Watershed Restoration Action Strategy (WRAS)
State Water Plan Subbasin 07K
Pequea Creek and Octoraro Creek Watersheds
(Susquehanna River and Chesapeake Bay)
Lancaster and Chester Counties

Introduction

Subbasin 07K consists of 495 square miles of Pequea Creek, Octoraro Creek, the Susquehanna River and east shore tributaries from south of the confluence of the Conestoga River to the Maryland line. The subbasin comprises most of the southern half of Lancaster County and the western edge of Chester County. Major subwatersheds are Octoraro Creek at 176 square miles, Pequea Creek at 154 square miles, and Conowingo Creek at 34.4 square miles. A total of 479 streams flow for 472 miles through the subbasin. The subbasin is included in **HUC Area 2050306**, Lower Susquehanna River a Category I, FY99/2000 Priority watershed in the Unified Watershed Assessment.

The Susquehanna River is impounded through this subbasin behind the Holtwood Dam in Pennsylvania and the Conowingo Dam in Maryland, which have hydroelectric power generating stations owned by Pennsylvania Power and Light Co. (PP&L) and PECO Energy. PP&L also has a coal-fired generating station at Holtwood Dam. A pumped storage reservoir owned by PECO impounds Muddy Run southeast of Holtwood. The Conowingo Creek and Octoraro Creek enter the Susquehanna River in Maryland. The Octoraro Creek enters downstream of the Conowingo Dam.

The subbasin also includes the 64-square mile Big Elk Creek and Northeast Creek watersheds in **HUC Code 2060002**, Chester-Sassafras Rivers, part of Pennsylvania's "forgotten watersheds" that flow directly into the Chesapeake Bay and are not included as part of Pennsylvania's 5 major river basins. Because these waters flow directly into the Bay, they are not under the water withdrawal jurisdiction of the Susquehanna River Basin Commission (SRBC) and are instead covered under the interstate Chesapeake Bay Agreement of 1987. The majority of this portion of the subbasin is in the Big Elk Creek subwatershed, which drains 57 square miles. The remaining portion is in the Northeast Creek basin.

Geology/Soils

The entire subbasin is in the Northern Piedmont Ecoregion, with the lower two-thirds in the Piedmont Uplands (64c) subsection, which consists of rounded hills and low ridges. The underlying rock is comprised of metamorphic and igneous strata, mainly schist and mica of the Wissahickon and Peters Creek formations. Small areas of gneiss and quartz are found at northeastern edge of the subbasin, adjacent to the southern edge of the Piedmont Lowlands. Small diabase dikes are scattered though the subbasin. Rock outcrops are common in and along streams and the Susquehanna River. The western portion of the watershed near the Susquehanna River which is known as the "River Hills" has much more rugged topography, with entrenched streams flowing in a southwesterly direction through steep gorges. These high gradient streams include the scenic gorges and waterfalls in Tuquan Glen, Kellys Run, Ferncliff Run, Wissler Run, and lower Pequea Creek. Several of the wooded gorges have been protected as natural areas and are owned by the Lancaster County Conservancy or PP&L. The land in these watersheds contains an abundance and diversity of wildflowers.

The Piedmont Uplands also includes an area of serpentine rocks called the State Line Serpentine Barrens located in southeastern Lancaster County and southwestern Chester County. This globally rare rock formation is high in magnesium, chromium, and nickel and low in calcium and contains very poor soils that are high in chromium. These barrens support a unique flora of dry oak and pine forest and prairie grasses and herbs. Several of these areas are protected by the Nature Conservancy and by Chester County as Nottingham County Park. The serpentine and associated rocks are mined as aggregates in a cluster of quarries near the Maryland border. Groundwater in some sections of the serpentine strata has pH as high as 10.0 from a high magnesium carbonate rock called Brucite.

Deep soils weathered from the schist and gneiss support diversified farms even though the soils are not as fertile as the limestone valley to the north. The soils have moderate infiltration rates when thoroughly wetted. Soils are very fine grained and rocky. Soil erosion along streambanks is a problem in these easily erodible clays.

Mineral mining was common in the subbasin in the 1800's and early 1900's. Chromium and magnetite were mined from the serpentine area. An area near the village of Gap called Nickel Mine Ridge was the main source of nickel for the United States from 1853 to 1893; copper was also mined there between 1730 to 1849. A narrow tongue of Peach Bottom Slate outcrops towards the Susquehanna River between the village of Wakefield and the Borough of Quarryville.

The upper portion of the subbasin in the upper and middle Pequea Creek and Beaver Creek watersheds and around Quarryville Borough is in the Piedmont Limestone/Dolomite Lowlands (64d) subecoregion. This terrain is nearly level to undulating and contains sinkholes, caverns and disappearing streams. The strata are highly folded and faulted. These rocks weather to fertile soils which are intensively farmed. Virtually all the forest has been removed and few wetlands remain. Many farm fields have been tiled to drain wet spots. A major fault called the Martic Fault near the boundary of the Piedmont Uplands and Limestone Lowlands has been the epicenter of small, regularly occurring earthquakes. Several limestone quarries are located in this region of the subbasin.

The limestone soils, low gradient topography and relatively long growing season provide excellent conditions for farming. The solubility of the limestone produces fertile soils and the numerous sinkholes and faults allow surface water to enter the groundwater system with little infiltration or filtering by the soil. These conditions also allow nutrients and chemicals from fertilizers and pesticides spread on farms to readily enter the groundwater and cause drinking water wells to be degraded with potentially harmful concentrations of nitrates and pesticides.

Land Use

The subbasin is largely in agricultural land use except for scattered woodlots in the Piedmont Lowlands and forested corridors along creeks, the Susquehanna River, the River Hills, and Nickel Mine Ridge in the Piedmont Uplands. A few isolated areas of virgin forest are found in the River Hills gorges of the Piedmont Uplands. PP&L Power Company owned lands in these ravines are maintained as public parks. Corn, soybeans, hay, and wheat farming are the main crops in the agricultural areas. Dairy cattle pastures make up the majority of grazing land. Cattle generally have free access to the streams and streambank erosion is widespread.

Over 67% of the Octoraro watershed drains an area under extensive agricultural production, mainly crops. This southern end of the subbasin also has numerous dairy farms, many of which are owned by Old Order Amish who follow traditional farming methods. Tobacco is also common crop in the southern end, especially in Amish farms. Most of the remaining forested land, which amounts to about 20% of the basin, occurs on steep slopes or highly erodible rocky areas that are not suitable for farming. The remaining 20% of the Octoraro Creek watershed is in residential use, ranging from low to high density. A small industrial area is located in the eastern portion of the watershed through the boroughs of Christiana, Atglen, and Parkesburg. The main line railroad for freight and passengers to Philadelphia follows the edge of this corridor at Parkesburg.

The upper portion of Pequea Creek watershed has been extensively farmed in the area with limestone soils and flat terrain. The watershed is home to some of the highest densities of dairy cows found anywhere in Pennsylvania. Row crops also cover a large area of farmland. Amish own the majority of the farms in the upper Pequea Creek watershed.

Residential and commercial development is spreading rapidly throughout the subbasin especially around the Borough of Quarryville and village of Willow Street. Scattered residential houses are also spreading through the wooded River Hills section of the subbasin. The subbasin population was 91,266 in 1990 and is projected to increase significantly to 134,144 by 2040. Pequea Township is one of the few municipalities that has enacted strict ordinances against the conversion of farms into residential development. Because of the strength of their land use ordinances, they were successful in preventing the conversion of an orchard into a quarry through the DEP Bureau of Mining and Reclamation's unsuitable for mining program.

Natural/Recreational Resources:

Small isolated natural areas in the River Hills, the serpentine barrens, and along the West Branch Octoraro Creek and Trout Run are protected as conservancy or private recreational lands. The largest are Rock Springs Preserve and Goat Hill Serpentine Barrens. PP&L has several recreational areas along the Susquehanna River and near Holtwood Dam. PECO Energy has 2 recreational areas, Fisherman's Park along the Susquehanna River near the Muddy Run Pumped Storage Reservoir outlet, and Muddy Run Recreational Park, which includes a small portion of the reservoir as a recreational lake. The pumped storage reservoir has a large population of over-wintering snow and Canada geese and swans. Other areas under protection include: Fishing Creek, Tucquan Creek, Wissler Run, Trout Run, Kellys Run, lower Pequea Creek, and a small area along the middle West Branch Octoraro Creek. A potential Rails to Trails corridor is located on the abandoned railroad right of way extending from Atglen/Christiana west through Quarryville Borough to the mouth of Pequea Creek.

SGL #136 is located near the West Branch Octoraro Creek. Susuehannock State Park, a small wooded park south of Muddy Run, which has a river overlook, is the only state park in the subbasin. The Nature Conservancy protects Gleisner's Swamp near Quarryville, a habitat locality for the bog turtle. Octoraro Reservoir and surrounding lands are open to the public for fishing, boating, and goose hunting. Bald Eagles have nested on Susquehanna River Islands near Muddy Run. The Chester Water Authority owns large wooded tracts along the middle reaches of the West Branch Octoraro Creek.

Pennsylvania Scenic Rivers:
Octoraro Creek and Tuquan Creek are designated as Pennsylvania scenic rivers under the DCNR Scenic Rivers Program. The Octoraro Creek was designated in 1983, with 12.25 miles as scenic and 24.25 miles as pastoral. A total of 4947 acres of stream corridors including floodplains and steep slopes were protected. The Octoraro Creek Task Force, comprised of the Octoraro Watershed Association, township and county planning commissions representatives, and DEP staff, was organized to implement the scenic rivers act. The task force prepared a management plan titled Octoraro Creek Corridors, Issues, and Management Recommendations in 1986.

Water Supplies:
The Octoraro Creek is impounded at the junction of the East and West Branches to form the 600-acre Chester Octoraro Reservoir, a water supply reservoir owned by the Chester Water Co., which supplies water to 200,000 people in Chester County. Water taken from the reservoir is exported out of the watershed to the Delaware River drainage. The amount exported amounts to about 25% of the potential watershed discharge. The Water Company monitors nutrient and sediment amounts at their White Rock gauging station on the West Branch. The reservoir receives nutrients and sediment from nonpoint sources in the upstream East and West Branches.

The City of Coatsville has a water supply intake on the West Branch of the Octoraro Creek near Kirkwood, which results in additional export of water to the Delaware River drainage.

PA Fish and Boat Commission Class A trout waters (highest biomass category):
- Conowingo Creek, source to SR3005, brown trout (5.5 miles)
- UNT to Conowingo Creek, brown trout (1.6 miles)
- UNT to Trout Run, brook trout (1.9 miles)

Chapter 93 Protected Uses:
Migratory Fishes:
Many of the streams in this subbasin have protected use status for migratory fishes which includes anadromous fish such as Shad and herring as well as the catadromous eels.

Exceptional Value (EV):
- Octoraro Creek Basin
  - "Black Run", source to Unnamed tributary at River Mile 2.50
  - Unnamed tributary to Octoraro Creek at River Mile 13.6
- Jordan Run and Barren Brook, tributaries to Little Elk Creek

High Quality (HQ):
- Pequea Creek Basin:
  - Main stem and unnamed tributaries, source to PA 897
  - Houston Run; Unnamed tributary to Pequea Creek at River Mile 3.35
  - Umbles Run
  - Unnamed tributary to Pequea Creek at River 3.35
  - Trout Run
- Susquehanna River Tributaries:
  - Reed Run
  - Tucquan Creek
  - Unnamed tributaries, east bank Susquehanna River, Muddy Run to PA-MD border

    - Wissler Run
    - Fishing Creek
    - Peters Creek
    - Haines Run
    - the Pennsylvania portions of Unnamed tributaries entering east bank Susquehanna River in MD
- Conowingo Creek:
    - Unnamed tributaries
    - Jackson Run
    - Little Conewingo Creek
- Octoraro Creek Basin:
    - Knott Run
    - Annan Run
    - West Branch Octoraro Creek
    - McCreary Run
    - "Reynolds Run"
- Chesapeake Bay Drainage:
    - Big Elk Creek
    - Little Elk Creek main stem and unnamed tributaries

Water Quality Impairment
Major water quality impairments are from agricultural practices, including soil and streambank erosion and excess nutrients and sediments from farm runoff. Crops are often planted right along the streams and roads; little contour farming and few grass waterways are employed, and cattle generally have free access to the creeks. Stormwater runoff from the increasing number of shopping centers and housing developments is another serious problem in parts of the watershed.

Monitoring/Evaluation:
The majority of the subbasin was evaluated under the Department's Unassessed Waters Program in 1999. A total of 512 miles in the subbasin have been assessed, with 182 miles (36%) impaired and 330 miles meeting water quality standards. Prior to this assessment, only a small portion of Pequea Creek and the entire main stem of Conowingo Creek were on the 1998 303d list. After the 1999 assessment was completed, more miles of the Pequea Creek and Octoraro Creek watersheds were added to impaired list. The major pollution source in the subbasin was determined to be from cropland and grazing agricultural land uses, which cause impairment from excess nutrients and organic enrichment/low dissolved oxygen (DO), and high levels of suspended solids and siltation.

DEP biologists use a combination of habitat and biological assessments as the primary mechanism to evaluate Pennsylvania streams under the Unassessed Waters Program. This method requires selecting stream sites that would reflect impacts from surrounding land uses that are representative of the stream segment being assessed. The biologist selects as many sites as necessary to establish an accurate assessment for a stream segment. The length of the stream segment assessed can vary between sites. Several factors are used to determine site location and how long a segment can be, including distinct changes in stream characteristics, surface geology, riparian land use, and the pollutant causing impairment. Habitat surveys and a biological assessment are conducted at each site. Biological surveys include kick screen sampling of benthic macroinvertebrates, which are identified to family in the field, and an evaluation of their tolerances to pollution. Benthic

macroinvertebrates are the organisms, mainly aquatic insects, that live on the stream bottom. Since they are short-lived (most have a one-year life cycle) and relatively immobile, they reflect the chemical and physical characteristics of a stream and chronic pollution sources or stresses. Habitat assessments evaluate how deeply the stream substrate is embedded, degree of streambank erosion, condition of riparian vegetation, and amount of sedimentation.

The unimpaired portions of the subbasin are largely within the River Hills, the rugged western edge of the subbasin that is comprised of Wissahickon schist in the Piedmont Uplands. This region is generally too hilly and steep for agriculture and still contains significant forested areas. Some of the less hilly areas are being developed with single family houses spread out along the rural roads or in small developments that retain some of the wooded landscape.

Pequea Creek Watershed:
A total of 27.10 miles of the upper main stem Pequea Creek are impaired by agriculture. All of the Pequea Creek tributaries from the source down to the Big Beaver Creek have some impaired segments, as does Big Beaver Creek and the South Fork Big Beaver Creek. The unimpaired section of main stem Pequea Creek is the forested River Hills portion downstream of Climbers Run which is generally too hilly and rocky for agriculture. PP&L owns portions of this stream corridor which they manage as parks open to the public.

Susquehanna River Drainage:
Most of Conowingo Creek and Little Conowingo Creek are impaired by agriculture.

Octoraro Creek Watershed:
The upper portion and headwater tributaries of the East Branch of Octoraro Creek show more severe impairment from agriculture than the main stem and the West Branch. The four uppermost tributaries of the East Branch, Buck Run, Williams Run, Pine Creek, and Valley Run and two headwater tributaries of the West Branch, Meetinghouse Creek and Nickel Mines Run, are impaired. If this impairment is not addressed, the downstream reaches of the East and West Branch and the Octoraro Reservoir may also suffer from increased nutrients and sediment and become impaired.

A total of nine point source discharges are located in the Octoraro Creek watershed upstream of the Octoraro Reservoir. Most of these are in the upper East Branch watershed in the vicinity of the Boroughs of Atglen, Christiana, and Parkesburg, about 12 linear miles upstream of the reservoir, and constitute a very minor portion of the discharge flow to the basin. Three small point source discharges are located in the upper West Branch watershed, two at schools and one at a township building.

Chesapeake Bay Drainage:
The Department has not assessed this portion of the subbasin that includes Big Elk Creek, Little Elk Creek and Northeast Creek.

Other Studies:
Millersville University conducted a study of the benthic macroinvertebrates and nutrients of three tributaries to the West Branch Octoraro Creek in 1997 and 1998. The study was done for the Octoraro Watershed Association as part of their DCNR Rivers Conservation Grant. The study found that the least disturbed tributary was Bowery Run, which also has the lowest concentrations

of nitrates. Nickel Mines Run was the most disturbed and the most affected by runoff and high nitrates. The nitrate concentrations doubled in Nickel Mines Run and Meetinghouse Creek after heavy rains. All four watersheds have extensive agricultural lands. Nickel Mines Run was the only one of the three streams that was bordered by pasture; trees bordered most of the other streams. Their study results agree with the results of the DEP assessment.

A report prepared by the Chester Water Authority indicated that the Octoraro Reservoir is degraded by chemical pollutants, namely excess nutrients from farm runoff, and sedimentation from natural erosion and poor farming practices. The Water Company estimated that up to 134 square miles of the upstream watershed are in cropland and have a high potential for polluted runoff from plowing and pesticide spraying. The watershed is also adversely affected by cattle watering in and around streambanks, which causes compaction and degradation of shorelines and leads to erosion. The Water Company has also noted a reduction in reservoir water depths due to erosion and sedimentation. The reservoir trophic state indicated a eutrophic status, with a calculated lake phosphorus retention rate of 21%.

Landstudies, Inc. completed a study of Knight Run, a tributary of the East Branch Octoraro Creek, for the Octoraro Watershed Association in 1999. Knight Run was selected as a representative subwatershed for the basin. This watershed is largely agricultural and also is traversed by two major high use roads, PA Routes 10 and 41. Soils in this watershed are weathered from schist and have good surface drainage. The stream aquatic habitat was rated fair to poor due to sediment and nutrient loading and a lack of riparian buffers. Much of the stream reaches are bordered by pasture, and cattle have direct access. Streambank erosion is severe in many places and in need of stabilization as well as fencing to exclude cattle. The study delineated areas in need of agricultural BMPs and channel restoration.

The Pequea/Mill Creek National Monitoring project sponsored by the USGS has been ongoing since 1991. Sampling and water quality analyses of 463 surface water sites by USGS from 1993 to 1997 indicated that Pequea Creek had the highest mean concentration of atrazine, and that nitrates often exceed the EPA maximum contaminant level of 10 mg/l nitrate. Ammonia in concentrations that have been found to be extremely toxic to aquatic life and 22 separate pesticides have been detected in surface and groundwater of the watershed.

The USDA National Resource Conservation Service (NRCS) had one of their Water Quality Initiative areas in Pequea-Mill Creek from 1991 to 1999 to coordinate and increase a voluntary approach to reduce agricultural nonpoint source pollution. Several private and other government agencies assisted in the project. Dairy farms are the dominant agricultural enterprise in these watersheds. Education was an important part of the project. Numerous information leaflets on the project were prepared and distributed, videos developed, field days were held, and visits made to farms. Components of the project included:

- Installation of manure storages, barnyard runoff controls and conservation practices
- Participation in cost-sharing for Integrated Pest Management (ICM)
- Streambank fencing, in cooperation with the Pennsylvania Game Commission and the U.S. Fish and Wildlife Service
- Implementation of rotational lot management systems to reduce the amount of runoff from cattle exercise areas
- Demonstrations of stream crossings, livestock watering and shade options, in cooperation with the Lancaster County Conservation District.

An EPA biological study of agricultural areas in the MidAtlantic region stated that it was impossible to find healthy streams in the Limestone/dolomite Lowlands Ecoregion of the Piedmont including Pequea Creek, due to poor farming practices in these watersheds during the past 100 years. Sampling of benthic macroinvertebrates also indicated severe degradation. The most severely impaired sites were on Pequea Creek tributaries, especially Eshelman Run, Houston Run, Umbles Run, Walnut Run, Goods Run, and unnamed tributaries. Main stem Pequea Creek was in slightly better condition than its tributaries. The contributing factor to impairment was determined to be the percent agricultural cover. Macroinvertebrate richness is normally reduced if the amount of agricultural land use in a watershed exceeds 15 percent. Traditional agricultural practices resulting in sedimentation, bank erosion, and lack of adequate riparian zones contribute to habitat, water quality, and biological impairment.

Future threats to water quality

Agriculture will continue to be the major source of nonpoint source pollution in the subbasin; however, as farms are converted to residential and commercial use, pollution from stormwater runoff will likely increase.

Restoration Initiatives

Pennsylvania Growing Greener Grants:

- $67,00 (FY2002) to Paradise Sportsmen's Association for Phase II streambank restoration of upper Pequea Creek watershed.
- $150,670 (FY2001) to the Octoraro Watershed Association for habitat restoration on Stewart Run.
- $67,000 (FY2000) to the Paradise Sportsmen Association/Lancaster Healthy Communities to implement restoration activities along 2500 feet of Eshelman Run in Paradise Township, including removing two dams, stabilizing streambanks, installing agricultural crossings and 2500 feet of stream fencing, and planting the riparian corridor.
- $151,000 (FY2000) to the Paradise Sportsman Association to restore 2800 feet of severely eroded streambank in a 2.18-mile impaired section of upper Pequea Creek in Salisbury Township. The Paradise Sportsmen have achieved excellent results in restoring stream habitat and reducing nonpoint source pollution from farm runoff in upper Pequea Creek watershed through previous stream fencing and restoration projects funded by NRCS. These Growing Greener funds will allow restoration efforts to continue.
- $7,712 (FY1999) to the Chester County Conservation District to hold an Earth Day awareness event on the Octoraro Creek.
- $80,000 (FY1999) to Elks Creeks Watershed Association to develop an outdoor classroom on Oxford Area School District property on an unnamed tributary to Little Elk Creek. The project will also include implementation of BMPs for erosion control and streambank stabilization, curriculum development, and field days.

U.S. EPA Clean Water Act Section 319 Grants:

- $198,000 (FY2003) to the Lancaster County Conservation District for installation of agricultural BMPs in Octoraro Creek watershed.
- $300,000 (FY2002) to the Lancaster County Conservation District for installation of agricultural BMPs. Part of this grant money will be used in the Octoraro Creek watershed.
- The Pequea/Mill Creek National Monitoring project sponsored by the USGS has been ongoing from FY1991 to 2001. The goal of this project is to evaluate the surface and groundwater

quality changes as a result of the implementation of agricultural Best Management Practices (BMPs) in carbonate zones. BMPs installed include streambank fencing and barnyard runoff controls.

- $300,000 (FY2001) to Lancaster County CD for installation of agricultural BMPs in the Octoraro Creek watershed, supporting the 1998 comprehensive watershed assessment funded under a DCNR Rivers Conservation Grant. Public awareness of water quality and habitat values will be fostered by activities to protect and improve bird habitats around Octoraro Reservoir, designated an Important Bird Area by the Pennsylvania Audubon Society.
- $190,000 (FY2000) to the Octoraro Watershed Association for a continuation of the Bendway weir method of streambank restoration on an adjacent stream segment of the West Branch.
- $125,000 (FY2000) to Ducks Unlimited, Inc. for streambank fencing and restoration of woody riparian buffers, installing stabilized cattle crossings, and restoring wetlands in the Octoraro Creek watershed in Lancaster and Chester Counties.
- $50,000 (FY1998) to Octoraro Nursery for streambank restoration of an agricultural impacted area on West Branch Octoraro Creek using the Bendway weir technique.
- $37,750 (FY1992) to Lancaster CD for streambank fencing in Pequea/Mill Creeks; most of work has been in the Mill Creek portion of study area (Subbasin 07J, Conestoga River).

Pennsylvania Watershed Restoration Assistance Program (WRAP):

- $4,250 grant to the Strasburg Borough Wellhead Protection Committee to develop a public awareness campaign to promote water resource awareness, good stewardship, and to assist with best management practices for contaminate spill contingencies to protect their water supply in the Little Beaver Creek watershed.

PA Chesapeake Bay Education Mini-Grants:

- $5,750 to the Solanco Future Farmers of America and the Octoraro Watershed Association for an Octoraro Creek educational demonstration site. Stream deflectors and mudsills were constructed along 500 feet of stream. The purpose of the project was to demonstrate to landowners how erosion control measures preserve and increase aquatic life. Twenty-four high school students are monitoring water chemistry and invertebrates at the study site.

Department of Conservation and Natural Resources (DCNR) Rivers Conservation Grants:

- $40,000 (1997) to the Octoraro Watershed Association to prepare a rivers conservation plan for the Octoraro Creek watershed. This plan will update the management plan developed as a result of the scenic rivers designation.
- The Brandywine Conservancy received a grant to develop a river conservation plan for the Elk Creek watershed.

Department of Conservation and Natural Resources (DCNR) Keystone Land Trust Program Grants:

- $40,000 to Lancaster County Conservancy to acquire 33 acres for expansion of the Tucquan Glen Nature Preserve in Martic Township.
- $240,000 to The Nature Conservancy to acquire 173 acres for expansion of the Rock Springs Serpentine Barren Preserve (1997).
- $25,000 to the Lancaster County Conservancy for acquisition of 30 acres along Fishing Creek Road to expand the Fishing Creek Nature Preserve (1997).

Coldwater Heritage Partnership Grant:

- $5,000 (1999) to the Lancaster County Conservancy for a preliminary assessment of Fishing Creek.

Agricultural Initiatives:

- U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) Programs:

- Pequea/Mill Project: Started in early 1990's, 70 miles of stream fenced in both watersheds, 20 to 30 manure storage facilities installed. About 40% of the work has been in Pequea Creek watershed.

- Chesapeake CARE (Conserving Agricultural Resources and the Environment): Wetland and riparian restoration program to reduce nonpoint source pollution and improve fish and wildlife habitat in Octoraro Creek watershed. The emphasis is exclusion of cattle from stream access, restoration of hydrology by blocking tile drains, filling ditches, and constructing dikes. Warm season grasses are also planted. Partners in this project included the Chesapeake Bay Foundation, Ducks Unlimited, Octoraro Creek Watershed Association, DEP, Pennsylvania Game Commission, US Fish and Wildlife Service. Fenced areas provide excellent wildlife habitat and help filter pollutants from farm runoff out of the water. The project has been the basis for articles in the Lancaster County Newspapers. Successful projects like this have helped show farmers the benefits of streambank fencing and helped sign up other farmers into the program who were once opposed to fencing.
- Lancaster County Farm Preservation: The county runs one of the strongest farm preservation programs in the US; the Lancaster Farmland Trust operates a private preservation program; and the Lancaster County Planning Commission has developed a controlled growth plan that sets urban boundaries.
- The Chester County Conservation District is involved with an incentive and cost-sharing program for farmers to implement agricultural BMPs such as stream fencing and crossings.

Chesapeake Bay Small Watershed Grants Program:

- $6,760 to Brandywine Conservancy to assist the Elks Creek Watershed Association to educate landowners about conservation practices, restore riparian buffers, and encourage adoption of ordinances supportive of sustainable development.

PENNVEST:

- $1.9 million loan to expand the capacity of sewage treatment system and install 5 miles of collection and transmission lines to serve the village of Gap and surrounding areas.

League of Women Voters (WREN) Mini-grants:

- $3,000 to the Octoraro Watershed Association to develop township liaison task forces in each of the watershed municipalities to hear ideas and concerns and to develop strategies regarding protection of the watershed.

Pennsylvania Fish and Boat Commission Aquatic Resource Conservation Grants:

- $800 (2000) to Paradise Sportsmen Association for riparian protection along Eshelman Run, a tributary to Pequea Creek.
- $1,000 (2000) to Solanco Future Farmers of America for instream habitat projects on Octoraro Creek in Lancaster County.

Citizen/Conservation Groups

- Octoraro Watershed Association has a network of stream watchers and concerned residents in the watershed who monitor changes and pollution violations. The association is also developing a watershed plan under a DCNR Rivers Conservation grant. In late 2000, the watershed association began hosting community meetings in the 19 municipalities that border the creek with the goal of forming groups of residents in each township to work with local officials on programs to improve water quality and protect the environment.
- The Brandywine Conservancy
- Martic Hills Watershed Association
- Elk Creeks Watershed Association

- Elk Valley Association
- Southern Lancaster County Farmers Sportsmen Association
- Paradise Sportsmen's Association has been active in restoring and fencing streambanks in Paradise Township in Pequea Creek and its tributary Eshelman Run.
- Lancaster Healthy Communities is a volunteer organization involved with promoting a healthy community lifestyle. They are one of 15 collaborators for the countywide Lancaster Community Indicator Project tracking water quality and stream health.
- Donegal Chapter Trout Unlimited has assisted other groups in stream restoration activities in the subbasin.
- Solanco Future Farmers of America

Public Participation/Outreach

Watershed Notebooks

DEP's website has a watershed notebook for each of its 104 State Water Plan watersheds. Each notebook provides a brief description of the watershed with supporting data and information on agency and citizen group activities. Each notebook is organized to allow networking by watershed groups and others by providing access to send and post information about projects and activities underway in the watershed. This WRAS will be posted in the watershed notebook to allow for public comment and update. The notebooks also link to the Department's Watershed Idea Exchange, an open forum to discuss watershed issues. The website is www.dep.state.pa.us. Choose Subjects/Water Management/Watershed Conservation/Watershed and Nonpoint Source Management/Watershed Notebooks.

A variety of federal and local agencies and staff from other Department programs reviewed or provided information for this WRAS. These included NRCS, the Chester and Lancaster County Conservation Districts, and the DEP South Central Regional Office. The public participation process has begun through distribution of this WRAS at various workshops and conferences and by the county conservation districts and DEP Regional Coordinators. Public input has been and will continue to be incorporated into expanding and fine tuning the WRAS for direction on use of 319 grant funds beyond FY2000.

Funding Needs

The total needed dollars for addressing all nonpoint source problems in the watershed is undetermined at this time and will be so until stream assessments are completed and necessary TMDL's are developed for the watershed. TMDL's have been drafted for Pequea Creek and Conowingo Creek. Public meetings on the TMDL's were held in January 2001. Existing programs that address nonpoint source issues in the watershed will continue to move forward until the remaining TMDL's are completed.

Pennsylvania has developed a Unified Watershed Assessment to identify priority watersheds needing restoration. Pennsylvania has worked cooperatively with agencies, organizations and the public to define watershed restoration priorities. The Commonwealth initiated a public participation process for the unified assessment and procedures for setting watershed priorities. Pennsylvania's assessment process was published in the *Pennsylvania Bulletin, DEP Update* publication and World Wide Web site. It was sent to the Department's list of watershed groups, monitoring groups, and Nonpoint Source Program mailing list. Department staff engaged in a significant outreach effort which included 23 additional events to solicit public comment. The Department received 23 written comments from a variety of agencies, conservation districts and

watershed groups. Pennsylvania is committed to expanding and improving this process in the future.

Total Maximum Daily Loads (TMDL's)
TMDL's identify the amount of a pollutant that a stream or lake can assimilate without violating its water quality standards. TMDL's are calculated to include a margin of safety to protect against a mathematical or data error. TMDL's are set for each pollutant causing impairment.

Draft TMDL for Pequea Creek
The Susquehanna River Basin Commission (SRBC) developed Total Maximum Daily Loads, or TMDL's, for the Pequea Creek watershed to address the impairments noted on Pennsylvania's 1996 and 1998 303(d) lists and the 2000 305(b) report. Portion 1 includes the downstream impaired area of Pequea Creek and three unnamed tributaries, Big Beaver Creek, South Fork Big Beaver Creek, Little Beaver Creek, Calamas Run, and Walnut Run. Portion 2 includes the upper impaired portion of Pequea Creek and four unnamed tributaries, Eshleman Run, Londonland Run, Houston Run, Indian Spring Run, two unnamed tributaries to Richardson Run, Umbles Run, and an unnamed tributary to Walnut Run. The protected uses of these portions of the watershed are water supply, recreation, and aquatic life. The aquatic life designation for the main stem Pequea Creek is primarily warm water fishes, with the headwater tributaries region designated high quality, cold water fishes.

Biological surveys indicated that impairments in these portions of Pequea Creek watershed were due to excessive amounts of sediment and nutrients, organic enrichment, and low dissolved oxygen (DO) from agricultural sources.

Pennsylvania does not currently have water quality criteria for sediment or nutrients. For this reason, Pennsylvania's Department of Environmental Protection developed a reference watershed approach to identify the TMDL endpoints, or water quality objectives, for nutrients and sediment in the impaired segments of the Pequea Creek watershed. The Reference Watershed Approach compares two watersheds, one attaining its uses and one that is impaired based on biological assessment. Both watersheds must have similar land cover and land use characteristics. Other features such as base geologic formation should be matched to the extent possible; however, most variations can be adjusted in the model. The objective of the process is to reduce the loading rates of nutrients and sediment in the impaired stream segment to a level equivalent to, or slightly lower than, the loading rates in the reference stream segment. This load reduction will allow the biological community to return to the affected stream segments.

A watershed that would satisfy all the characteristics mentioned above could not be found in the same Ecoregion as Pequea Creek because not all stream segments in the Northern Piedmont Ecoregion where Pequea Creek watershed is located have been assessed and all watersheds that have similar levels of agricultural land use and geologic rock type as Pequea Creek watershed are also impaired. A portion of the Conococheague Creek watershed was used as a reference for the Pequea Creek watershed. The Conococheague Creek is located in the Ridge and Valley Ecoregion in State Water Plan (SWP) Basin 13C, Franklin County. Most of the Conococheague Creek watershed was assessed and found to be unimpaired. The two watersheds are comparable in area, geology, and land use.

The ratio of the amount of nitrogen (N) to the amount of phosphorus (P) is often used to determine which nutrient is limiting. If the N/P ratio is less than 10, nitrogen is limiting; if the N/P ratio is greater than 10, phosphorus is the limiting nutrient. A ratio equal to 10 indicates neither phosphorus nor nitrogen is limiting. In the case of Pequea Creek, the N/P ratio is approximately 9 and 11 for Portions 1 and 2 respectively. Since the average N/P ration is 10, both nitrogen and phosphorus were addressed by the TMDL. Controlling the nutrient loading to Pequea Creek will limit plant growth and raise dissolved oxygen levels.

By comparison to a similar non-impaired watershed, the amount of phosphorus loading that will meet the water quality objectives for Pequea Creek was estimated at approximately 35,500 lbs/yr (pounds per year) and 40,900 lbs/yr for Portions 1 and 2 respectively. Nitrogen loading must be limited to 646,000 lbs/yr and 746,000 lbs/yr for Portions 1 and 2 respectively. Sediment loading must be limited to 7,270,000 lbs/yr and 8,400,000 lbs/yr for Portions 1 and 2 respectively. When these values are met, Pequea Creek will support its aquatic life uses.

Unit Area Loads for the Pequea and Conococheague Creek Watersheds

Watershed	Unit area load for P (lbs/acre/yr)	Unit area load for N (lbs/acre/yr)	Unit area load for Sediment (lbs/acre/yr)
Pequea Creek Portion 1	2.26	20.6	1,180
Pequea Creek Portion 2	1.62	18.0	843
Conococheague Creek	0.98	17.9	200

TMDL Computation for Pequea Creek

Pollutant	Unit Area Loading Rate in Conococheague Creek (lbs/acre/yr)	Total Watershed Area (acres)	TMDL Value (lbs/yr)
Portion 1			
Phosphorus	0.98	36,193	35,500
Nitrogen	17.85	36,193	646,000
Sediment	200	36,193	7,270,000
Portion 2			
Phosphorus	0.98	41,785	40,900
Nitrogen	17.85	41,785	746,000
Sediment	200	41,785	8,400,000

The portions of Pequea Creek watershed addressed in this TMDL also contain point sources from sewage treatment plants, two in Portion 1 and three in Portion 2. These discharges were entered into the TMDL endpoints as wasteload allocations (WLA). The assigned permit limits for the discharges were used in the computations of the TMDL. The nonpoint sources are considered the load allocations (LA) in calculation of the TMDL. The margin of safety (MOS) is the portion of loading that is reserved to account for any uncertainty in the data and computational methodology used for the analysis, represented by 10% of the TMDL value.

TMDL's for Pequea Creek

Pollutant	TMDL (lbs/yr)	WLA (lbs/yr)	LA (lbs/yr)	MOS (lbs/yr)
Portion 1				
Phosphorus	35,500	2,400	29,500	3,550
Nitrogen	646,000	17,400	564,000	64,600

Sediment	7,270,000	0	6,540,000	727,000
Portion 2				
Phosphorus	40,900	2,500	34,310	4,090
Nitrogen	746,000	5,300	670,000	74,600
Sediment	8,400,000	0	7,560,000	840,000

Loadings and reductions need to meet water quality criteria for specific streams and segments of the Pequea Creek watershed and additional information on calculations of the TMDL's can be found in the TMDL Report posted on the Department's website at http://www.dep.state.pa.us/, directLINK, TMDL's, Pequea Creek.

The pollutant reductions in the TMDL's are allocated to agricultural and residential/urban development activities in the watershed. Implementation of best management practices (BMPs) in the affected areas should achieve the loading reduction goals established in the TMDL's. Substantial reductions in the amount of sediment reaching the streams can be made through the planting of riparian buffer zones, contour strips, and cover crops. These BMPs range in efficiency from 20% to 70% for sediment reduction. Implementation of BMPs aimed at sediment reduction will also assist in the reduction of phosphorus. Additional phosphorus reductions can be achieved through the installation of more effective animal waste management systems and stone ford cattle crossings. Other possibilities for attaining the desired reductions in phosphorus and sediment include streambank stabilization and fencing. Field assessments will be performed in order to assess both the extent of existing BMPs and to determine the most cost-effective and environmentally protective combination of BMPs required to meet the required nutrient and sediment reductions. Proposed remediation efforts include streambank fencing, bank stabilization, stone ford cattle crossings, and fish enhancement structures.

Draft TMDL for Conowingo Creek:

The Susquehanna River Basin Commission (SRBC) developed Total Maximum Daily Loads or TMDL's for Conowingo Creek watershed to address the impairments noted on Pennsylvania's 1996 and 1998 303(d) lists and the 2000 305(b) report. Biological surveys indicated that impairments in the Conowingo Creek watershed were due to excess nutrient and sediment loads from agricultural sources. In stream systems, elevated nutrient loads (nitrogen and phosphorus) can lead to increased productivity of plants and other organisms. Additional problems can also occur if nutrient loads are not reduced. Impaired segments in the Conowingo Creek watershed include portions of the main stem and unnamed tributaries of Conowingo Creek and Little Conowingo Creek.

Pennsylvania does not currently have water quality criteria for sediment or nutrients. For this reason, Pennsylvania's Department of Environmental Protection (Pa. DEP) developed a reference watershed approach to identify the TMDL endpoints, or water quality objectives, for nutrients and sediment in the impaired segments of the Conowingo Creek Watershed. The Reference Watershed Approach compares two watersheds, one attaining its uses and one that is impaired based on biological assessment. Both watersheds must have similar land cover and land use characteristics. Other features such as base geologic formation should be matched to the extent possible; however, most variations can be adjusted in the model. The objective of the process is to reduce the loading rates of nutrients and sediment in the impaired stream segment to a level equivalent to, or slightly lower than, the loading rates in the reference stream segment. This load reduction will allow the biological community to return to the affected stream segments.

The watershed used as a reference for the Conowingo Creek watershed was the North Branch Muddy Creek watershed, located in State Water Plan (SWP) Basin 07I, York County. All of the North Branch Muddy Creek stream segments have been assessed and were found to be unimpaired. Land cover/use distributions in both watersheds are fairly similar. The agricultural land use, which is the source of impairment in Conowingo Creek watershed, accounts for 83% of the total land area as compared to 63% in North Branch Muddy Creek watershed. North Branch Muddy Creek watershed has significantly less agricultural lands, however, the difference is protective of the Conowingo Creek watershed. The surface geologies of the Conowingo Creek and North Branch Muddy Creek watersheds are a perfect match; both consist entirely of igneous/metamorphic rock and are in the Northern Piedmont Uplands Ecoregion. The bedrock geology affects primarily surface runoff and background nutrient loads through its influences on soils and landscape as well as fracture density and directional permeability. These watersheds also compare very well in terms of average precipitation and soil K factor. The portion of North Branch Muddy Creek watershed selected for the analyses is approximately 44 square miles, comparable to the 34 square miles of the Conowingo Creek watershed. Conowingo Creek, however, has more land in agricultural use, 83% vs. 63% for North Branch Muddy Creek.

The ratio of the amount of nitrogen (N) to the amount of phosphorus (P) is often used to determine which nutrient is limiting. If the N/P ratio is less than 10, nitrogen is limiting; if the N/P ratio is greater than 10, phosphorus is the limiting nutrient. A ratio equal to 10 indicates neither phosphorus nor nitrogen is limiting. In the case of Conowingo Creek, the N/P ratio is approximately 13. Since the N/P ration is 13, only phosphorus was addressed by the TMDL. Controlling the phosphorus loading to Conowingo Creek will limit plant growth and result in raising the dissolved-oxygen levels.

Typically, the quantities of trace elements are plentiful in aquatic ecosystems; however, nitrogen and phosphorus may be in short supply. The nutrient that is in the shortest supply is called the limiting nutrient, because its relative quantity affects the rate of production (growth) of aquatic biomass. If the nutrient load to a water body can be reduced, the available pool of nutrients that can be utilized by plants and other organisms will be reduced. In most efforts to control eutrophication processes in water bodies, emphasis is placed on the limiting nutrient. In some instances, this may not always be the case. For example, if nitrogen is the limiting nutrient, it still may be more efficient to control phosphorus loads if the nitrogen originates from difficult to control sources such as nitrates in ground water.

By comparison of Conowingo Creek with the similar non-impaired watershed, Muddy Creek in York County, the amount of phosphorus loading that will meet the water quality objectives for Conowingo Creek was estimated approximately 19,400 lbs/yr (pounds per year). Sediment loading must be limited to 20,400,000 lbs/yr. When these values are met, Conowingo Creek will support its aquatic life uses.

Unit Area Loads for the Conowingo Creek and North Branch Muddy Creek Watersheds

Watershed	Unit area load for P (lbs/acre/yr)	Unit area load for N (lbs/acre/yr)	Unit area load for Sediment (lbs/acre/yr)
Conowingo Creek	2.43	30.7	1,270
North Branch Muddy Creek	0.90	18.5	950

TMDL Computation for Conowingo Creek			
Pollutant	**Unit Area Loading Rate in North Branch Muddy Creek (lbs/acre/yr)**	**Total Watershed Area for Conowingo Creek (acres)**	**TMDL Value (lbs/yr)**
Phosphorus	0.90	21,500	19,400
Sediment	950	21,500	20,400,000

TMDL Endpoints for the Conowingo Creek Watershed			
Pollutant	**Current Loading (lbs/yr)**	**TMDL (lbs/yr)**	**Percent Reduction in Loads Needed to Meet TMDL**
Phosphorus	52,400	19,400	63%
Sediment	27,300,000	20,400,000	25%

Loadings for specific segments and land use types in the Conowingo Creek watershed can be found in the TMDL report posted on the Department's website at http://www.dep.state.pa.us/, directLINK, TMDL's, Conowingo Creek.

The pollutant reductions in the TMDL's are allocated to agricultural and residential/urban development activities in the watershed. Implementation of best management practices (BMPs) in the affected areas should achieve the loading reduction goals established in the TMDL's. Substantial reductions in the amount of sediment reaching the streams can be made through the planting of riparian buffer zones, contour strips, and cover crops. These BMPs range in efficiency from 20% to 70% for sediment reduction. Implementation of BMPs aimed at sediment reduction will also assist in the reduction of phosphorus. Additional phosphorus reductions can be achieved through the installation of more effective animal waste management systems and stone ford cattle crossings. Other possibilities for attaining the desired reductions in phosphorus and sediment include streambank stabilization and fencing. Field assessments will be performed in order to assess both the extent of existing BMPs, and to determine the most cost-effective and environmentally protective combination of BMPs required to meet the nutrient and sediment reductions. Proposed remediation efforts include streambank fencing, bank stabilization, stone ford cattle crossings, and fish enhancement structures.

Collaborative efforts between several state, federal, and local agencies have identified segments for implementation of BMPs; however, no funding has been allocated to the Conowingo Creek watershed. Restoration efforts could be improved through the establishment of a watershed association.

Restoration Needs

The assessment of the subbasin is close to completion. Impaired waters have been placed on the 303d list. Restoration activities have begun in many portions of the subbasin. In 1986, the DEP Chesapeake Bay Program estimated that $7.6 million would be needed for agricultural BMPs to reduce nonpoint source pollution in the Pequea Creek, Octoraro Creek and Conowingo Creek watersheds.

Impaired Stream Sections:

The following stream sections are impaired by agricultural practices and in the greatest need of agricultural BMPs such as cattle exclusion through streambank fencing, cropland terraces, and manure storage management, streambank stabilization and restoration of riparian buffers.

- Pequea Creek:
  - The upper 27.1 miles of the Pequea Creek and its tributaries from the headwaters down to Little Beaver Creek (total of 55.23 miles).
  - Little Beaver Creek: 5.83 miles of main stem and 6.06 miles of unnamed tributaries
  - Calmus Run, entire basin (total of 5.34 miles)
  - Big Beaver Creek: the entire 2.81 miles of main stem, 1.96 miles of one unnamed tributary and 8.51 miles of South Fork Big Beaver Creek watershed
- Conowingo Creek:
  - Lower 12.64 miles of the main stem and 9 miles of unnamed tributaries
  - Little Conowingo Creek: 9.27 miles of main stem and unnamed tributaries
- Octoraro Creek:
  - The entire main stem East Branch and tributaries Buck Run, Williams Run, Pine Creek, Valley Run, Knight Run, and Bells Run (total of 36.76 miles).
  - The upper 1.12 miles of the West Branch from Hollow Road upstream through the headwater tributaries of Meetinghouse Creek and Nickel Mines Run (15.26 total miles).

Restoration efforts in the subbasin have been implemented and funded by a variety of agencies and citizens groups, including the U.S. Fish and Wildlife Service, U.S. NRCS, DEP, Ducks Unlimited, the Lancaster County Conservation District, USGS, and local watershed associations. These restoration efforts need to continue and be coordinated to assure that BMPs are placed in locations that will achieve the highest load reductions. The conservation districts and NRCS should continue their initiatives for the education of farmers on proper and safe use of pesticides and manure spreading on fields to help reduce infiltration of nitrates and residual pesticides into groundwater. USGS and the DEP citizen volunteer monitoring programs are spearheading water quality monitoring of restoration efforts.

The installation of agricultural BMPs should be continued in the Pequea Creek portion of the subbasin which is smaller than the Octoraro Creek basin but has almost twice as many impaired miles (101.44 vs. 52.2 miles). The NRCS and Paradise Sportsmen's Association have worked together with other agencies to exclude cattle, install restricted stream crossings and restore streambanks. Establishing a watershed association for Pequea Creek could help guide and oversee restoration and protection efforts throughout the watershed.

Results of the USGS Pequea/Mill Creek National Monitoring Project indicated that streambank fencing in connection with other BMPs such as stream crossings, manure storage, and rotational grazing is effective in reducing polluted runoff and improving water quality during both base flow and storm flow events. Many more BMPs are necessary in the subbasin to complete the restoration efforts already underway. Additional improvements in water quality are expected with installation of additional BMPs; however, because of the magnitude of the problem, achievement of water quality standards may not be observed for some time.

Implementation of BMPs for agricultural sources in the impaired areas should reduce nutrients and sediment loadings. Streambank stabilization and fencing should reduce phosphorus and sediment loads in the affected areas. Streambank fencing will keep livestock out of the streams and allow restoration of riparian zones to trap sediment and phosphorus, thus keeping these pollutants from reaching the stream. A reduction coefficient of 75% for nutrients and sediment is reasonable to

expect with these BMPs. The 75% reduction in loading from BMP implementation is derived from empirical data from previous studies of BMP effectiveness reported in the literature and used by the Susquehanna River Basin Commission in their efforts to model pollutant reductions that may result from various load reduction strategies.

Stream segments in need of protection:

- The upper section 1.8 miles of Conowingo Creek has a Class A brown trout fishery and should be protected from encroaching urbanization from the nearby village of Buck and a housing development near Tanglewood Golf course.
- The majority of the West Branch of Octoraro Creek is unimpaired; however, the upper reaches and headwater tributaries are impacted by agriculture. Protection measures such as streambank stabilization and restoration of riparian buffers may be needed to ensure that the aquatic habitat and water quality in lower stream sections does not become impaired. Implementation of agricultural BMPs in the upper West Branch Octoraro Creek tributaries would also help reduce siltation to the Octoraro Reservoir.
- Lower Pequea Creek. Continuing implementation of agricultural BMPs and riparian buffer restoration in upper Pequea Creek should help protect and reduce siltation and protect aquatic habitat in the unimpaired lower section of Pequea Creek.

Watershed Activities

Jenner's Pond Wetland Restoration and Stream Restoration Project:

Residents of Jenner's Pond Retirement Community are enjoying the streams and wetlands on their property, which were once an overgrown tangle of invasive plants. The two-year project was initiated by Stroud Water Research Center and completed with collaboration of the Chester County Conservation District, the Chesapeake Bay Foundation, and local residents and volunteers. Bern Sweeny of Stroud Center told the residents that restoration would improve the overall water quality and aesthetics of their water habitats, which are tributaries of Big Elk Creek. Restoration of these small headwater streams and the wetlands are critical to the success of the massive efforts to clean up the Chesapeake Bay. The restoration efforts on this property also serve as an example for other retirement communities, housing developments, and the public. The project received monetary support for clearing and purchase of native species through the Chesapeake Bay Foundation and the Jenner's Pond Retirement Community. Equipment and tree shelters were provided by the Chester County Conservation District. Stroud Center donated design and coordination services.

Removal of invasive species such as multiflora rose and oriental bittersweeet proved difficult, requiring months of manual labor with mowing and machetes. The work was done by a combination of paid and volunteer labor. In fall 2001, after removal of invasive species, hundreds of native species were planted and protective covers added. Several hundred more plants were added in fall 2002. Other native species have become established through seeds carried by the wind or wildlife. After the project was completed, the residents were able to start a walking trail along the streams that allows them to exercise and view nature.

References/Sources of Information

- State Water Plan, Subbasin 7, Lower Susquehanna River. Department of Environmental Protection, February 1980
- USGS Topographic Maps
- 319 project proposals and summaries
- DEP: information from Unified Watershed Assessment, website, files and databases.

- Map of Draft Level III and IV Ecoregions of Pennsylvania and the Blue Ridge Mountains, Ridge and Valley, and Central Appalachians of EPA Regions III
- Seasonal Study of Benthic Macroinvertebrates as Water Quality Indicators in Four Headwater Stream sites in the West Branch Octoraro Creek, PA. Department of Biology, Millersville University, 1998.
- Reconnaissance of the Octoraro Watershed. A Report by Patrick Fasano, Watershed Superintendent, Chester Water Authority. 1997 revision.
- Knight Run Subwatershed Study. A Report prepared for the Octoraro Watershed Association. Landstudies, Inc. 1999.
- The Biological Condition of Streams in the Pequea and Mill Creek Watersheds in Pennsylvania. March 1999. US Environmental Protection Agency, Region III, Biology Group, Wheeling, WV.
- Pequea-Mill Creek Hydrologic Unit Project Progress Report and information leaflets. U.S. Department of Agriculture.
- Draft TMDL's for Pequea Creek and Conowingo Creek watersheds. DEP Bureau of Watershed Conservation. 2000.

Streams in Subbasin 07K: 303d/305b Listings

Pequea Creek Watershed

Stream	**Stream Code**	**Drainage area square miles**	**Miles Impaired**	**Miles Attained**	**Causes/Sources/ *Comments***
2-**Pequea Creek**	07450	154	27.10 Upper main stem, 25.3, 16 UNTs	22.61 Lower main stem 21.19, 15 UNTs	AG-Organic enrichment/low DO, nutrients, siltation *HQ-CWF, main stem & UNTs to PA 89, UNT at RM 3.35*
3-"Indian Spring Run"	07538		2.03 Main stem; 2 78, one UNT	3.0 Main stem; 0.42, one UNT	AG-Organic enrichment/low DO, nutrients, siltation
3-Umbles Run & 2 UNTs	07524	8.38	5.84		AG-Organic enrichment/low DO, nutrients, siltation *HQ-CWF*
3-Richardson Run & 3 UNTs	07525	4.42	9.03		AG-Organic enrichment/low DO, nutrients, siltation
3-Houston Run	07523	3.40	4.53		AG-Organic enrichment/low DO, nutrients, siltation
3-Eshleman Run	07513	10.9	1.24		AG-Organic enrichment/low DO, nutrients, siltation
4-Londonland Run	07515	6.47	0.84		AG-Organic enrichment/low DO, nutrients, siltation
3-Watson Run & one UNT	07511	2.74	3.26		AG-Organic enrichment/low DO, nutrients, siltation
3-Walnut Run	07499	2.69	3.18		AG-Organic enrichment/low DO, nutrients, siltation
3-Little Beaver Creek	07488	13.3	5.83 Main stem; 6.06, 4 UNTs	3.50 Main stem; 1.84, 2 UNTs	AG-Organic enrichment/low DO, nutrients, siltation
4-Calmus Run & 3 UNTs	07495	3.03	5.34		AG-Organic enrichment/low DO, nutrients, siltation
3-Big Beaver Creek	07471	21.4	2.81 Main stem; 1.96, one UNT	4.34 Main stem; 6.52, 4 UNTs	AG-Organic enrichment/low DO, nutrients, siltation
4-South Fork Big Beaver Creek & 4 UNTs	07477	6.90	8.51		AG-Organic enrichment/low DO, nutrients, siltation
3-Huber Run & 2 UNTs	07466	4.76		7.75	
3-Goods Run & one UNT	07464	4.54		5.68	
3-Silver Mine Run	07463	0.91		1.51	
3-Climbers Run	07455	6.01		1.61	
4-Trout Run & 2 UNTs	07457	3.89		5.88	*HQ-CWF*

Susquehanna River Drainage

Stream	Stream Code	Drainage area square miles	Miles Impaired	Miles Attained	Causes/Sources/ *Comments*
1-**Susquehanna River**	06685			16.91	*Unnamed tributaries are HQ-CWF*
2-Reed Run	07425	0.49			*HQ-WWF*
2-Tuquan Creek & 3 UNTs	07420	6.54		10.15	*HQ-CWF*
2-Kellys Run & one UNT	07414	2.13		3.59	
2-Muddy Run near Holtwood & one UNT	07400	9.38		4.60	
2-Wissler Run	07399	1.82			*HQ-WWF*
2-Fishing Creek & 13 UNTs	07253	14.2		28.48	*HQ-CWF*
2-Peters Creek & 3 UNTs	07238	10.4		9.15	*HQ-WWF*
4-Puddle Duck Creek & 2 UNTs	07239	4.25		6.33	
2-Haines Branch	07233	1.03			*HQ-WWF*
2-**Conowingo Creek**	07162	34.4	12.64 Main stem; 9.0, 6 UNTs	1.8 Main stem; 18.06, 13 UNTs	AG-Organic enrichment/low DO, nutrients, siltation *Class A brown trout, upper 5.5 miles; UNTs are HQ-CWF*
3-Jackson Run	07185	1.82		2.77	*HQ-CWF*
3-Little Conowingo Creek, 3 UNTs	07176	6.44	9.27		AG-Organic enrichment/low DO, nutrients, siltation *HQ-CWF*

Octoraro Creek Watershed

Stream	Stream Code	Drainage area square miles	Miles Impaired	Miles Attained	Causes/Sources/ *Comments*
2-**Octoraro Creek** & 9 UNTs	06947	176		21.2	*EV: UNT at RM 13.6 & "Black Run"*
3-**East Branch Octoraro Creek**	07070	90.6	16.29 Main stem	10.78, 10 UNTs	AG-Organic enrichment/low DO, nutrients, siltation
4-Buck Run & 3 UNTs	07144	18.1	7.44		AG-Organic enrichment/low DO, nutrients, siltation
5-Williams Run & one UNT	07143	4.89	4.46		AG-Organic enrichment/low DO, nutrients, siltation

5-Pine Creek & one UNT	07150	2.73	3.43		AG-Organic enrichment/low DO, nutrients, siltation
5-Valley Run	07141	10.6	2.98		AG-Organic enrichment/low DO, nutrients, siltation
4-Valley Creek	07131	10.6			
5-Glen Run	07139	1.01			
5-Officers Run	07133	5.83			
4-Knott Run	07127	1.81		2.58	*HQ-CWF*
4-Annan Run	07125	1.14		2.01	*HQ-CWF*
4-Knight Run UNT	07111	9.04		0.96	
4-Ball Run	07108	3.58		4.75	
4-Bells Run	07104	4.17	2.16		AG-Organic enrichment/low DO, nutrients, siltation
4-Muddy Run near Cream	07086	14.7			
5-Rattlesnake Run	07095	2.62			
4-Coopers Run & 3 UNTs	07081	6.33		10.57	
4-Leech Run	07071	5.22			
3-**West Branch Octoraro Creek**	07033	48.1	1.12 Main stem; 0.76, one UNT	10.36 Main stem; 15.5, 9 UNTs	AG-Organic enrichment/low DO, nutrients, siltation *HQ-CWF*
4-Nickel Mines Run & 3 UNTs	07066	4.63	7.00		AG-Organic enrichment/low DO, nutrients, siltation *HQ-CWF*
4-Meetinghouse Creek & one UNT	07064	5.26	6.38		AG-Organic enrichment/low DO, nutrients, siltation *HQ-CWF*
4-Bowery Run & 5 UNTs	07056	7.83		10.82	*HQ-CWF*
4-Stewart Run & 4 UNTs	07050	5.87		8.95	*HQ-CWF*
4-Kings Run	07045	1.25		2.60	*HQ-CWF*
4-Gables Run & 2 UNTs	07034	2.38		4.19	*HQ-CWF*
3-Tweed Creek & 2 UNTs	07026	6.12		5.64	
3-McCreary Run & 6 UNTs	07016	4.38		8.47	
3-Blackburn Run & 2 UNTs	07012	2.52		3.23	
3-Black Run	07004	4.31		1.78	
3-Hog Run	07003	1.15		3.23	
3-“Reynolds Run”					*HQ-CWF*
3-Stone Run	06979	1.01			

Chesapeake Bay Drainage

Stream	**Stream Code**	**Drainage area square miles**	**Miles Impaired**	**Miles Attained**	**Causes/Sources/ *Comments***
1-Cheasapeake Bay (MD)					
2-Northeast Creek	06840	7.99			
2-Elk River (MD)					
3-**Big Elk Creek**	06686	57.0			*HQ-TSF*
4-East Branch Big Elk Creek	06739	15.9			*HQ-TSF*
4-West Branch Big Elk Creek	06725	10.3		1.24	*HQ-TSF*
4-Hodgson Run	06709	6.08			*HQ-TSF*
3-Little Elk Creek	06687	13.4			*HQ-TSF*
4-Jordan Run	06697	2.92			*EV*
4-Barren Brook	06694	1.61			*EV*

Most of the subbasin except for the Chesapeake Bay drainage (Northeast Creek and Big Elk Creek watersheds) were assessed under the DEP unassessed waters project in 1999.

Total miles listed as impaired or attained include unnamed tributaries (UNTs) where indicated.

Streams are listed in order from upstream to downstream. A stream with the number 2 is a tributary to a number 1 stream, 3's are tributaries to 2's, etc. Susquehanna River=1.

AG= agriculture, DO= Dissolved Oxygen,

EV= Exceptional Value, HQ= High Quality, CWF= cold water fishes, TSF= trout stocked fishes, WWF= warm water fishes; RM= River Mile