Updated 9/2003

Watershed Restoration Action Strategy (WRAS)
State Water Plan Subbasin 07G
Chickies Creek and East Conewago Creek Watersheds
Susquehanna River Basin
Lancaster, Dauphin, and Lebanon Counties PA

Introduction

Subbasin 07G watershed comprises about one-forth of northwestern Lancaster County and small portions of lower Dauphin and western Lebanon Counties. Chickies Creek drains the largest portion of the watershed, 126 square miles. (East) Conewago Creek, which has a 52.5 square mile drainage area, forms the boundary between Lancaster and Dauphin Counties. The subbasin also includes the Susquehanna River and its east shore tributaries from Royalton to Washington Boro. The subbasin drains 253 square miles and includes 246 streams flowing for 411 miles. The subbasin is included in **HUC Area 2050306**, Lower Susquehanna River a Category I, FY99/2000 Priority watershed in the Unified Watershed Assessment.

Geology/Soils

The entire basin is in the Northern Piedmont Ecoregion. The upper third of the basin (Conewago Creek and Conoy Creek watersheds) is within the Triassic Lowlands section (64a), consisting of mostly red sandstone and gray shale. This section consists of low rolling terrain with broad valleys and isolated hills. The soils derived from these rocks are generally less fertile than those derived from Piedmont limestone rocks but are more fertile than those derived from Piedmont igneous and metamorphic rocks. The sandstone and shale rocks are poorly cemented and have good porosity and permeability. These soils generally have moderate to high infiltration rates and yield a good supply of groundwater.

The Trap Rock and Conglomerate Uplands section (64b), an area of diabase intrusions, forms the upper boundary along the base of Blue Mountain. Diabase is a fine-grained very impervious igneous rock that serves as a barrier to groundwater movement. The diabase intruded the Triassic sandstone as a series of linear sills and dikes. These intrusions heated the base rock and altered them into harder, denser, and less porous rock. Water yields for wells can be poor in this section except where fractures are encountered. Soils have slow infiltration rates. The many boulder fields limit agriculture and residential development and is largely forested.

The lower two-thirds of the basin, the area with the richest farmlands, is in the Limestone/ Dolomite Lowlands section (64d). Numerous faults pass through the region, especially in the lower end, near Columbia. Several limestone quarries are located within the subbasin.

The limestone soils and low gradient topography in the lower two-thirds of the basin provide excellent conditions for farming. The solubility of the limestone produces fertile soils and the numerous sinkholes allow surface water to enter the groundwater system without having to infiltrate 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 nitrates and pesticides. The upper third of the basin has slightly higher slopes and sandy to shaley soils.

Land Use

Land use in the basin is largely agriculture, with many high intensity chicken farms. The lower third of the basin is made up of limestone soils that are used for a variety of crops and grazing of livestock. The Chickies Creek watershed contains over 56,000 head of beef and dairy cattle.

The basin contains the boroughs of Elizabethtown, Marietta, Mount Joy, and Manheim, and many townships and scattered villages. Manheim Borough has an expanding commercial zone, with numerous car dealerships and a large auto auction. Industrial zones with food processing plants and feed mills, foundries, other light industry and quarries are located in or around the boroughs. The basin is also being developed with small-lot single family houses, especially adjacent to the boroughs. PA Route 283, a major divided highway corridor between Harrisburg to Lancaster, traverses the basin. The population was 94,000 in 1990 and is projected to increase to 129,000 by 2040.

Pennsylvania Chapter 93 Designated Exceptional Value (EV) and High Quality (HQ) Streams:
EV: None
HQ:

- Shearers Creek
- Donegal Springs (upper 1 mile of western headwater branch)

PA Fish and Boat Commission Class A trout waters (highest biomass category):

- ShearersCreek, headwaters down to powerline near county line, brown trout (1.7 miles)

Water Quality Impairment

The subbasin can be divided into two sections: Chickies Creek and the Susquehanna River tributaries, Conewago Creek, Conoy Creek, and Snitz Creek. More than of 1/3 of each subwatershed is impaired. Portions of the subbasin are affected by sedimentation and excess nutrients from agricultural runoff and urban areas. Conewago Creek also receives treated sewage treatment plant effluent.

Monitoring/Evaluation

The subbasin was assessed under DEP's Unassessed Waters Program in 1997 and 2000. A total of 152.4 miles or 44 percent of the subbasin is impaired and listed on the 303d list, mainly due to excess nutrients and sediment from agriculture, with municipal point source, habitat modification, and urban/ stormwater runoff as secondary sources. The entire limestone section of the subbasin is impaired. A total of 225.6 miles were identified as attaining water quality.

Sources of Impairment in Subbasin 07G		
Agriculture	132.56	87.0%
Other	34.33	22.5%
Urban Runoff/Storm Sewers	31.56	20.7%
Source Unknown (Fish Tissue Consumption Advisory)	18.88	12.4%
Habitat Modification	6.79	4.5%
Municipal Point Source	0.92	0.6%

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.

A 1996 USGS study documented elevated concentrations of nitrate and phosphate in all but the forested headwater part of the basin and elevated concentrations of Triazine herbicide at the mouth of Chickies Creek.

Future threats to water quality:
As development expands out from the suburbs around the boroughs and villages of the subbasin, agriculture may contribute less impairment and the stormwater runoff impairment potential will increase. The increased development and paving may further impede water infiltration and groundwater recharge, increase the need for public water supplies wells, which could decrease groundwater quantity and affect stream base flow.

Nonresidential development, which includes office, industrial, and commercial development, is booming in the subbasin. This type of development has a high potential for impact on surface and groundwater resources due to the massive site grading, removal of vegetation, and large areas of paving for parking lots. Local land use planning should encourage these developments to maintain open space, reduce unnecessary paving, improve land use standards, and better fit of the design to the landscape contours.

Urbanization and paving can have a severe effect on stream aquatic life. Studies by the Maryland Department of Natural Resources showed that a reduction in stream aquatic species diversity can begin with as little as 2% impervious cover. Maryland streams with above 15% impervious cover were rated fair to poor for aquatic species. When the impervious cover reached 25%, species diversity was significantly reduced. Riparian vegetation removal and paving affect both stream water temperature and habitat for aquatic species. Organisms most affected include many species of reptiles and amphibians, brook trout, and stoneflies. Stormwater runoff from paved areas can also wash out oil and grease and other pollutants into streams. The paved areas also restrict replenishment of groundwater and contribute to flash flooding during storm events and extreme fluctuations in stream water levels. Extreme flow fluctuations cause difficulties in the attachment of bottom dwelling organisms to the stream substrate and also cause a scouring of the substrate. Retention of riparian vegetation in unnamed headwater tributaries, known as first order streams, which may comprise as much as 50% of the streams in a watershed, can be especially critical to the protection of organisms in the downstream watershed.

Restoration/Protection Initiatives
Pennsylvania Growing Greener Grants:
- $2,000 (FY2003) to Mount Joy Borough Authority to form the Little Chiques Watershed Association.
- $5,000 (FY2002) to Lancaster County Conservation District for start-up of a new watershed association for the East Conewago Creek.
- $66,120 (FY2001) to the Chiques Creek Watershed Alliance for stream restoration and relocation at Mummau Park.
- $48,700 (FY2001) to Shawnee Run Greenway, Inc. for development of riparian buffers and a greenway along Shawnee Run.
- $8,400 (FY2000) to the Donegal Fish and Conservation Association to install 11 rock deflectors and weirs to improve 1000 feet of stream channel to address sediment and thermal pollution in a flow-through pond on Donegal Creek.
- $90,000 (FY2000) to Elizabethtown College to create 1.5 acres of wetlands, restore 500 feet of stream channel, plant 500 feet of riparian buffer, and establish 3 acres of native meadow grasses and

wildflowers. The site will be used by the college in their environmental education curriculum and as a demonstration of stormwater control systems.

- $48,000 (FY2000) to Rapho Township to assist in the formation of a new watershed association and to conduct a watershed assessment of Chickies Creek.
- $175,000 (FY1999) to Columbia Downtown Development Corporation for development and implementation of restoration on a 2.4-mile stream segment of Shawnee Run. The project will include preparation of a watershed master plan, wetland bioretention and enhancement, establishment of forested riparian buffer and native plant management and improvement.

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

- $75,500 (FY2004) to Tri-County Conewago Creek Association to assess and develop a restoration plan in the Conewago Creek Watershed.
- $300,000 (FY2002) to the Lancaster County Conservation District for installation of agricultural BMPs. Part of this grant money will be spent in the Chickies Creek watershed.
- $102,000 (FY1999) to Ducks Unlimited (DU) for installation of livestock fencing to exclude livestock from 15 miles of streambank, to establish 12 miles of streambank planting of native woody vegetation, and to install 30 livestock stream crossings in Chickies Creek watershed. DU and its partner in the project, the Chesapeake Bay Foundation, through their Chesapeake Bay Initiative are providing an additional $44,500 for the project. A new incentive will be initiated to allow landowners to earn cost-share credits by agreeing to fence streams with a wider than the minimum 12-foot buffer.
- $137,000 (FY1996) to Lancaster County Conservation District (LCCD) for fencing 7 miles of Donegal Creek. The project was completed in 1998. Donegal Chapter Trout Unlimited (TU) participated and provided additional funding for the project. The publicity generated by the this project and through the new and ongoing LCCD and other stream restoration efforts in the watershed should serve as incentives for additional farmers to sign on for water quality improvement programs. The project also involved the following agencies: Pennsylvania Fish and Boat Commission, Chesapeake Bay Foundation, Alliance for the Chesapeake Bay, Pennsylvania Association of Conservation Districts, Pennsylvania Department of Conservation and Natural Resources, and Donegal Fish and Conservation Association.

Pennsylvania Nutrient Management Act 6 Programs:

- Lancaster County CD (LCCD) has an agreement to implement Act 6 nutrient management activities in Lancaster County. A total of 112 plans were reviewed and approved by LCCD at the end of 1998. Another 150 farm operators have registered with LCCD to have Act 6 plans written for their farms. These projects require farmers to install BMPs to prevent animal manure from entering streams.
- LCCD is using Act 6 funds to educate farmers on benefits of nutrient management and effects of excess nitrogen and phosphorus. Act 6 has allowed LCCD to educate all farm operators, not just livestock operators, on the benefits of nutrient management.
- Commercial Act 6 plan writers have been educating farm operators on the need to protect streams and have incorporated BMPs into the nutrient management plans they have written.

Pennsylvania Watershed Restoration Assistance Program (WRAP):

- $9,687 (FY1998) to Lancaster County Conservation District for East Branch Donegal Creek. A one-acre wetland will be constructed in conjunction with a stormwater basin to reduce pollutant loading from urban runoff.

US Natural Resource Conservation Service (NRCS) Environmental Quality Incentive Program (EQIP) Grants:

- Chickies Creek watershed received a $1.5 million grant for agricultural best management practices (BMP) cost shares. The focus will be installing agricultural BMPs.

DEP Wellhead Protection Program:

- Participants include Mount Joy and Elizabethtown Boroughs and Mount Joy, Rapho, and East and West Donegal Townships.

League of Women Voters (WREN) Mini-grants:

- $2,950 to Mainheim Township School District to develop a watershed protection and restoration project as part of the sixth grade curriculum

Other:

- Lancaster County Conservation District (LCCD) is planning to lead the county in a watershed approach to deal with water quality issues in conjunction with the Governor's 21st Century Environment Commission Report of September 1998.
- The Lancaster County Conservation District receives $200,000 per year through the Chesapeake Bay program for water quality improvement activities in the county.
- The US Fish and Wildlife Service has participated in stream bank restoration and fencing efforts in the basin under their Partners for Fish and Wildlife Program.

Public Outreach Programs

The Lancaster County Conservation District (LCCD) has several projects in the works to help restore water quality in streams affected by farming and storm water runoff. LCCD has started a watershed awareness campaign to educate county citizens so that they can improve the water quality in their own watershed. Three public workshops were held as a part of this awareness campaign. LCCD also provided local groups with organizational, technical, and financial procurement assistance.

The Donegal Creek 319 project brought together a partnership of many public conservation and educational groups to restore Donegal Creek and to learn about stream restoration. The partnership included the Alliance for the Chesapeake Bay, Boy Scouts of America, CBF, Columbia Fish and Game, Donegal High School, Federation of Fly Fishers, and Lancaster County Youth Conservation School. The project provided numerous occasions for education of the public on stream restoration. The project was the subject of more than 10 newspaper articles, one TV show, and many tours for conservation organizations.

Citizen/Conservation Groups

- Two local groups, the Donegal Chapter of Trout Unlimited and the Donegal Fish and Conservation Association, are active in conservation issues and stream restoration activities including streambank fencing to exclude cattle from subbasin streams.
- The Chesapeake Bay Foundation (CBF) and the Alliance for the Chesapeake Bay (ACB) conduct education and awareness, water quality, and stream restoration activities in county streams.
- Columbia Downtown Development Corp. is a nonprofit organization interested in improving the quality of Shawnee Run and helping to develop a greenway from Lancaster City to Columbia Borough on an abandoned railway bed.

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.

Funding Needs:

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. After development of the initial WRAS a public participation process will take place to incorporate public input into expanding and "fine tuning" the WRAS for direction on use of 319 grant funds beyond FY2000.

The total needed dollars for addressing all nonpoint source problems in the watershed is undetermined at this time and will be so until all necessary TMDL's are developed for the watershed. However, existing programs that address nonpoint source issues in the watershed will continue to move forward. The final TMDL was completed for Donegal Creek in fall 1999. Draft TMDL's for Chickies Creek and Conewago Creek watersheds were completed by Penn State University. Copies of these TMDL's have been posted on the DEP website.

Restoration Needs
The following subbasin stream sections are impaired by agricultural practices and in the greatest need of agricultural BMPs such as cattle exclusion, cropland terraces, contour farming, grass waterways, and manure management. Streambank stabilization and restoration of riparian buffers are also needed in these watersheds.

- Conewago Creek watershed: lower 15.76 miles main stem, 18.37 miles unnamed tributaries
  - Hoffer Creek main stem and 2 unnamed tributaries
  - Lynch Run entire watershed
- Conoy Creek: lower 7.16 miles main stem, 6.9 miles of 8 unnamed tributaries (also urban runoff/storm sewers in Elizabethtown Borough area)
- Chickies Creek: lower 21.99 miles main stem, 8.66 miles of 3 unnamed tributaries
  - Rife Run main stem and 4 unnamed tributaries
  - Little Chickies Creek 11.4 miles main stem (vicinity of Mt. Joy and downstream)
  - Donegal Creek, 6.82 miles main stem, one unnamed tributary
- Strickler Run all except one unnamed tributary (also urban runoff problems vicinity of Columbia Borough)
- Stamans Run entire watershed

A watershed assessment conducted under the Chesapeake Bay program in 1987 for the Chickies Creek watershed estimated a cost of $3.25 million for BMPs for nutrient management on 39 farms and erosion controls on 11,500 acres. The Lancaster County Conservation District is continuing their efforts to install agricultural BMPs and to provide public education and awareness through programs funded through EQIP, Nutrient Management Act 6, and Chesapeake Bay. The US Fish and Wildlife Service, Ducks Unlimited, Trout Unlimited, Chesapeake Bay Foundation, and Alliance for the Chesapeake Bay are continuing their public awareness, streambank reforestation and fencing, and habitat improvement efforts in Chickies Creek basin. Implementation of BMPs for agricultural sources in impaired areas should reduce nutrient and sediment loading.

The Columbia Downtown Development Corp. received a DCNR Rivers Conservation Grant and a Growing Greener grant to study Shawnee Run which flows through Columbia Borough. The DCNR grant is being used to develop a 2.4-mile greenway along an abandoned railway, part of the Columbia-

Ready Greenway project. They are also developing a watershed restoration plan that will assess the health of Shawnee Run and recommend best management practices to improve water quality.

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 Chickies Creek:
TMDL's were developed for the Chickies Creek watershed to address the impairments noted on Pennsylvania's 1996 and 1998 Clean Water Act Section 303(d) Lists. The determination that Chickies Creek was not meeting its designated water quality uses for protection of aquatic life was first based on a 1994 aquatic biological survey, which included kick screen analysis of stream bottom dwelling macroinvertebrates and habitat surveys. In 1997, the Department again surveyed the stream and found the stream to be impaired. As a consequence of the surveys, Pennsylvania listed Chickies Creek on the 1996 and 1998 Section 303d Lists of Impaired Waters. The 1996 303d List reported 10 miles of the main stem to be impaired by by nutrients and siltation from agriculture. The 1998 list increased the mileage of impairment of the main stem and added new segments for a total impaired mileage of 39.9.

One segment was also listed as impaired by urban runoff/storm sewers but the cause of the impairment was listed as unknown. A field verification noted the presence of an industrial site and railroad tract in the subwatershed corresponding to this stream segment. Despite stagnant water due to gentle slopes and algae in the steam near this site, no apparent upland runoff and sediment production originate from the industrial site. In addition, this part of the stream was protected by stream buffers; therefore, no TMDL was conducted for the stream segment with "unknown" causes of impairments from urban runoff/storm sewers.

The protected uses of the Chickies Creek watershed are water supply, recreation and aquatic life. The designated aquatic life use for the main stem of Chickies Creek, the tributaries Boyers Run, Rife Run, and Dellinger Run, and several unnamed tributaries is warm water fishes. The designated use for the tributary Shearers Creek is cold water fishes. The latter is also specially protected due to the high quality of its waters.

The primary land use in the Chickies Creek watershed is agriculture (73%), with areas adjacent to the stream used for cropland and pasture. A field survey of the watershed indicated that cattle generally have free access and the majority of the streams have no protected riparian zones. The 1997 survey showed that nutrients from agricultural activities were causing increased algae growths. Sediment deposited in large quantities on the streambed degraded the habitat for bottom-dwelling macroinvertebrates.

In stream systems, elevated nutrient loads (nitrogen and phosphorus) can lead to increased productivity of plants and other organisms. Aquatic plants use oxygen at night and animals in the stream use oxygen during the day. Excessive nutrient input can lead to elevated levels of productivity, which can subsequently lead to depressed dissolved oxygen levels when an abundance of aquatic life is drawing on a limited oxygen supply. Additional problems arise when these organisms die because the microbes that decompose this organic matter also consume large amounts of oxygen. A second effect of nitrogen (specifically ammonia) occurs when bacteria convert ammonia-nitrogen to nitrate-nitrogen. This process, called nitrification, also results in lower dissolved oxygen levels in streams.

Pennsylvania presently does not have water quality criteria for nutrients and sediments; therefore, a reference watershed approach was developed to identify the TMDL endpoints or water quality objectives for nutrients and sediments in the impaired segments of Chickies Creek watershed. In stream systems,

elevated nutrient loads (nitrogen and phosphorus in particular) can lead to increased productivity of plants and other organisms. In most fresh water bodies, phosphorus is the limiting nutrient for aquatic growth. Determination of which nutrient is the most limiting is often difficult; therefore, the ratio of the amount of N to the amount of P is often used to make this determination. 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. The nutrient loading for this watershed only addresses phosphorus because phosphorus was determined to be the limiting nutrient since the N/P ratio in Chickies Creek is 17 to 1.

The Pennsylvania approach to TMDL development involves comparing nutrient and sediment loads of the impacted watershed to those of a reference watershed. Based on the predominance of agricultural land use, nutrients and sediments are the most likely pollutants causing Chickies Creek to violate the aquatic life use; therefore, the TMDL's propose reducing the phosphorus and sediment loadings in Chickies Creek watershed to levels consistent with Conococheague watershed, the reference watershed. Because of the similarities in size, land use, and geology existing between the two watersheds, achieving nutrient and sediment loadings in the Chickies Creek TMDL will ensure that the aquatic life use is achieved and maintained as evidenced in the Conococheague watershed.

Three factors were considered in selecting a suitable reference watershed. The first factor is to use a watershed that has been assessed by the Department using the Unassessed Waters Protocol and has been determined to attain water quality standards. The second is to find a watershed that closely resembles Chickies Creek watershed in physical properties such as land cover/land use, ecoregion, and geology. Finally, the size of the reference watershed should be within 20-30% of the impaired watershed area. A watershed that would satisfy all the characteristics mentioned above could not be found in the same ecoregion as Chickies Creek because not all stream segments in the Northern Piedmont Ecoregion where Chickies Creek watershed is located have been assessed and all watersheds that have similar levels of agricultural land use and geologic rock type distributions as Chickies Creek watershed were also determined to be impaired.

The watershed used as a reference for the Chickies Creek Watershed was a subwatershed of the Conococheague Creek watershed. This watershed is located in the Ridge and Valley Ecoregion in State Water Plan (SWP) Basin 13C. Most of Conococheague Creek stream segments have been assessed and were found to be unimpaired. This section of the Conococheague Creek has an area of 62.6 square miles or 93% of the Chickies Creek watershed area, which is within the size range for a reference stream. The two watersheds are similar in land use, geology, and soil K factor.

Chickies Creek has less topographic relief, a shallower streambed, more continuous corn crops and less hay/pasture, more animals (particularly dairy and poultry operations), and less evidence of conservation practices. Conococheague Creek has more topographic relief, a deeper streambed, more hay/pasture and cover crops, more crop residue left, more use of strip cropping and forest buffers along streams, more evidence of conservation practices, and fewer animals.

The TMDL was developed using the Generalized Watershed Loading Function (GWLF) model which provides the ability to simulate runoff, sediment, and nutrient (N and P) loadings from a watershed with variable size source loads, e.g., agricultural, forested, and developed land. Septic loads may also be calculated and point sources may be included where applicable. Adjustments were made to the model to compensate for the differences between the impaired and reference watershed. Load allocations were made for the sources of P and sediment from hay/pasture, row crops, coniferous, mixed forest, deciduous, low and high intensity development, quarries, groundwater, and septic systems.

TMDL Total Load Computation			
Type of Pollutant	Unit Area Loading Rate in Conococheague Creek (lbs/acre/yr)	Total Watershed Area in Chickies Creek (acres)	TMDL Total Load (lbs/yr)
Phosphorus	0.98	40,772	39,956
Sediment	200.98	40,772	8,194,278

Additional information and loadings calculated for individual land use categories can be found in the Draft TMDL on the Department's website at http://www.dep.state.pa.us/, choose directLINK, TMDL, Chickies Creek.

The pollutant reductions in the TMDL's are allocated entirely to agricultural 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 to assess the extent of BMPs installed and to determine the most cost-effective and environmentally protective combination of BMPs required to meet the nutrient and sediment reductions outlined in the TMDL report.

Restoration activities have begun in the Chickies Creek watershed through a grant from the Clean Water Act 319 program to Ducks Unlimited and through the Cheasapeake Bay Foundation. A NRCS EQIP grant was also awarded in the watershed. These grants have funded installation of fencing to exclude livestock, plantings of native woody vegetation in riparian areas, installation of livestock stream crossings, and other BMPs. Formation of a watershed association for the Chickies Creek watershed could help direct restoration needs, determine where new BMPS should be installed and evaluate the effects of installed BMPs through citizen monitoring. Rapho Township received a Growing Greener grant in December 2000 for the formation of such a group and to assess the watershed.

TMDL for Donegal Creek:
The primary land use in Donegal Creek is agriculture with areas adjacent to the stream in row crops and pasture. Cattle generally have free access to the stream. In 1994, the stream had no protected riparian buffers. The 303d list states that Donegal Creek impairment is organic enrichment/low dissolved oxygen (DO); however, DO was not measured directly. Extensive algal blooms were noted and assumed to contribute to the low DO.

In June 1992, the Pennsylvania Fish and Boat Commission published the results of a study of the East Branch of the Donegal Creek, which showed the stream to be moderately degraded and nutrient enriched. In 1994, the Department conducted an aquatic biological survey on Donegal Creek to collect background information on the benthic macroinvertebrate community and to determine the water quality of the stream. Results clearly identified that Donegal Creek was degraded due to extensive agricultural activities in the watershed, primarily from lack of riparian vegetation in pastures where cattle have complete access to the stream, causing severe streambank erosion. The biologists concluded that water quality would remain poor until buffer zones are established to protect the streams

Excess nutrients and sediment loads from agricultural sources cause impairment to Donegal Creek watershed. No point sources are known in the impaired portion of the watershed. The nutrient portion of

the TMDL focuses on control of phosphorus, which is generally held to be the limiting nutrient in a water body when the nitrogen/phosphorus (N/P) ratio exceeds 10:1. The Donegal Creek N/P ratio is 37:1.

Since Pennsylvania does not have water quality criteria for phosphorus, a reference watershed approach as described above for the Chickies Creek watershed was developed to identify the TMDL endpoints or water quality objectives in the impaired segments. Brubaker Run was chosen as the reference watershed.

The selection process for establishing a reference watershed indicated a good fit between Donegal Creek and Brubaker Run in physical properties such as land use/cover, ecoregion, and size. The bedrock geology of the two watersheds is different, however. Donegal Creek is limestone based and Brubaker Run consists of metamorphic rocks, sandstone and shale. Geology influences soil type, soil permeability, and number and extent of fractures. Additional comparisons showed the factors contributing to the Donegal Creek impairment were less topographic relief, more continuous corn crops, more animals (particularly poultry operations), geology more conducive to N leaching, and less evidence of conservation practices. Brubaker Run exhibited more topographic relief, more corn-hay rotations, more crop residue left in place, more use of strip cropping and stream buffers, half the density of animals as in Donegal Creek watershed, and shale and metamorphic rocks which are less conducive to N leaching.

The TMDL was developed using the Generalized Watershed Loading Function (GWLF) model which provides the ability to simulate runoff, sediment, and nutrient (N and P) loadings from a watershed with variable size source loads, e.g., agricultural, forested, and developed land. Septic loads may also be calculated and point sources may be included where applicable. Adjustments were made to the model to compensate for the watershed differences. Load allocations were made for sources of P and sediment from hay/pasture, row crops, probably row crops, coniferous, mixed forest, deciduous, low intensity development, high intensity development, quarries, groundwater, and septic systems.

The TMDL's are allocated to the agricultural non-point sources (Load Allocations-LAs) with 10% of the allowable loading reserved as a margin of safety (MOS). There are no wasteload allocations (WLA) for point sources because there are no known point source discharges in the impaired areas of the watershed. The TMDL's cover a total of 9.67 miles of the main stem Donegal Creek and an unnamed tributary.

The current P load for Donegal Creek was calculated at 5,924 pounds per year. The amount of P loading that will meet water quality objectives in Donegal Creek was estimated at 3,287 pounds per year. Reducing the phosphorus (P) load will limit plant growth and raise the dissolved oxygen level. The current sediment load was calculated to be 1.8 million pounds per year. The amount of sediment loading needed to meet water quality objectives was estimated at 792,998 pounds per year. The TMDL established a phosphorus load reduction of 50% from the current yearly loading and a reduction in sediment loading of 61% from the current yearly loading of 1,813,165 pounds for 9.67 miles of the main stem and an unnamed tributary. When these values are met, Donegal Creek should support its aquatic life uses of trout stocked fishes, recreation and aquatic life.

TMDL for Donegal Creek				
Pollutant	**TMDL (lb/yr)**	**LA (lb/yr)**	**WLA (lb/yr)**	**MOS (lb/yr)**
Phosphorus	3,287	2,958	0	329
Sediment	792,998	713,698	0	79,300

TMDL Computations for Brubaker Run and Donegal Creek			
Pollutant	Unit Area Loading Rate in Brubaker Run (lbs/acre/year)	Total Watershed Area in Donegal Creek (acres)	TMDL Value (lbs/year)

Phosphorus	0.30	10956	3,287
Sediment	72.38	10956	792,998

Additional information and loadings calculated for individual land use categories can be found in the Draft TMDL on the Department's website at http://www.dep.state.pa.us/, choose directLINK, TMDL, Donegal Creek.

Implementation of BMPs for agricultural sources in the affected areas should achieve the loading reduction goals since agriculture is the source of the impairment. Streambank stabilization and fencing will be used to reduce phosphorus and sediment loads in the affected areas. Stabilizing the streambank will reduce instream erosion. Fencing will keep livestock out of the stream and provide a riparian zone along the stream to trap sediment and phosphorus, keeping these pollutants from reaching the stream. A reduction coefficient of 75% for nutrients and sediment is reasonable to expect with these particular 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 as used by the Susquehanna River Basin Commission in their efforts to model pollutant reductions that may result from various BMP reduction strategies.

An extensive watershed restoration effort is currently underway in the watershed. In April 1995, the Lancaster County Conservation District and the Donegal Fish and Conservation Association entered into an MOU to promote and implement the Donegal Creek Restoration Project. The primary remediation activities were streambank stabilization and fencing. The conservation district agreed to administer grant funds, oversee and design cattle crossings, oversee installation of rip-rap and fish enhancement structures, and provide technical assistance to landowners for the design and installation of best management practices. The Donegal Fish and Conservation Association worked with cooperating landowners and helped install and maintain BMPs. Improvements have already been seen in streamside habitat and aquatic biologic community following the implementation of these agricultural best management practices.

The Donegal Creek Restoration project included the following activities to reduce sediment and phosphorus loadings to the stream and restore designated uses:

	Best Management Practices	**Pollutant Reduction**
1.	4.9 miles of streambank fencing	75%
2.	6.67 miles of stream stabilization measures; bioengineering methods/rip-rap	75%
3.	21 stone-ford cattle crossings with fencing	
4.	200 fish enhancement structures	

The Donegal Fish and Conservation Association is conducting water quality and habitat monitoring at eight different stations in the watershed. Monitoring began prior to the installation of BMPs and includes biota, water chemistry and bank stability. Although stream quality has shown steady improvement, Donegal Creek has not yet fully recovered from the impairments. The 1998 list designated more impaired stream miles than the 1996 303(d) list, reflecting a more accurate means of reporting water quality status. The Department has completed stream GIS coverage at the 1:24,000 scale. In addition, the use of dynamic segmentation to accurately delineate the impaired segments has resulted in adding minor streams that had not been previously reported.

DEP will make the final determination regarding stream recovery. Recent surveys conducted by DEP biologists have documented an approximate 90% reduction of silt in some areas after BMP installations.

Riparian zones have stabilized and stream channels have narrowed. Several locations in the watershed were described as being capable of supporting a reproducing trout population. Follow-up surveys will continue to be conducted to document stream conditions. A publication entitled "Fixing a Broken Trout Stream, the Donegal Creek Restoration Project" has been published and is available from the Lancaster County Conservation District.

Draft TMDL for East Conewago Creek:
Total Maximum Daily Loads or TMDL's were developed for the Conewago Creek watershed to address the impairments noted on Pennsylvania's 1996 and 1998 Clean Water Act Section 303(d) Lists. The protected uses of the watershed are water supply, recreation and aquatic life. The designated aquatic life use for Conewago Creek is trout stocking fishes. The primary land use in the Conewago Creek watershed is agriculture (53%), with areas adjacent to the stream used for cropland and pasture. A field survey revealed that cattle have free access to some of the impaired stream segments in the watershed and that some stream segments had no protected riparian zones.

The first determination that Conewago Creek was not meeting its designated water quality uses for protection of aquatic life was based on a 1994 aquatic biological survey, which included kick screen analysis of benthic macroinvertebrates and habitat evaluations. A 1997 survey found that the stream was impaired. Pennsylvania then listed Conewago Creek on the 1996 and 1998 Section 303(d) Lists of Impaired Waters. The 1996 303 (d) List reported that 10 miles of Conewago Creek were impaired by agricultural nutrients. The 1998 list has 15.8 miles of the main stem, 3.6 miles of an unnamed tributary, and tributaries 11.2 miles of Lynch Run, and 5.7 miles of Hoffer Creek as impaired. These segments are impaired by nutrients and/or siltation due to agriculture and/or habitat alterations.

Because neither Pennsylvania nor EPA has water quality criteria for phosphorus or sediments, the Reference Watershed Approach as described above for the Chickies Creek TMDL was employed for the Conewago Creek TMDL's.

A watershed that would satisfy all the characteristics mentioned above could not be found in the same ecoregion as Conewago Creek because not all stream segments in the Northern Piedmont Ecoregion where Conewago Creek watershed is located have been assessed and all watersheds that have similar levels of agricultural land use and geologic rock type distributions as Conewago Creek watershed are also impaired. For this reason, a watershed in the Ridge and Valley Ecoregion, Lehman-Muddy Run in Franklin County, part of the Conodoguinet Creek watershed in State Water Plan Subbasin 07B was selected as the reference watershed. Most of stream segments in this watershed have been assessed and were not found to be impaired.

The watershed selected for reference is 24.6 square miles, whereas the Conewago Creek watershed is 53.1 square miles. Since a reference watershed should be within 20 to 30% of the impaired watershed, Conewago Creek watershed was subdivided into two parts, Subwatershed A (upper half) and Subwatershed B (lower half), for model simulations of nutrients and sediments. The areas of these subwatersheds are 28.7 and 24.4 square miles respectively.

Conewago Creek subwatersheds and the Lehman-Muddy Run watersheds are similar in topographic relief, surface geology, and conservation practices (strip cropping, amount of residues left on the field, etc.). The only difference is that cattle have free access to the stream and have trampled the streambanks in some areas of Conewago Creek Subwatershed A.

The TMDL was developed using the Generalized Watershed Loading Function (GWLF) model which provides the ability to simulate runoff, sediment, and nutrient (N and P) loadings from a watershed with variable size source loads, e.g., agricultural, forested, and developed land. Septic loads may also be

calculated and point sources may be included where applicable. Adjustments were made to the model to compensate for the watershed differences. Load allocations were made for sources of P and sediment such as hay/pasture, row crops, probably row crops, coniferous, mixed forest, deciduous, low intensity development, high intensity development, quarries, groundwater, and septic systems.

Conewago Creek was listed as being impaired due to problems associated with nutrient loads and siltation. In stream systems, elevated nutrient loads (nitrogen and phosphorus in particular) can lead to increased productivity of plants and other organisms. In most fresh water bodies, phosphorus is the limiting nutrient for aquatic growth if the N/P ratio is greater than 10. The N/P ratio is approximately 21 in Conewago Creek, indicating that phosphorus is the limiting nutrient. Controlling the phosphorus loading to Conewago Creek will limit plant growth and raise the dissolved oxygen level.

TMDL Total Load Computation			
Pollutant	Unit Area Loading Rate in Lehman-Muddy Run Creek (lbs/acre/yr)	Total Watershed Area in Subbasin A (acres)	TMDL Total Load (lbs/yr)
Subwatershed A			
Phosphorus	0.25	18,087.42	4,521.86
Sediment	172.69	18,087.42	3,123,516.56
Subwatershed B			
Phosphorus	0.25	15,320.64	3,830.16
Sediment	172.69	15,320.64	2,645,721.32

Summary TMDL's for Conewago Creek Subwatersheds (lbs/yr)						
Pollutant	**TMDL**	**MOS**	**WLA**	**LA**	**LNR**	**ALA**
Subwatershed A						
Phosphorus	4,521.86	452.19	0	4,069.67	1,406.17	2,663.50
Sediments	3,123,516.56	312,352.66	N/A	2,811,164.90	299,476.96	2,511,687.94
Subwatershed B						
Phosphorus	3,830.16	383.02	0	3,447.14	1451.60	1,995.54
Sediments	2,645,721.32	264,512.13	N/A	2,381,149.19	111,918.75	2,269,230.44

Additional information and loadings calculated for individual land use categories can be found in the Draft TMDL on the Department's website at http://www.dep.state.pa.us/, choose directLINK, TMDL, Conewago Creek.

The pollutant reductions in the TMDL's are allocated entirely to agricultural 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 to assess the

extent of BMPs installed and to determine the most cost-effective and environmentally protective combination of BMPs required to meet the nutrient and sediment reductions outlined in the TMDL report.

Few restoration activities have been implemented in the Conewago Creek watershed. Formation of a watershed association for the Conewago Creek watershed could help direct restoration needs and determine where BMPS should be installed.

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: Watershed Notebooks, Unified Assessment Document, and information from 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
- Lancaster County Conservation District Newsletter
- Final Total Maximum Daily Load for Donegal Creek Watershed. DEP 1999. Draft Total Maximum Daily Loads for Chickies Creek and Conewago Creek Watersheds. DEP 2000.

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

Stream	**Stream Code**	**Drainage area square miles**	**Miles Impaired**	**Miles attained**	**Sources/Causes/ *Comments***
1-**Susquehanna River**	06685				
2-Susquehanna River unnamed tributaries			3.34, 2 UNTs	4.26	AG siltation, nutrients, urban runoff/ storm sewers, habitat modification, unknown
2-**(East) Conewago Creek**	09217	52.5	15.76 main stem; 18.37, 4 UNTs	7.61 main stem; 42.96, 44 UNTs 0.92 UNT	AG nutrients, siltation, Municipal point source, organic enrichment/low DO, suspended solids; Habitat modification Municipal point source
3-Little Conewago Creek & 8 UNTs	09286	5.91		12.29	
3-Hoffer Creek	09267	5.92	4.68 main stem; 0.82, 2 UNTs	5.95, 6 UNTs	AG siltation, nutrients, habitat alteration
3-Brills Run & 8 UNTs	09249	3.69		8.04	
3-Lynch Run & 10 UNTs	09232	4.25	11.24		AG turbidity, siltation; unknown causes
2-Snitz Creek & 4 UNTs	09202	3.75		7.85	
2-Conoy Creek	08278	19.1	7.16 main stem; 6.9, 8 UNTs	4.34 main stem; 10.73, 6 UNTs	Habitat modification, urban runoff/storm sewers, AG siltation, other habitat alterations
2-**Chickies Creek**	07919	126	21.99 main stem; 8.66, 3 UNTs	8.5 main stem; 21.39, 17 UNTs	AG nutrients, sediment; urban runoff/ storm sewers
3-Shearers Creek & 2 UNTs	08012	6.5		10.32	*EV, Class A brown trout*
3-Boyers Run	08010	1.82		2.35	
3-Rife Run	07990	6.52	3.67 main stem; 5.74, 4 UNTs	2.02, 3 UNTs	AG siltation
3-Dellinger Run & 3 UNTs	07985	2.82		4.48	
3-**Little Chickies Creek**	07941	44.5	11.14 main stem	9.62 main stem; 29.41, 25 UNTs	AG nutrients, siltation

4-Brubaker Run & 5 UNTs	07955	8.41		11.36	
4-Back Run & 2 UNTs	07944	5.25		7.39	
3-Donegal Creek	07920	17.2	6.82 main stem; 2.53, one UNT	0.98 main stem; 16.64, 13 UNTs	AG organic enrichment/low DO, nutrients, siltation
4-"Donegal Springs"	07933				*HQ-CWF*
2-Shawnee Run & one UNT	07879	2.25		5.15	
2-Strickler Run	07875	6.16	5.02 main stem; 3.45, 2 UNTs	0.89, one UNT	Urban runoff/ storm sewers, AG siltation
2-Shumans Run	07871	0.4		1.67	
2-Stamans Run & one UNT	07868	2.45	4.80		AG siltation, nutrients

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.

UNT= Unnamed tributary, AG= agriculture, DO= dissolved oxygen

Chapter 93 information: EV= Exceptional Value; HQ= High Quality; CWF= coldwater fishes