EXECUTIVE SUMMARY

Study Background and Purpose

The Quittapahilla Creek Watershed is situated in the Ridge and Valley physiographic region in Lebanon County, Pennsylvania. Quittapahilla Creek is a tributary to Swatara Creek and is part of the Susquehanna River Basin. Its headwaters begin just southeast of Lebanon, Pennsylvania and it enters the Swatara Creek near North Annville, Pennsylvania.

The major land use in the watershed is agricultural. There are significant areas of urbanization along the Route 422 corridor in the City of Lebanon, West Lebanon, Cleona, and Annville. In addition, new development in the watershed is replacing farms with suburban communities. Past and current land use and land management practices in the rural areas, suburban communities, and urban centers have resulted in degraded water quality, stream bank and bed erosion, sedimentation, flooding, and the loss of riparian and in-stream habitat throughout the Quittapahilla Creek Watershed.

Studies conducted in the 1980's and 1990's by the Pennsylvania Department of Environmental Protection (DEP) clearly indicated impairment of aquatic resources in the Quittapahilla Creek Watershed. In fact, the mainstem as well as all of the major tributaries to the Quittapahilla Creek were listed as impaired in the 303(d) listings. The 2000 305(b) Report prepared by DEP indicated that there are 88.9 miles of stream in the Quittapahilla Creek Watershed. Only 1.82 miles of stream (2%) were found to support designated aquatic life uses. The identified land use activities contributing to impairment include agriculture, crop related agriculture, urban/storm sewers, and bank modification. Sources of impairment include nutrients, siltation, suspended solids, organic enrichment/low dissolved oxygen concentrations, flow alteration, and other habitat alterations.

The Total Maximum Daily Loads (TMDLs) Report (PADEP, 2000) cited excessive sediment and nutrient levels as a major water quality problem in the Quittapahilla Creek Watershed. The report indicated that these pollutants are causing increased algae growth, large accumulations of fine sediments on the streambed, and degradation of in-stream habitat. Although the report attributed the excessive sediment and nutrient levels principally to agricultural activities, these pollutants are also associated with other upland sources (e.g., urban runoff) as well as in-stream sources (e.g., stream bed and bank erosion).

The Quittapahilla Creek Watershed Association has been working with a number of private organizations and public agencies to improve the water quality and aquatic habitat of Quittapahilla Creek. However, there has been no comprehensive assessment, nor coordinated effort to identify and prioritize water quality, habitat and stream channel stability problems throughout the watershed. As a consequence, targeting of stream reaches for improvements has been on a project-by-project basis. There is no Master Plan for the Quittapahilla Creek Watershed that serves to focus funding and restoration and management efforts where they are most needed.

The Quittapahilla Creek Watershed Association believes that their best chance for resolving the existing problems and avoiding future problems is to step back from the current project-based approach and develop a comprehensive plan of action based on an assessment of the entire watershed. They believe that this approach will serve to focus funding and restoration and management efforts where they are most needed. They also believe that it is the approach that has the greatest chance for long-term success.

The objectives of this project were:

1. Establish benchmarks for evaluating and documenting changes in the watershed by assessing current hydrologic, water quality, in-stream habitat, and channel stability conditions.
2. Identify and prioritize restoration and management strategies to address existing hydrologic, water quality, in-stream habitat, and channel stability problems.
3. Determine the potential for future hydrologic, water quality, in-stream habitat, and channel stability problems.
4. Develop recommendations for management and protection strategies that will prevent and/or minimize future problems.

An interdisciplinary team that included Clear Creeks Consulting LLC; Skelly & Loy, Inc.; U.S. Fish & Wildlife Service, Chesapeake Bay Field Office; Penn State Institutes of the Environment, Pennsylvania State University; Department of Biology, Lebanon Valley College; and U.S. Geological Survey, New Cumberland Field Office conducted the watershed assessment and developed the restoration and management plan for the Quittapahilla Creek Watershed Association. The Quittapahilla Creek Watershed Project was supported by Growing Greener Grants received from Pennsylvania DEP in 2001 and 2003.

The major components of this study included watershed characterization, morphologic stream assessment, subwatershed analysis, ecological assessment, water quality modeling, water quality monitoring, problem identification and prioritization, and restoration and management recommendations. Each of the assessment study components is presented in a section of Volume 1 – Findings Report. Problem identification and prioritization and restoration and management recommendations are presented in Volume 2 – Restoration and Management Plan.

Volume 1 – Watershed Assessment Findings Report

The Assessment Phase of this project was focused on: evaluating the natural watershed characteristics such as soils, geology, land use, hydrology, as well as an assessment of current stream channel morphology and stability, in-stream habitat, biological communities, and water quality conditions of Quittapahilla Creek and its tributaries.

Section 2 – Watershed Characterization summarizes the regional weather patterns, natural watershed characteristics, and historic and current land use practices of Quittapahilla Creek and its tributaries.

Section 3 – Morphologic Stream Assessment summarizes the results of the morphologic stream assessment that was conducted along the mainstem Quittapahilla Creek.

Section 4 - Subwatershed Analyses summarizes the results of a field reconnaissance that was conducted to assess and document existing conditions in each of the major subwatersheds from their headwaters to confluence with Quittapahilla Creek.

Section 5 – Ecological Assessment summarizes the results of a comprehensive assessment that was conducted of the existing habitat conditions and the biological communities in the Quittapahilla Creek watershed.

Section 6 – Water Quality Assessment summarizes the results of the water quality modeling analyses and water quality monitoring program developed to evaluate existing water quality conditions along Quittapahilla Creek and its tributaries.

Volume 2 – Restoration and Management Plan

Section 2 – Methods for Identifying and Prioritizing Restoration and Management Strategies outlines the comprehensive analysis that was conducted to identify and prioritize potential best management practices and restoration projects in the subwatersheds and along the main stem of Quittapahilla Creek.

Section 3 – Potential Best Management Practices summarizes a comprehensive evaluation and prioritization of general as well as site specific Best Management Practices (BMPs) for controlling agricultural and urban runoff in the subwatersheds and along the main stem of Quittapahilla Creek.

Section 4 – Potential Restoration Measures summarizes a comprehensive evaluation of general as well as site specific restoration measures to correct stream stability and habitat problems along the main stem Quittapahilla Creek and its tributaries.

Section 5 – Long-Term Management Strategies summarizes current policies and programs and outlines recommendations for policies and programs focused on stream, wetland and floodplain protection and management.

Summary of Findings

Morphologic Stream Assessment

The condition of Quittapahilla Creek is generally characterized by lateral erosion, high sediment supply, and vertical instability (i.e., aggradation) with lateral and mid-channel bars, riffles embedded with fine sediments, and debris jams along many reaches.

From the construction of the first mill dam in the early 1730's to the construction of the Hazel Dike in the early 1900's and the extension of the flood protection works following Hurricane Agnes in 1972, the creek has undergone significant alterations. These channel modifications in addition to the changes that occurred in land use as the watershed went from forest to agriculture, and more recently urbanization, have all contributed the current sedimentation and stability problems.

Notwithstanding the significant amount of impervious area in its headwaters and the concrete flumes rapidly conveying storm flows to the natural sections of the channel, the creek is holding its own. Several factors have contributed to the Quittapahilla's overall ability to withstand land use and channel alterations. The cohesive nature of the silt clay banks along most reaches of the creek provides resistance to the erosive forces of storm flows. As a consequence, annual erosion rates along most of the creek are measured in tenths of feet per year as opposed streams with banks composed of sands and gravels where erosion rates are often measured in feet per storm event.

The nature of the creek bed has prevented it from incising as many creeks do in response to a changing hydrologic regime associated with urbanization. Although not always evident, the creek bed along most of its length rests on bedrock. Along many reaches a layer of gravel, sand and silt covers the bedrock. Where these finer materials have been removed by storm flows the bedrock is exposed as ledges, drops and chutes. A number of the upper reaches have sections of composed of boulder and cobble riffles. Bank heights are limited by the depth the stream can down cut before encountering bedrock or some other grade control mechanism. Although the silt, sand and gravel layer is thickest in the downstream reaches, the relatively shallow depth to bedrock over much of the upper creek and along key sections throughout has kept bank heights relatively low. This has contributed to overall lower bank erosion rates.

Although riparian buffers are lacking along many reaches, the significant length of the mainstem that has a woody riparian buffer is remarkable for a creek with the type of land use activities present along the Quittapahilla Creek corridor. The presence of mature trees and shrubs along significant lengths of the creek also contributes to overall lower bank erosion rates.

Subwatershed Analyses

Although conditions vary among the subwatersheds, the effects of land use activities on channel stability, water quality and habitat are evident in all of the subwatersheds. Field observations indicate that agriculture, mining, timber harvesting, development, channel alterations, water diversions, and wastewater discharges have all contributed to the current problems. While impacts from these activities were anticipated, it appears that some of the well-intentioned habitat improvement projects completed in the past also have contributed to channel instability and poor habitat.

- Agriculture

The most significant impacts in the subwatersheds are associated with agricultural practices. In particular, unrestricted livestock grazing along the tributaries has directly impacted channel morphology by trampling of the banks, widening of the channel, and increasing sedimentation. Historic vegetation control practices such as spraying and mechanical removal of undesirable vegetation probably contributed to the loss of much of the woody vegetation from the banks and riparian zone along creeks. However, the current lack of woody vegetation and the subsequent loss of channel stability is a direct result of the unrestricted grazing activities.

Table ES 1 – Summary of the effects of livestock grazing based on length of stream impacted.

Watershed	Total Stream Length (Miles)	Length of Stream Impacted (Miles)	Percent of Total
Killinger Creek	6.8	1.85	27.0
Buckholder Creek	2.0	0.0	0.0
Gingrich Run	3.8	0.9	23.5
Bachman Run	6.4	1.4	21.0
Beck Creek	6.8	1.9	28.0
Snitz Creek	8.33	0.8	9.0
Brandywine Creek	5.3	0.0	0.0
Unnamed Tributary	4.28	1.03	24.0
Quittapahilla Creek	18.0	0.0	0.0

- Stream Bank Fencing Program

The efforts of the Watershed Association were evident. Reaches along the tributaries where landowners have agreed to fence their sections of the creeks show definite signs of recovery.

As of November 2005, the stream bank fencing program included 18 farms with a total of 35, 566 feet (6.7 miles) of the main stem Quittapahilla Creek and its tributaries fenced. Beck Creek has been the biggest beneficiary of this program with 11,491 feet of stream fenced, followed by Bachman Run, Main Stem Quittapahilla Creek, Snitz Creek, and Gingrich Run with 7,716 feet, 6,350 feet, 5,639 feet and 4,390 feet, respectively.

Livestock crossings are often installed as part of the fencing program. Thus far, 21 crossings have been installed.

The success of these fencing projects is strongly influenced by the landowner's level of commitment to maintain their project over the long-term. During the field reconnaissance it was observed that a number of the farms were not maintaining their stream bank fencing. Some fences were in poor condition or completely down. It was obvious that livestock still had relatively easy access to the stream on these properties. The type of fence also appears to influence the success of the project.

- Other Streamside Agricultural Best Management Practices

A number of farms were observed to be utilizing some of the currently accepted best management practices for cultivated areas (e.g., grass filter strips, grass waterways, no till cultivation, cover crops, etc.).

- Logging and Lumber Mills

Logging operations in riparian areas has impacted the headwaters of Killinger Creek and Buckholder Run. The failure to utilize any type of best management practices has contributed to especially unstable conditions in the logged areas of upper Buckholder Run.

In 1996 the headwaters of Gingrich Run were severely impacted by storm water runoff from the Walter H. Weaber & Sons, Inc lumber mill site, which carried wood fibers, saw dust, mulch, and leachate from wood by-products. Under a PADEP Consent Order issued in 1997, corrective actions were taken.

- Quarries

Based on observations made during the tour it was apparent that the mining operations at this facility are contributing to increased turbidity and sedimentation along lower Killinger Creek and Quittapahilla Creek downstream of the confluence. Much of the very fine material that makes its way to the creek is a by-product of the operation and would probably be very difficult to completely eliminate from the wastewater stream discharging from the sedimentation ponds. However, runoff from the material processing areas and conveyors appears to be a contributing source as well.

During the geomorphic mapping of the main stem Quittapahilla Creek it was observed that the discoloration and increased turbidity caused by the quarry was still evident as far as the Blauch Farm, which is approximately 3.5 miles downsteam of the discharge point.

- Development

The land along the Quittapahilla Creek and its tributaries is rapidly developing. Development has already impacted reaches along Killinger Creek, Bachman Run, Beck

Creek, Snitz Creek, the Unnamed Tributary draining South Lebanon, and Brandywine Creek.

- Channel Alterations

Some of the earliest alterations to Quittapahilla Creek and its tributaries occurred when as many as 50 grist mills and saw mills were constructed along the creeks during the 1700's and 1800's. Operating a mill required the construction of a dam on the creek to form a millpond with a dependable supply of water. A race or small stream was dug to divert stream flow to turn the water wheel which operated the millworks. Although the dams have been removed, some of these old mill sites still exist. These mill dams had a significant effect on sediment transport and sediment storage causing the channels and floodplains upstream of each dam to aggrade over time. In addition, they created barriers to fish movement.

Upper Quittapahilla Creek, the Unnamed Tributary draining South Lebanon, and Brandywine Creek have been most severely affected by channel alterations. The Hazel Dike constructed to protect the City of Lebanon from floods like the one that occurred in 1889 converted much of the upper Quittapahilla Creek to concrete flume during the early 1900's. The flooding that occurred during Hurricane Agnes in 1972 prompted the City of Lebanon to complete additional flood mitigation works. A significant portion of the Upper Quittapahilla Creek is now conveyed through the City in a concrete flume.

Almost the entire length of the Unnamed Tributary is concrete flume or pipe. In fact, one of the few remaining open channel sections in its headwaters was being piped when the field reconnaissance was conducted. Significant portions of lower Brandywine Creek are concrete flume or pipe, as well.

Stream channel alterations associated with flood mitigation such as those that have been implemented along the Upper Quittapahilla Creek, Unnamed Tributary and Brandywine Creek create channels that are virtually devoid of habitat. Although not as dramatic, varying degrees of channel alterations have occurred along all of the major tributaries in the Quittapahilla Creek Watershed. Removal of stream bank vegetation, stabilization with riprap, and ditching are the most common alterations in the rural areas of the watershed.

Table ES 2 – Summary of the effects of channel alterations based on length of stream channel altered.

Watershed	Total Stream Length (Miles)	Length of Stream Impacted (Miles)	Percent of Total
Killinger Creek	6.8	1.2	17.5
Buckholder Creek	2.0	0.43	21.0
Gingrich Run	3.8	0.94	25.0
Bachman Run	6.4	2.0	31.0
Beck Creek	6.8	1.3	19.0
Snitz Creek	8.33	1.7	20.0
Brandywine Creek	5.3	3.5	66.0
Unnamed Tributary	4.28	0.0	0.0
Quittapahilla Creek	18.0	3.7	20.5

- Flow Diversions

A number of flow diverting structures were observed along the major tributaries. Generally these diversions were designed to maintain water levels in ponds in the adjacent floodplain. While most were for irrigation water for nurseries or livestock watering, some were purely for aesthetics.

While the majority of the diversion structures observed appeared to be designed to limit the volume flow of baseflow diverted to a small percentage of the total, a number of the diversions observed included channel manipulation that was diverting a considerable proportion of the baseflow out of the channel and into ponds. Given that Summer 2001 was a drought period, these baseflow diversions significantly impacted the reaches along the ponds. In addition, ponds can significantly raise the temperature of the diverted flow before it is returned to the stream, thereby affecting reaches downstream of the pond as well.

- Fish Barriers

Although major channel obstructions were few, several small dams and on-line ponds are creating significant barriers to fish migration.

- Fish Habitat Structures

Habitat improvement projects completed in the past have contributed to channel instability and poor habitat.
Inappropriate selection and placement of habitat structures can lead to channel instability and failure of the structures. Typical channel instability caused by improperly selected/placed habitat structures include: 1) flattening of local channel slope, loss of sediment transport capacity, channel aggradation, lateral adjustments and channel widening; and 2) steeping of local channel slope, increased bed and bank scour, lateral adjustments and channel widening.

Ecological Assessment

- In-Stream Habitat Evaluation

Upper Quittapahilla Creek

The upstream limit is the downstream end of the concrete flume near 19th Street in Lebanon and the downstream limit is the confluence with Bachman Run.

Throughout this segment the daily maximum summer water temperatures routinely exceeded the optimum for adult and juvenile Brown Trout. The maximum temperatures recorded during the period were only slightly lower than the upper tolerance limit for this species. These high temperatures are likely a result of the effects of the concrete flume in the upper reaches as well as runoff from the City of Lebanon, and Towns of Cleona and Annville along the middle and lower reaches. By early November, the time during which brown trout would normally begin spawning, water temperatures had fallen into the range at which spawning could occur. In mid-November a maximum daily water temperature peak was recorded that exceeded the upper tolerance limit for brown trout embryos. However, by late November and early December the maximum temperatures had dropped into the optimum range for embryo development. The recorded data suggest that overall the water temperature conditions along this segment would provide a stressful environment for all life stages of trout.

The measured dissolved oxygen and pH levels were consistently within the optimum range. However, measured nitrate-nitrogen levels were well above the optimum. Other water quality parameters of concern include: conductivity, suspended and dissolved solids, turbidity, total nitrogen, total Kjeldahl nitrogen, total phosphorus, ortho-phosphate, alkalinity, hardness, copper, and lead. The extremely high levels of these constituents are indicative of pollution caused by urban runoff from the City of Lebanon the Towns of Cleona and Annville, discharges from the Lebanon WTTP, as well as agricultural runoff contributed by Snitz and Beck Creeks.

Along most reaches in this segment the range and average depths of pools and riffles are optimum. However, pools make up only a small percentage of the total bed features. With the exception of the lower reaches, most of the pools that do exist are small with limited or no structure. Along the lower reaches the majority of the pools are large and deep with good structure. With the exception of the middle reaches, there is a fair amount of in-stream cover (e.g., debris, logs, and boulders) for adult trout under low flow conditions. Spawning habitat was limited and a significant portion of the lower reaches are impacted by a high percentage of fine sediments. There is a minimal amount of substrate of adequate size to provide escape or resting cover for fry or juveniles. With the exception of the upper reaches the riffles and runs did not include enough coarse substrate material to support an abundant macroinvertebrate community.

Numerous in-stream habitat structures were installed along the reaches upstream of Quittie Creek Nature Park at some time in the past. The design and placement of these habitat structures makes them of questionable value. More recently, in-stream habitat structures were installed along reaches in Quittie Creek Nature Park. Although most of the structures appeared to be functioning as intended, a steep, constructed riffle near the middle of the reach was directing flow into the adjacent right bank causing considerable erosion.

The dominant bank vegetation along the upper reaches is mature trees and shrubs. The percentage of the banks covered with vegetation is relatively high. The segment is heavily shaded along most reaches. Along the middle reaches, the lack of a riparian buffer is a common problem. In residential neighborhoods along the right floodplain mowed lawns with scattered trees are the typical vegetation. On agricultural land along the left floodplain row crops with scattered trees are the typical vegetation. The percentage of the banks covered with vegetation is relatively low and these reaches are not well shaded.

Middle Quittapahilla Creek

The upstream limit is the confluence with Bachman Run and the downstream limit is the confluence with the Unnamed Tributary that drains the Steelstown area of North Annville.

Although the maximum daily summer water temperatures measured along the main stem have been decreasing in a downstream direction, the maximum temperatures along all reaches in this segment still exceed the optimum for adult and juvenile Brown Trout. Water temperatures recorded along the middle reaches appeared to moderate by August. The high temperatures along this segment are likely a result of stormwater runoff from the Towns of Cleona and Annville and the low percentage of shading along many of the reaches in this segment.

By early November water temperatures had fallen into the range at which spawning could occur. The mid-November maximum water temperature peak observed in Upper Quittapahilla Creek was observed in this segment as well. The peak exceeded the optimum for brown trout embryos. By late November and early December the maximum temperatures were consistently in the optimum range for embryo development. Although water temperature along the upper reaches of this segment still have the potential to provide a stressful environment for all life stages of trout, temperature conditions have improved along the lower reaches of this segment to the point that stressful conditions would generally be associated with temporary fluctuations that all life stages of trout could weather.

Although the measured dissolved oxygen was consistently within the optimum range, the maximum and minimum concentrations were lower than measured along Upper Quittapahilla Creek. The measured pH level was consistently within the optimum range. Measured nitrate-nitrogen levels were still well above the optimum. Other water quality parameters of concern include: conductivity, suspended and dissolved solids, turbidity, total nitrogen, total Kjeldahl nitrogen, total phosphorus, ortho-phosphate, alkalinity, hardness, copper, and lead. The extremely high levels of these constituents are indicative of pollution caused by urban runoff from the City of Lebanon, the Towns of Cleona and Annville, discharges from the various wastewater treatment plants along the main stem and tributaries, agricultural runoff contributed by the tributaries, as well as discharges from the Millard Quarry on Killinger Creek.

Along most reaches in this segment the range and average depths of pools and riffles are optimum. Several reaches have ideal pool/riffle ratios. However, pools make up only a small to moderate percentage of the total bed features along the remainder of the segment. Unfortunately, the majority of pools are moderate size and with minimal structure. With the exception of several reaches there is a minimal amount of in-stream cover (e.g., logs, undercut trees, and overhanging vegetation) for adult trout under low flow conditions. Potential spawning sites were very limited due to a high percentage of fine sediments along almost all reaches. Most reaches lacked substrate of adequate size to provide escape or resting cover for fry or juveniles. Along most reaches macroinvertebrates would be limited to colonizing woody debris or submerged aquatic vegetation.

With the exception of a few reaches, the lack of a riparian buffer is a common problem throughout much of the segment. On agricultural land along the floodplain pasture or old field with scattered trees is the typical vegetation. The percentage of the banks covered with vegetation is relatively low and these reaches are not well shaded.

Lower Quittapahilla Creek

The upstream limit is the confluence with the Unnamed Tributary that drains the Steelstown area of North Annville and the downstream limit is the confluence with Swatara Creek.

The most downstream station at which water quality monitoring was conducted was at the Palmyra-Bellegrove Bridge in the middle segment. As a consequence, there is no data available to evaluate temperature conditions along this lower segment. The temperature data could have been extended downstream along this segment. However, it was determined that this would not be an appropriate use of the temperature data. It was determined that extending the other water quality data beyond the middle segment was inappropriate as well. Therefore, the habitat evaluation of this segment was limited to the physical habitat parameters actually measured in the field.

Along most reaches in this segment the range and average depths of pools and riffles are optimum. Several reaches have ideal pool/riffle ratios. Unfortunately, pools make up only a very small percentage of the total bed features along the remainder of the segment. The majority of pools along the upper reaches are large and deep with good structure. Most of the pools along the middle and lower reaches are small with minimal structure.

The upper reaches of this segment have a fair amount of in-stream cover (e.g., logs, undercut trees, and overhanging vegetation) for adult trout under low flow conditions. With the exception of one reach, the middle and lower reaches have very little in-stream cover for adult trout under low flow conditions. Although some potential spawning sites were observed, in general they are limited due to a high percentage of fine sediments along most reaches. Most reaches lacked substrate of adequate size to provide escape or resting cover for fry or juveniles. Only the riffles and runs along the upper reaches included enough coarse substrate material along most reaches to support an abundant macroinvertebrate community. Along most reaches macroinvertebrates would be limited to colonizing woody debris or submerged aquatic vegetation.

The middle reaches had a high percentage of bank cover composed of mature trees and shrubs and are well shaded. However, the lack of a riparian buffer is a common problem throughout much of the segment. On agricultural land along the floodplain row crops with scattered trees are the typical vegetation. The percentage of the banks covered with vegetation is relatively low and these reaches are not well shaded.

- Biological Communities

Quittapahilla Creek appears to be in relatively good condition biologically given its past history and heavily impacted watershed. Past studies that have been reviewed depict severely impacted conditions throughout much of the main stem and in several tributaries. Has previously noted, Bachman Run and Snitz Creek have been stocked since the early 1960's. However, earlier trout stocking along the main stem Quittapahilla Creek conducted by the Pennsylvania Fish Commission was halted in 1967 due to high pollution levels. Recognition of improving conditions led the Pennsylvania Fish & Boat Commission to begin stocking trout along the lower sections of Quittapahilla Creek (Swatara Creek – Clear Springs Road) in 1985. The Commission began stocking along Section 3 (Snitz Creek – Spruce Street) and Section 4 (Spruce Street – Quittie Park) in 1990 and 1992, respectively.

Most of the previous studies reviewed for the Quittapahilla watershed were conducted by the Pennsylvania Department of Environmental Resources. These reports range from 1972 to 1987. More recent reports may exist but were not reviewed. Other reports reviewed were authored by the Pennsylvania Fish Commission or private consultants for industries, primarily for the former Bethlehem Steel plant in Lebanon.

The early studies paint a very bleak picture of Quittapahilla Creek, with high levels of contaminants and limited biological communities dominated by pollution tolerant organisms. These early investigations were conducted prior to the enactment and enforcement of the Clean Water Act and subsequent regulations. Later studies show improving conditions along the main stem Quittapahilla and in its tributaries. Benthic macroinvertebrate densities and diversity increase, with pollution intolerant taxa appearing. Limited available fish data show a similar trend. The several more intensive investigations along the main stem show similar trends of improving conditions and biological communities in a downstream direction. Exceptions are obvious downstream of the sewage treatment plants.

The current general downstream trend in Quittapahilla Creek appears to be one of recovery from urban impacts. These impacts include the general urban impacts of imperviousness and stream channel manipulation in addition to documented and undocumented point discharges. Notable exceptions to the general trends are stations Q2 and Q5, which are the first stations downstream from municipal sewage treatment plants, and have generally lower numbers and taxa.

Numbers of benthic macroinvertebrates and taxa generally increase in a downstream direction, with more sensitive taxa appearing only in the lowest reaches. Fish data does not show a readily discernable trend, but this is somewhat attributable to sampling limitation in the lower mainstem reaches.

The tributaries all appear to be in better overall condition than the receiving Quittapahilla Creek. Urban impacts and point discharges are much reduced in the tributary watersheds, but agricultural impacts increase. Notable exceptions include the several industrial plants on Snitz Creek and the quarry on lower Killinger Creek.

Snitz Creek stands out for producing the highest diversity of fishes of any site, along with the highest diversity of mayfly taxa. Beck Creek and Bachman Run are very similar in biological community structure. Similarities include large numbers of sowbugs and nearly identical EPT taxa, and these are the only stations to produce large ostracods, water mites, and the leptocerid caddisfly *Triaenodes*. They do possess distinctions, however, with the sowbugs and copepods much more numerous in Beck Creek versus Bachman Run, and an apparently warmer water fish fauna in Beck Creek. Killinger Creek stands out as the most inhospitable on first glance with the heavy sediment load and deposition, but actually exhibits the lowest biotic index score and produced a wide variety of intolerant organisms.

Water Quality Assessment

- Water Quality Model Application and Results

For this particular study, the AVGWLF modeling tool was run for each of twenty-one sub-watersheds comprising the larger Quittapahilla Creek watershed (see Figure ES 2 and Table ES 3). In each case, weather data for a period of ten years (1988-1998) was used to calculate mean annual sediment, total nitrogen and total phosphorus loads.

To properly account for the effect of existing agricultural BMPs and stream protection activities, information on the type and extent of these activities was compiled by the local watershed group and subsequently used within AVGWLF via the “scenario editor” function. The extent of such activities is summarized by sub-watershed in Figure ES 3.

The calculated mean annual loads for each sub-watershed (in both total and per unit area loads) are shown in Table ES 4. The stream names associated with each of the numbered sub-watershed are given in Table ES 3. For the entire Quittapahilla, the mean annual total nitrogen, total phosphorus, and sediment loads were approximately 1,201,064 lb/yr, 31,450 lb/yr, and 20,800,647 lb/yr, respectively. The corresponding mean annual loading rates for nitrogen, phosphorus, and sediment are approximately 24.4 lb/ac, 0.64 lb/ac, and 423 lb/ac, respectively.

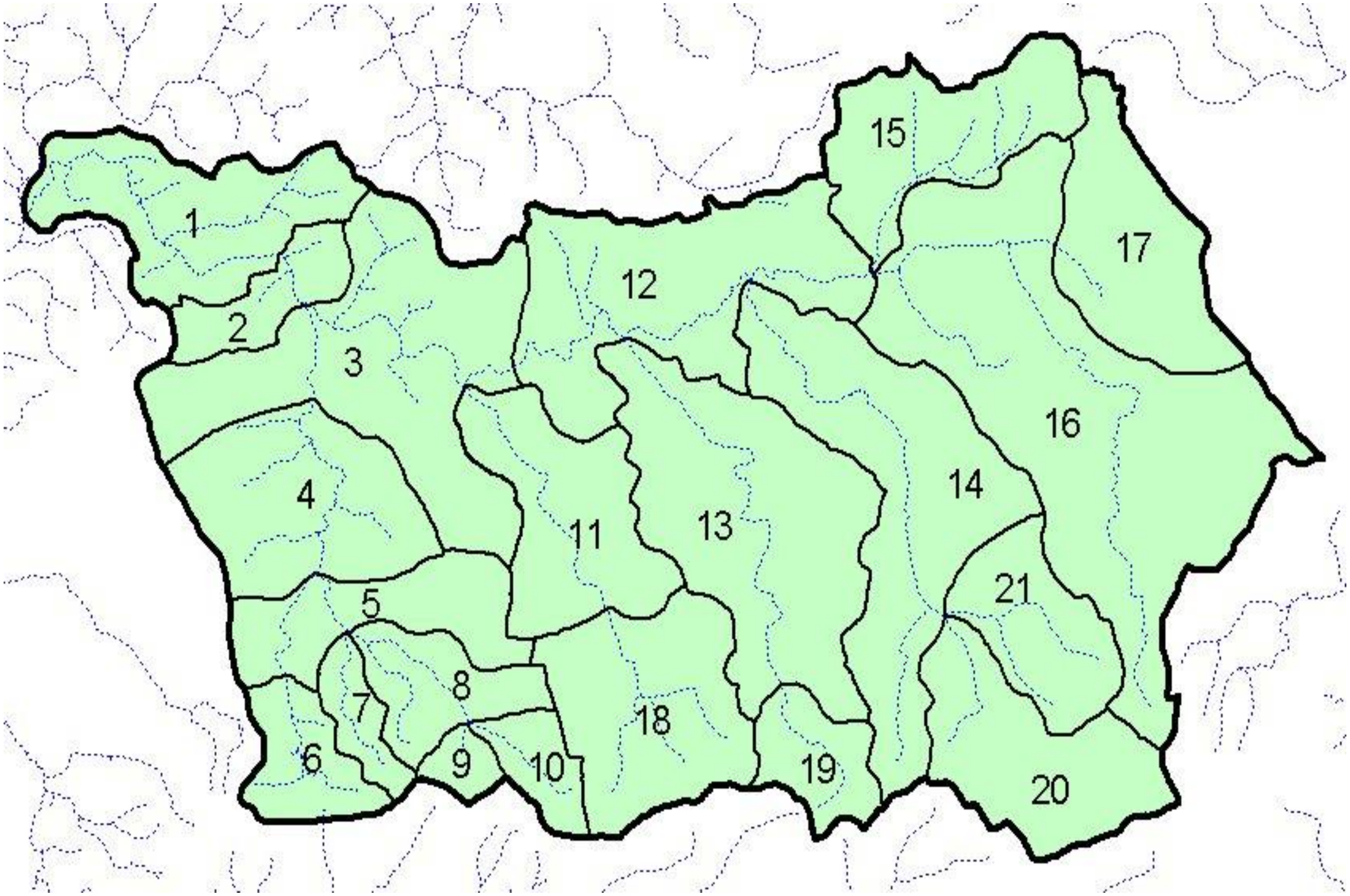

Figure ES 2 – Location of sub-watersheds.

Basin Number	Name Based on Principal Stream
1	Mouth of Quittapahilla Creek
2	Lower Quittapahilla Creek
3	Confluence of Killinger and Quittapahilla Creeks
4	Middle Killinger Creek
5	Upper Killinger Creek – Gingrich Run
6	Upper Killinger Creek
7	Buckholder Run
8	Middle Gingrich Run
9	Tributary to Gingrich Run
10	Upper Gingrich Run
11	Lower Bachman Run
12	Quittapahilla near confluence of Beck and Snitz Creeks
13	Lower Beck Creek
14	Lower Snitz Creek
15	Brandywine Creek
16	Middle Quittapahilla Creek
17	Upper Quittapahilla Creek
18	Upper Bachman Run
19	Upper Beck Creek
20	Upper Snitz Creek
21	Tributary to Snitz Creek

Table ES 3 – Subwatershed Basin Numbers and Names

BMP's FOR QUITTAPAHILLA WATERSHED

Sub-Watershed 1 — Quittapahilla Creek

BMP	Feet
Fencing	6330 ft
Rip.Buffer	6330 ft

Sub-Watershed 4 — Killinger Creek

BMP	Acres
nutrient mngt.	148.4
Fencing	4390 ft.
Rip.Buffer	4390 ft.

Sub-Watershed 11 — Bachman Run

BMP	Acres
nutrient mngt.	242.3
cons. Crop rotation	198.2
no-till	266.7
residue mngt./mulch till	111
cover crop	88.6
Fencing	7716 ft
Rip.Buffer	7716 ft

Sub-Watershed 13 — Beck Creek

BMP	Acres
Fencing	7945 ft
Rip Buffer	13,124.4 ft
Cons. Crop Rotation	469.5
strip cropping	151.5
cover crop	128.4
residue mngt.-mulch till	170.3
prescribed grazing	32.1

Sub-Watershed 14 — Snitz Creek

BMP	Feet
Fencing	5639 ft
Rip.Buffer	5639 ft

Sub-Watershed 16 — Un-named tributary

BMP	Acres
Cons. Crop rotation	92
residue mngt.	59
nutrient mngt.	92
no-till	59

Sub-Watershed 19 — Beck Creek

BMP	Feet
Fencing	3554 ft
Rip Buffer	3554 ft

NOTE: THE FENCING AND BUFFERS WEF
COMPLETED BY THE WATERSHED
ASSOCIATION FROM 2001 - 2003
THE REMAINING BMP's WERE FOR
THE LAST TWO YEARS

Figure ES 3 – Summary of existing BMP usage within the watershed.

Basin	Size (acres)	N-Total (lbs)	N-Rate (lbs/acre)	P-Total (lbs)	P-Rate (lbs/acre)	S-Total (lbs)	S-Rate (lbs/acre)
1	2495	23,333	9.35	900	0.36	843,413	338.1
2	857	12,458	14.54	452	0.53	465,255	542.8
3	4419	235,776	53.36	6787	1.54	3,143,889	711.5
4	2628	49,223	18.73	1292	0.49	1,274,490	485.0
5	1635	39,066	23.89	1100	0.67	1,187,613	726.3
6	968	41,064	42.41	481	0.50	332,735	343.6
7	529	5,746	10.87	223	0.42	211,680	400.5
8	1109	20,167	18.18	556	0.50	629,087	567.2
9	299	820	2.74	62	0.21	85,995	287.7
10	598	4,106	6.87	143	0.24	187,866	314.3
11	2285	45,994	20.13	981	0.43	74,188	325.7
12	3767	57,204	15.19	1762	0.47	1,844,483	489.7
13	4298	102,515	23.85	1960	0.46	1,122,786	261.2
14	4080	275,733	67.57	6681	1.64	1,613,840	395.5
15	2213	40,431	18.27	750	0.34	592,263	267.6
16	7291	120,660	16.55	3925	0.54	3,293,829	451.7
17	2225	33,381	15.00	878	0.39	714,641	321.1
18	2650	42,243	15.94	1067	0.40	1,113,084	420.0
19	906	4,284	4.73	146	0.16	91,287	100.7
20	2302	9,704	4.22	476	0.21	466,358	202.6
21	1526	37,143	24.33	829	0.54	841,869	551.5

Table ES 4 – Load results for Quittapahilla Creek by sub-watershed.

The values cited above indicate relatively high loading rates in comparison with other watersheds in Pennsylvania. This is not surprising given that the Quittapahilla Creek watershed is dominated by urban development and agricultural activities. Disturbed areas (i.e., mines and quarries) also appear to contribute substantial loads, particularly with respect to sediment.

Within the Quittapahilla Creek watershed as a whole, the predominant sources of nitrogen include agricultural activities (including livestock operations such as dairy farms), disturbed areas (e.g., mines and quarries), point source discharges, and septic systems. The principal sources of phosphorus include agricultural activities, disturbed areas, and point source discharges. The primary sources of sediment appear to be agricultural activities, disturbed areas, and streambank erosion. All areas of the Quittapahilla watershed are affected by pollutants generated via agricultural activities. To a lesser extent, and to varying degrees, subwatersheds are also affected by loads from disturbed areas, point source discharges, and streambank erosion.

- Water Quality Monitoring Program

The levels of nearly all water quality parameters measured along the Quittapahilla Creek and its tributaries fall into the range of concentrations considered problematic for limestone streams. The results were discussed above under in-stream habitat.