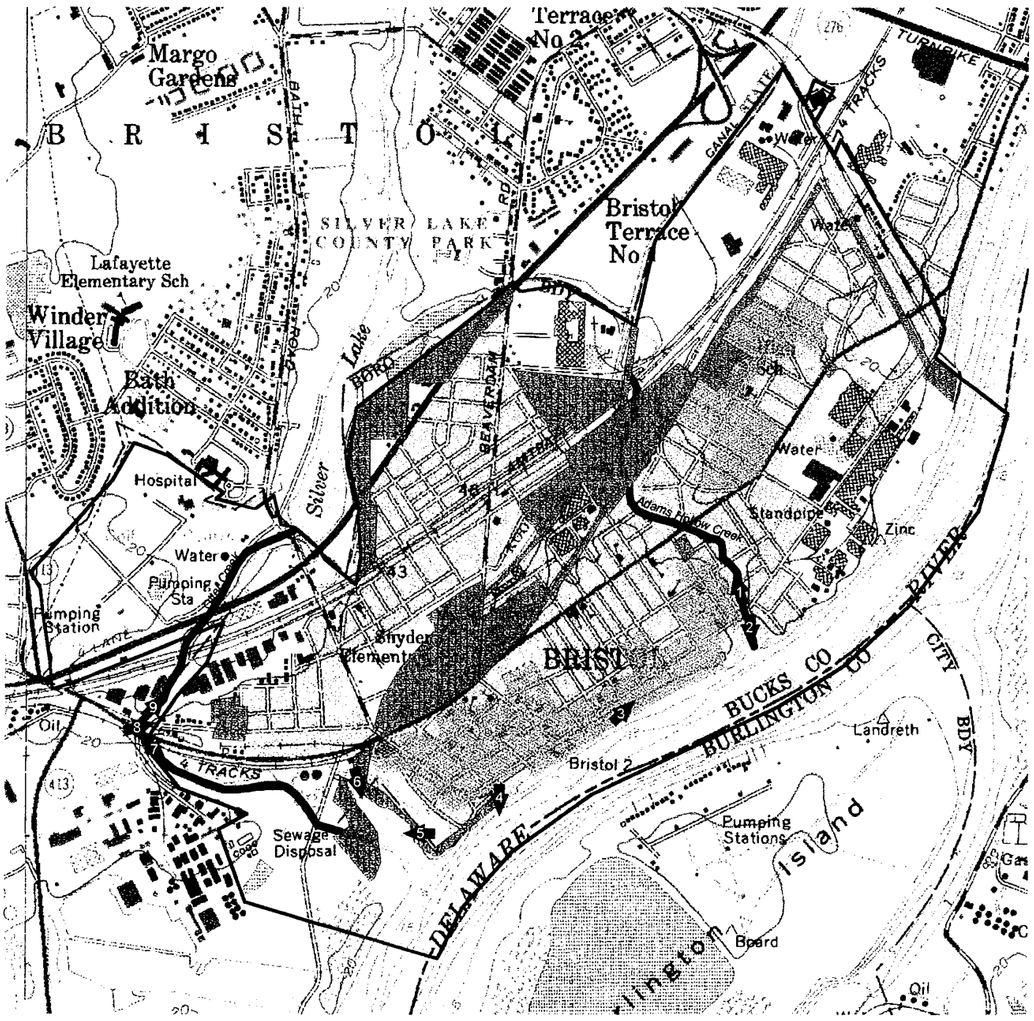


Photo 5 - View across Bristol Marsh Nature Preserve. Important natural area to protect. Location of the mouth of Otter Creek.

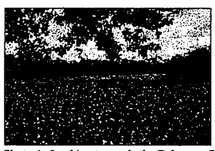


Photo 6 - Looking towards the Delaware River across Bristol Marsh. Important view of the river near the mouth of Otter Creek.

Photo 7 - Looking downstream at Otter Creek crossing industrial properties. Recommendation: Protect existing natural buffer. Negotiate easement for future public trail right-of-way.

Photo 8 - Downstream side of Sutter St. bridge crossing Otter Creek. Creek heavily impacted by stormwater runoff and street crossings. Would be a difficult point for a recreation trail crossing.

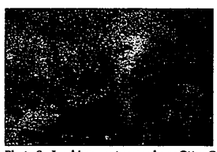


Photo 9 - Looking upstream along Otter Creek from Sutter St. crossing. Existing buffer vegetation. Recommendation: Protect existing buffer and look to widen buffer area during future developments. Provide public access and recreation opportunities. Link Silver Lake County Park to waterfront area.

Legend

- Photographs
- Municipal Boundary
- Open Space
- Historic District
- Streams

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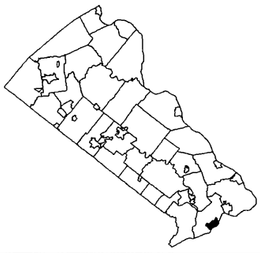

Bristol Borough
Bucks County, Pennsylvania

December 1998

Lower Delaware River Conservation Plan
developed through
Pennsylvania Department of Conservation and Natural Resources

DCNR

Visual Stream Assessment
funding provided by

Pennsylvania Environmental Council

Projects and Mapping
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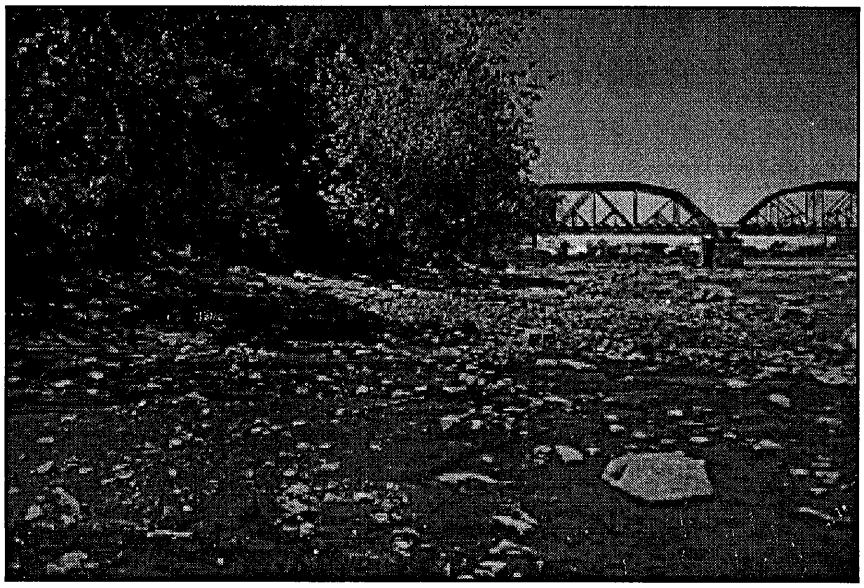
Morrisville Borough
Visual Assessment Report

developed by the
Morrisville Borough
Environmental Advisory Council



The Delaware River

prepared in support of the
Lower Delaware River Conservation Plan
PA Department of Conservation and Natural Resources

funding for this project provided by
Pennsylvania Environmental Council

project prepared by

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Doylestown, PA 18901
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"Preserving our Natural and Historic Heritage"

August 1999

Introduction
The Morrisville Environmental Advisory Countil (MEAC) in partnership with Heritage Conservancy (HC) has completed a visual assessment of borough drainage and the Delaware River waterfront. The assessment provides a working knowledge of borough drainage patterns and identifies locations for implementation projects in support of the Lower Delaware River Conservation Plan (LDRCP).

This project was funded through the Pennsylvania Environmental Council (PEC). PEC provided financial support for HC to perform the visual assessment mapping as match funding for the LDRCP grant through PA DCNR. In addition to supporting the work of the Lower Delaware River Management Plan, the project provided specific information to the Morrisville EAC of environmental conditions within the borough.

The visual assessment project began with Morrisville EAC meeting with HC to determine key borough areas to assess. HC provided borough maps and assessment forms for volunteers to use in collecting field data. EAC members walked through the borough noting conditions of drainages and the Delaware River waterfront. Using the inventory completed by the EAC, HC verified conditions and photographed key sites to be identified for mapping purposes.

Following are the evaluations completed by EAC members and recommendations for implementation projects supporting the goals of the Lower Delaware River Conservation Plan. Photos indicated in the report are included on the accompanying Visual Assessment Map.

Observations and Findings
Drainage in Morrisville Borough occurs primarily through underground culverts draining to the Delaware River or Delaware Canal. As the borough was developed streams were directed into underground culverts. No surface streams exist for extended lengths through the municipality. In some areas, underground culverts will overflow during storm events causing localized flooding. EAC members have identified areas of concern and are continuing to assess drainage patterns and their impact in the borough.

The Delaware River is a significant resource for this small community. The borough owns a number of riverfront properties. Williamson Park is an important community recreation area along the Delaware River but a number of additional municipal properties remain undeveloped. While not developed, these properties provide access to the Delaware River and informal recreational opportunities for borough residents. In addition to the Delaware River, the Delaware Canal is an important cultural and recreational resource. Recognizing the importance of teh Delaware Canal and towpath, the borough is developing ways to weave this historic resource back into the community.

The borough lies primarily in the Coastal Plain Physiographic Province. The Coastal Plain landscape is characteristically flat with soils consisting of gravelly sand deposits. Characteristic

woodland communities include the River Birch-Swamp Maple and Sweet Gum-Willow Oak forests.

The River Birch-Swamp Maple forest is found along the Delaware River and its tributaries. It usually occurs on low-lying tracts and on the floodplains of streams. This forest association is predominantly comprised of hardwoods. Some of the species associated with River Birch-Swamp Maple forest community include:

- Silver Maple (Acer saccharinum)
- Red Maple (Acer rubrum)
- Box Elder (Acer negundo)
- White Oak (Quercus alba)
- Swamp White Oak (Quercus bicolor)
- Swamp Hickory (Carya cordiformis)
- Sycamore (Platanus occidentalis)
- River Birch (Betula nigra)
- White Ash (Fraxinus americana)
- Black Walnut (Juglans nigra)
- Red Osier (Cornus sericea)
- Various species of Willow (Salix spp.)

The Sweet Gum-Willow Oak forest community occurs along the Coastal Plain. Characteristic species of this community include:

- Willow Oak (Quercus phellos)
- Sweet Gum (Liquidambar styraciflua)
- Laurel Magnolia (Magnolia virginiana)
- Common Highbush Blueberry (Vaccinium corymbosum)
- Coast Pepperbush (Clethra alnifolia)
- Red Chokeberry (Pyrus arbutifolia)

Delaware River North

The first segment of the Delaware River begins at Bridge Street and continues north for just over one mile to the borough boundary with Lower Makefield Township. The riverfront in this area has two distinctly different characters. Between Bridge Street and Trenton Avenue, the river is bounded by a flood control dike (Photos 1, 2). Behind the dike the property has been developed by the borough for recreational use (Photo 3).

North of Trenton Avenue, the riverfront is typically gently sloping and wooded between North Delmorr Avenue and the Delaware River (Photo 4). An area of severe erosion does occur on the north side of Calhoun Street bridge. The Calhoun Street bridge crossing is significant in that it is the location of the Fall Line, the inland most reach of the tidal influence on the Delaware River.

At the borough line with Lower Makefield an unnamed stream empties into the Delaware River. The streambed widens to approximately 10 feet and is experiencing some erosion near the river.

Delaware River South

The second segment of the Delaware River begins at Bridge Street and continues downstream to the borough boundary with Falls Township. The Delaware River is tidal, and riverfront areas are characteristically wooded and undeveloped (Photos 5, 6, 7). At low tide, the riverbank is generally rocky with small areas of silt and sand. A number of small seeps, streams and drain outlets empty into the Delaware (Photos 8, 9). Drainage flows below Delmorr Avenue and surfaces east of the road to flow directly into the Delaware River. A tidal wetland area occurs between Bridge Street and the Route 1 expressway

(Photo 10). A small stream flows into the low-lying area from the borough.
This nearly 4800 feet of riverfront is undeveloped, and a number of properties are owned by the borough. Areas are currently used informally by local residents for recreation activities including hiking and biking on undeveloped trails, fishing and visually accessing and enjoying the Delaware River (Photos 11, 12, 13, 14, 15).

Crown Heights District
A major drainage system passes through the district originating from an underground spring ont he Morrisville Presbyterian Church property. As it flows to the Delaware River, the channel occurs both on the surface and below grade. Beginning at the Morrisville Presbyterian Church on the north side of Trenton Avenue, the system collects stormwater and flows underneath the road opening into a flowing naturalized stream for approximately 300 feet. The stream is bounded by dense herbaceous and understory growth before it submerges (Photo 16). The stream flows under Maple Avenue remaining underground for approximately 500 feet before daylighting near the firehouse parking lot south of Maple Avenue. Here the stream channel widens to 8 feet with a stone wall on the south bank. The stream flows beneath Crown Street continuing east. The north side of the stream channel is experiencing erosion, leaving exposed tree roots. A large amount of trash and debris have been deposited in the channel. The south bank is gently sloping and wooded. The stream then flows under Hillside Avenue. East of Hillside Avenue the north bank of the stream is heavily vegetated (Photo 17). Stone walls direct the stream with the channel being approximately 4 feet wide. The south bank is mown by the adjacent property owner to the edge of the stone wall. The stream flows approximately 150 feet from Hillside Avenue before emptying into the Delaware Canal (Photo 18). As it empties into the Delaware Canal, the channel is eroded on both banks with sediment deposits extending into the canal.

A newly rebuilt waste gate and concrete spillway for the Delaware Canal drains water from the canal to the Delaware River opposite the stream emptying into the canal (Photo 19). The outflow from the Delaware Canal passes through a 15-foot open channel with eroding banks on the north and riprap on the south. Debris is visible in the channel. The outflow passes below Delmorr Avenue before emptying into the Delaware River.

Sewage Treatment Plant and Staley Industrial Properties
These two properties contain a significant portion of remaining woodland areas within the borough. A small stream drains through each property and the woodlands. Through the Staley property, the unnamed stream surfaces for approximately 400 feet (Photo 20). The stream is directed into a culvert flowing beneath the railroad tracks and empties into the Delaware River. The low-lying sewage treatment plant property drains toward the river with a stream becoming defined only near the railroad tracks. An additional wet, low-lying area on the property has been colonized by Phragmites, an invasive, exotic plant species. Much of the prop-

erty remains undeveloped providing opportunities for wildlife habitat and passive recreation (Photos 21, 22).

Old Quarry Site

In the southwest corner of the borough, an old sand and gravel quarry pit remains (Photos 23, 24). The quarry pit has filled with water creating a small lake. The areas immediately surrounding the lake are mostly wooded. The banks are extremely steep in many areas. Discarded tires in the lake and evidence of dumping on the property are visible. EAC members noted that fish were seen in the water and people were fishing in the lake.

Glenside

A small drainage system flows through the borough from northeast to southwest. The unnamed stream begins north of Glenside Avenue at its intersection with Stockham, flows southwest into Falls Township under the Route 1 expressway before emptying into the Delaware Canal near the Morrisville Borough – Falls Township municipal boundary. The drainageway flows approximately 3000 feet through the borough and a total length of approximately one mile. The stream starts as a low-lying swale feeding into a series of culverts to flow beneath numerous road crossings and residential properties. The stream crosses Bridge Street between Cox Avenue and Harding Street flowing into Falls Township. The stream surfaces and flows with a more naturalized channel. The stream is impacted by adjacent land uses, with debris and evidence of runoff entering directly into the streambed. Continuing into Falls Township, the stream flows through a wooded area with some native vegetation (wild geranium, virginia creeper). The banks are sparsely vegetated and unstable with extensive debris visible in the stream channel. Continuing downstream and nearing Route 1, the channel bottom becomes silty with intermittent gravel deposits. Streambanks are experiencing slight to moderate erosion. The stream flows through a culvert below Route 1 continuing 800 feet through wooded conditions before emptying into the Delaware Canal (Photo 25).

Headwaters of Rock Run

A portion of the headwaters of Rock Run begins in the Borough behind residential properties on Rutland Road, Melvin Ave., and Lynns Court as it is mapped on the Morrisville Zoning District map (Nov. 1991). The stream runs south-south westward through this neighborhood and then bends more westward, to pass through a narrow wooded corridor (Photo 26) between the Cambridge Crossing townhouse complex and a single-family home property on Melvin Avenue. After crossing the Melvin Avenue entrance to the complex, the stream enters a stormwater detention basin (Photo 27) on the Cambridge Crossing complex property. The detention basin outfall is culvertized beneath the north-south street/parking lot in the townhouse complex. The stream then discharges via an open channel between the backyards of two townhouses onto the property of Snipes' Farm in Falls Township, just behind the Orchard View Apartment complex.

At the time of Morrisville's Visual Stream Assessment in Mid-May 1999, the stream and detention basin were dry. The area was subjected to a flash flood

in August 1999. During the flash flood, approximately 1-2 feet of standing water was retained in the parking area, and basements on the south side of the detention basin were flooded. Melvin Avenue is divided into two segments by the Cambridge Crossing townhouse complex. It ends in a "t" intersection in the townhouse complex and resumes just beyond the west boundary of the complex. A resident on the western segment of Melvin Avenue reported that flooding of the southern portion of this section of Melvin Avenue occurs during high runoff/snowmelt events. The resident said that water sometimes flows under the townhouse complex fence onto the west segment of Melvin Avenue (Photo 28). Flooding is reported to extend several feet into residents' yards along the street.

Summary

As the borough developed, small streams and drainages have been directed into culverts and buried. When streams do surface often they are channelized with stone walls or riprap to prevent destruction of adjacent properties. The streams have lost their natural character, and few areas of native riparian vegetation remain. During storm events, these underground streams often exceed their capacity flooding nearby properties. A better understanding of the hydrology and stormwater drainage through the borough is needed to address localized flooding and the impacts of current land use and future development on the storm drainage system.

With few surface streams, the borough has lost a natural linkage to plan and build upon when considering development of recreational facilities, trails or a borough-wide open space network. Existing greenways and corridors can provide pedestrian connections through a community allowing residents to access a variety of recreation facilities.

The Delaware River provides an exception to the drainage and stream conditions found in the borough. Extensive wooded areas along the riverbank extend from Trenton Avenue north to the borough line and from Bridge Street south to the borough line. While the width of these wooded areas is limited due to Delmorr Avenue paralleling the river north to south through the borough, the woodlands are part of the habitat corridor and greenway of the Delaware River.

With the recent acquisition of the Gray Stones property, the borough has taken a first step in protecting remaining natural areas of the borough. Developing strategies to maintain and enhance natural areas such as Gray Stones as well as the Delaware Canal and the flood control dike along the Delaware River are a continuing priority.

River access is an important issue locally and a priority in the regional river conservation planning effort. River access not only includes boating, fishing and other active water-related activities, but also includes providing opportunities for people to walk, bicycle or drive along the waterfront to enjoy the river.

Morrisville Borough has a unique opportunity in that significant areas along the Delaware River remain undeveloped. The river is a resource that can potentially provide a variety of recreational opportunities for local residents.

If planning is done to develop recreation and improve access to the Delaware, considerations need to be given to protecting the wildlife habitat values of these areas. A detailed inventory of the flora and fauna found in these areas and a determination of the impacts of proposed plans on significant habitats can assist the community in making decisions about the best use of these areas.

Two additional areas assessed by the EAC have potential as future river conservation projects. The adjoining properties of the Morrisville sewage treatment facility and the Staley industrial facility have significant areas of woodland and open space in low-lying areas. These naturalized areas and associated drainages provide habitat and serve as a sediment and nutrient filter for stormwater drainage from surrounding properties. Another potential project is the site of an old quarry in the southwest corner of the borough. The property is currently undeveloped and remains vacant. With a small lake in the old quarry pit, the property has potential to be an important recreational facility for the community. A feasibility study and clean up program will likely be needed prior to allowing public access to the site. Clean up of this site would be a priority. Both of these projects will need to be evaluated by the borough prior to their implementation.

Recommendations

The following projects are recommended for future consideration by the borough when implementing the Lower Delaware River Conservation Plan. The projects will be included in the plan and may be eligible for implementation grant funding through PA Department of Conservation and Natural Resources (DCNR) and other grant programs. Successful completion of these projects will involve active cooperation with state and non-profit organizations.

Stormwater and Riparian Area Management

- Hire a consultant to study the hydrology of the borough and prepare a stormwater management plan addressing issues related to subsurface drainage and flooding.
- Work cooperatively with private property owners to restore stream channels and vegetative buffers on selected sites identified in the visual assessment study.
- Complete a detailed inventory of the flora, fauna and unique habitats along the Delaware River.
- Evaluate current state of the Delaware River dike in the borough, planning for regular maintenance and construction of steps for safe public access along the river.
- Develop a general Morrisville Riverfront Management Plan for the Delaware River.

Future Development

- Coordinate riverfront plans for the entire length of the Delaware River in Morrisville Borough addressing public access, corridor protection, pedestrian connections to the Delaware Canal and future land acquisitions. Incorporate regional recreational efforts.
- Prepare a feasibility study for the development of a public recreation facility at the site of the old quarry in the southwest corner of the borough.

Planning and Zoning

- Hire a consultant to review and update the borough comprehensive plan and zoning/subdivision ordinance addressing preservation and conservation of significant/sensitive natural and cultural resources.
- Coordinate efforts with Lower Makefield Township and Falls Township to manage those watersheds that cross municipal borders.

Best Management Practices (BMPs) and Education

- Develop a clean up program for the old quarry site and lake.
- Develop an educational video on using native plants for stream and landscape management promoting wildlife habitat development.
- Develop materials and distribution program to educate borough residents about proper stream management including the need to eliminate dumping of yard waste and other refuse in streams, the canal and the river.
- Hold a volunteer clean up day for clearing trash and debris along the Delaware River and support the existing clean up day for the Delaware Canal.
- Expand programs to place markers on stormwater drains discouraging dumping of motor oil and other toxic liquids.

Land Acquisition and Preservation Strategies

- Acquisition should be coordinated with the borough open space plan.
- Acquire conservation easements on woodland and wetland areas on the Sewage Treatment and Staley Industrial properties. The easements would protect the natural areas for wildlife habitat and open space. The easements could allow for public access to be developed at a future time.
- Evaluate acquisition of the quarry property for a municipal park following a feasibility study.
- Acquire easements or additional properties along the Delaware River and Delaware Canal (as determined in riverfront plans) to protect natural areas and improve river access.

Delaware River North

Photo 1 - View of Delaware River from top of sea wall. Recommendation: Develop riverfront plan providing access and recreation along river.

Photo 2 - View of Calhoun Street Bridge and Delaware River. Recommendation: Develop public access and viewing area along river.

Photo 3 - Borough recreation area along Delaware River. Recommendation: Connect existing and new recreation sites along river.

Photo 4 - Wooded riverbank north of Trenton Avenue. Recommendation: Partner with Bridge Commission to provide public access with parking and trail.

Delaware River South

Photo 5 - Undeveloped area along Delaware River south of Bridge Street. Recommendation: Protect natural area.

Photo 6 - Extensive undeveloped riverfront property south of railroad bridge. Recommendation: Protect as open space.

Photo 7 - Undeveloped riverfront south of railroad bridge. Recommendation: Provide public access and passive recreation.

Photo 8 - Stream draining into Delaware River. Recommendation: Monitor stormwater impacts in local streams and river.

Photo 9 - Drain outlet into Delaware River. Recommendation: Continue to reduce stormwater runoff through infiltration Best Management Practices.

Photo 10 - Wetland and natural area along Delaware River. Recommendation: Protect natural area, provide visitor viewing area.

Photo 11 - Resident constructed sign along Delaware River. Recommendation: Provide amenities for visitors along riverfront.

Photo 12 - Undeveloped parking area along Delaware River. Recommendation: Provide parking and access facilities for visitors.

Photo 13 - Open area along Delaware River. Recommendation: Maintain and provide passive recreation amenities.

Photo 14 - Informal trail along Delaware River. Recommendation: Evaluate opportunity to develop formal trails along entire Delaware River in the borough.

Photo 15 - Biking trail along Delaware River. Recommendation: Evaluate opportunities to address various user groups in a comprehensive plan.

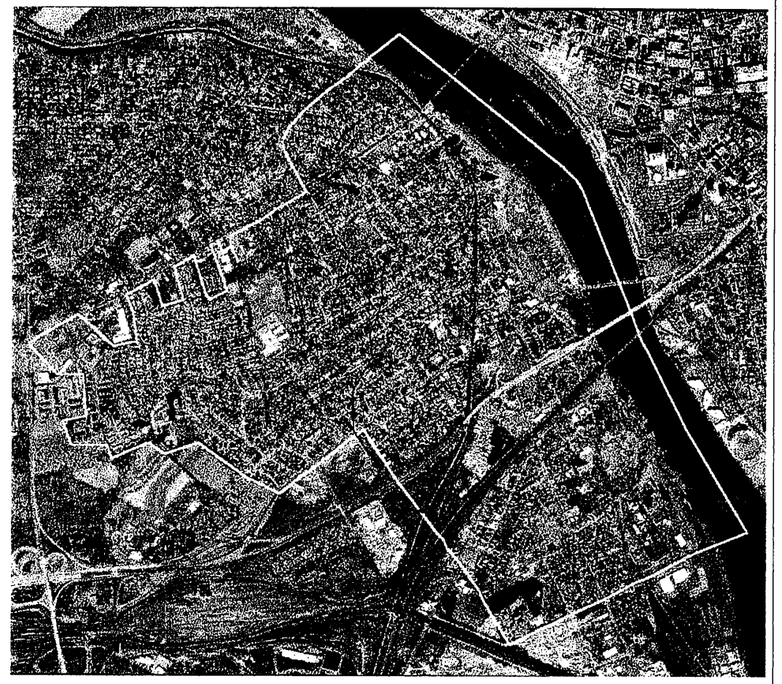
Crown Heights District

Photo 16 - Site of underground stream. Recommendation: Work with property owner to evaluate and improve stream management.

Photo 17 - Surface stream on residential property. Recommendation: Stabilize streambank, educate property owners along streams on management of riparian areas.

Photo 18 - Stream emptying into Delaware Canal. Recommendation: Monitor stormwater flows and restore streambank vegetation.

Photo 19 - Delaware Canal spillway and channel to Delaware River. Recommendation: Work with private property owner to reestablish vegetation along channel.



Staley Industrial Property

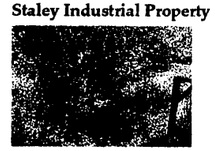


Photo 20 - Surface stream on industrial property. Recommendation: Work with private property owner to monitor stormwater flows and protect corridor vegetation.

Sewage Treatment Plant

Photo 21 - Playground near waterworks property. Recommendation: Develop additional recreational amenities for various age groups.

Photo 22 - Open space area on municipal lands. Recommendation: Protect as open space for wildlife habitat. Develop connections to Delaware River and parks.

Old Quarry Site

Photo 23 - Lake in abandoned quarry site. Recommendation: Organize clean up of lake and restore exposed shoreline.

Photo 24 - abandoned quarry property near lake. Recommendation: Clean up property and develop recreation master plan for the site.

Glenside

Photo 25 - Stream emptying into Delaware Canal. Recommendation: Reduce upstream stormwater flows, protect wooded corridor.

Rock Run - Melvin Heights

Photo 26 - Upper reaches of Rock Run in Morrisville Borough Recommendation: Prepare stormwater and flood management plan.

Photo 27 - Stormwater detention basin along Rock Run drainage. Recommendation: Implement stormwater BMPs.

Photo 28 - Location of localized flooding from Rock Run drainage during storm events Recommendation: Implement flood management strategies.

Morrisville Borough

Environmental Assessment Project

developed by the
Morrisville Environmental Advisory Council

prepared in support of the
Lower Delaware River Conservation Plan

Visual Assessment Map

Photo Locations
Drainageways
Municipal Boundary

Morrisville Borough
Bucks County, Pennsylvania

Scale: 1 Inch = 1000 Feet

1000 0 1000 2000 Feet

Lower Delaware River Conservation Plan

developed through Pennsylvania

Environmental Assessment

funding provided by

Mapping
prepared by

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August 1999