PART A:
PROJECT DESCRIPTION

Purpose

Over the past four decades, there have been numerous studies conducted and plans developed for the Valley Creek watershed. In the 1960's and 1970's, the studies and environmental action within the watershed focused on water quality impacts, as the carbonate geology can allow contaminants and pollution to move rapidly throughout the watershed. Recent studies and environmental actions have identified stormwater runoff as a major threat to the integrity and health of the Valley Creek watershed. Ineffective or uncontrolled stormwater runoff has led to numerous problems within the Valley Creek watershed. These problems include accelerated streambank erosion that has impacted the communities' infrastructure such as roads and utility pipes; stream channel damage that has impacted private property as well as aquatic habitat and species health, including the naturally reproducing brown trout population; and increased flooding that has damaged private and public property and lands adjacent to creeks. Thus, one of the high priority objectives identified in Chester County's ***Watersheds*** Plan (Chester County, 2002) for the Valley Creek watershed is to reduce flooding and related stormwater impacts.

This watershed assessment was conducted under a Pennsylvania Growing Greener Grant and in conjunction with a PA Act 167 Stormwater Management Study for the Valley Creek watershed. The Act 167 Plan will establish criteria and standards for managing stormwater runoff from new development. Phase I of the Act 167 study was conducted simultaneously with this watershed assessment. Phase II of the Act 167 study is anticipated to be completed within the next two to three years (dependent upon the availability of funding). While the final Act 167 plan will address runoff management from new development, the intent of simultaneously conducting this watershed assessment is to also address existing problems and characterize the natural conditions that influence runoff and related problems. Thus, the combined outcome will be an "integrated stormwater management plan" that provides a single plan with combined results, conclusions, and recommendations for watershed restoration and stormwater management.

This Technical Compendium presents the data, results, conclusions and recommendations gained from the watershed assessment. These will be utilized as appropriate for the Phase II Act 167 study. In the interim, this Technical Compendium can be used to assist other entities in evaluation and selection of watershed management and restoration projects.

Valley Creek watershed – an introduction

The Valley Creek watershed includes approximately 23.3 square miles containing portions of 7 municipalities within Chester County and Montgomery County, as shown in Figure A-1. Valley Creek and its tributaries include an estimated 34 miles of streams, and flow through the Valley Forge National Historical Park before joining with the Schuylkill River in the Delaware River Basin. Valley Creek and Little Valley Creek (its tributary) are the main water courses in the watershed. The Valley Creek watershed is a rapidly urbanizing watershed with dense development along the Route 30 corridor

(including the Borough of Malvern and the village of Paoli), scattered suburban, commercial and industrial development, and major limestone quarry operations.

The watershed also includes segments of the Pennsylvania Turnpike, Route 202 multi-lane highway and Route 30 multi-lane major arterial road. An 8% increase in residential population growth is projected for the watershed from 2000 to 2020, raising concerns about additional stormwater and pollutant runoff problems and increased flooding. Also, significant areas of the existing development were constructed several decades ago and therefore has aging, limited and/or no stormwater management controls in place.

Although there is significant, and continuing, development within the watershed, it remains a popular watershed for anglers and others who enjoy the water resources and heritage of the watershed. The entire Valley Creek watershed is designated as Exceptional Value Waters and certain reaches of Valley Creek and Little Valley Creek are identified as Class A Wild Trout Streams. The watershed also has areas that contain or may contain rare and endangered species as noted in the Pennsylvania Natural Diversity Index. The topographic characteristics of the watershed include steep, easily erodible slopes with a broad relatively flat valley floor. The underlying geology of the Valley Creek watershed includes mostly carbonate rock units, with smaller portions of crystalline rock units and the Stockton formation underneath the valley walls.

One of the most significant cultural/historical sites in the nation, Valley Forge National Historical Park, is located within and at the mouth of the watershed. Impacts of flooding and in-channel erosion present a serious threat to the historical resources and infrastructure within the National Historical Park.

The regional setting

In the regional context, the Valley Creek watershed is approximately 20 miles northwest of Philadelphia and it is reported to be unusually rare for a watershed with a naturally reproducing brown trout population to be located so close to a major city. The majority of the Valley Creek watershed is located in northeastern Chester County, with roughly 97% of the watershed in Chester County. The remaining 3% of the watershed is in Montgomery County, with that entire area located within the Valley Forge National Historical Park.

Valley Creek is a tributary to the Schuylkill River that in turn joins the Delaware River in Philadelphia. As a tributary watershed to the Schuylkill River within Chester County, the Valley Creek watershed is considered a part of the Schuylkill River National and State Heritage Area. Its mission is to “Conserve, interpret and develop the historical, cultural, natural and recreational resources related to the industrial and cultural heritage of the Schuylkill River Valley of Southeastern Pennsylvania.” Flows from the Valley Creek watershed also contribute to the sources waters for the City of Philadelphia drinking water supplies.

Insert Fig A-1 Basemap

Trends within the watershed over the past 60 years

Valley Creek watershed, like many areas in the suburbs of Philadelphia, experienced a boom in growth in the 1950's and 1960's. New employment opportunities and transportation infrastructure made Chester County and the Valley Creek watershed an attractive place to live and work. The U.S. Census Bureau reports that from 1950 to 1960, population growth in the East Whiteland and Tredyffrin Townships (the two most representative municipalities within the watershed) more than doubled from 9,576 to 21,082 residents. Then from 1960 to 1970 an increase of an additional 9,497 residents occurred in these two municipalities, bringing the total population to more than triple the population than just twenty years before (CCPC, circa 1971). A more detailed discussion of population changes, and projections, in the watershed is included later in this chapter under Watershed Characteristics.

Review of aerials photos from 1946 (GTS, 2004), 1958, 1970 and 2000 illustrate the changes that have occurred within the watershed and the region over the past 60 years. The land use within the Valley Creek watershed was predominately agriculture in the 1940's, and remained significantly agriculture into the late 1950's. The only sizable population areas within the watershed were concentrated around the Borough of Malvern and the village of Paoli. In 1946, the remainder of the watershed was agricultural fields or woodlands with small clusters of houses and the early quarry operation at the Cedar Hollow Quarry.

By 1958, a handful of small residential communities had developed along the Route 30 corridor, however the balance of the watershed remained in agricultural uses. By 1970, there was significant growth of residential and business development within the watershed, specifically in the upper areas of the watershed. Although there were increases in development throughout the watershed, the biggest change in land use occurred in the headwaters, while the lower portion of the watershed remained more agricultural and natural. Currently, the watershed is significantly developed with residential, commercial (e.g. office parks, retail, etc.) and industrial land use. Additional discussion of the current land use patterns within the watershed is included later in this chapter.

Challenges facing the watershed

As the land uses within the watershed have changed over the past 60 years, the results of these changes have caused significant impacts within the watershed. As development of residential communities increased in the 1950's and 1960's, the use of package wastewater treatment plants and some untreated wastewater discharges caused the streams to experience poor water quality due to failing treatment plants or untreated wastewater. The completion of the Valley Forge Regional Sewer system (by the Valley Forge Sewer Authority) in 1976, removed the individual wastewater outfalls and re-moved the municipal wastewater effluent from the watershed entirely (Heister, 2004). The collected wastewater is now treated and discharged to the Schuylkill River near Phoenixville.

In addition to the individual sewage outfalls, the management and operation of the Knickerbocker Landfill, in East Whiteland Township, has had numerous impacts to the ground water and surface waters of the watershed. As described in the following chapter on the water quality assessment, the land-fill was a source of metals, phenol and suspended solids. The landfill was closed in 1982, however there was limited filling within the landfill until 1990.

Other water quality problems within the watershed resulted in part from the economic strength of the watershed, the industrial/manufacturing uses. Various chemical pollutants have entered the environment from three superfund sites: the Paoli Rail Yard, the Chemclene Corp (also known as the Malvern TCE) site and the Foote Mineral site. These sites are all in various stages of control and remediation, as described in the following chapter.

While water quality concerns have not been eliminated from the watershed, the greatest remaining current challenge in the watershed is reducing the impacts of stormwater runoff. These impacts include runoff from the agricultural and developed land areas, carrying pollutants and sediments as well as the tremendous hydraulic energy of the watershed's runoff that scours and erodes the stream channels. Additionally, the stormwater runoff raises stream temperatures that impact aquatic species. Stormwater runoff has also caused infrastructure and property damage, increased risk to public safety, and other flooding related damages.

Framework for meeting those challenges

One of the most challenging aspects to those working in watershed management is to determine which areas are most in need, and what strategies will yield the most benefit to the watershed. The results of the watershed assessment, and this Technical Compendium, provide a framework of goals and priorities to address the needs and challenges for the Valley Creek watershed consistent with the guidance of the Chester County ***Watersheds*** Plan.

Watersheds was adopted by the Chester County Board of Commissioners in September 2002 as the water resources element of ***LANDSCAPES***, Chester County's comprehensive plan. In 1996, the Chester County Board of Commissioners adopted ***LANDSCAPES*** as the County's comprehensive plan policy document. The vision of ***LANDSCAPES*** is to "preserve and enhance the unique character of Chester County's landscapes by concentrating growth in the most appropriate areas." (Chester County, 1996)

One of the high priority objectives identified in ***Watersheds*** for the Valley Creek watershed is to reduce flooding and related stormwater impacts. Valley Creek watershed also ranked as a high priority watershed for "Restoring Stream Water Quality" which strengthens the need for an "integrated stormwater management plan" that considers existing land use and watershed characteristics, as well as potential impacts from new land development and re-development.

The Valley Creek Watershed Technical Compendium has been organized to build on and coordinate with the other planning and restoration efforts within the watershed. A complete discussion is provided later in this chapter of the stakeholders and their efforts throughout the watershed. Special emphasis has been placed on coordinating this work effort with the Valley Creek Trustee Council's *Valley Creek Draft Restoration Plan/Environmental Assessment*. The conclusions and recommendations of these two watershed-wide assessments are intended to complement each other while focusing on their particular objectives. The two primary objectives of the restoration efforts proposed in the *Valley Creek Draft Restoration Plan/Environmental Assessment's* are to enhance the Valley Creek fishery and restore the natural resources in the watershed towards restoring lost environmental and recreational values of the watershed caused by the contamination of the Paoli Rail Yard site. (VCTC, 2004)

Objectives of this watershed assessment

The objectives of this Valley Creek watershed assessment are to:

- compile existing water quality and habitat studies to characterize the relative health and integrity of the streams of the Valley Creek watershed,
- conduct a fluvial geomorphology assessment, with particular emphasis on stream stability and evolution, to more fully understand flooding and erosion problems, and to provide a basis for better design of effective and lasting stream restoration measures,
- evaluate the interactions of the land use and the stream system to identify the root causes of stream instability problems that have been identified, and
- identify site specific restoration and management needs within the watershed, including priorities for implementation, estimated costs and potential restoration techniques.

Organizations and stakeholders throughout the watershed

In many watersheds throughout the region, the principal watershed characteristics that would need to be understood for restoration and planning are the physical characteristics, i.e. the geology/hydrology, topography and land uses with the watershed. However, within the Valley Creek watershed, one of the most important watershed characteristics are the stakeholders including those governments, businesses, private entities, non-profit organizations, and educational institutions who are involved in land and or water management within the watershed.

Valley Creek watershed has benefited from the long-established stewardship of a watershed association (Green Valleys Association), numerous environmental advocacy groups and 2 watershed-wide partnerships (Valley Creek Restoration Partnership and Valley Creek Coalition) that have provided leadership and stewardship initiatives to protect and restore Valley Creek and its tributaries. In addition to these volunteer-based environmental organizations, there are active corporate citizens, research institutions, municipalities, and governmental agencies with diverse interests and perspectives for watershed management.

The following is a listing of key stakeholder agencies and groups involved in resource and land management within the watershed:

Municipalities

There are 7 municipalities within the watershed:

- Charlestown Township, Chester County
- East Whiteland Township, Chester County
- Malvern Borough, Chester County
- Schuylkill Township, Chester County
- Tredyffrin Township, Chester County
- Upper Merion Township, Montgomery County
- Willistown Township, Chester County

Under Pennsylvania law, decisions on local land use issues are the responsibility of the municipality. Through their comprehensive plan, each municipality can articulate its vision for the future of the municipality. However, the comprehensive plan is not a regulatory document; it is through the zoning ordinance and subdivision/land development ordinance that the municipality can regulate land use and development. Other municipal planning tools that can be used to implement the municipal vision include an Official Map, Open Space, Recreation and Environmental Resources Plan, and a Wastewater Facilities Plan.

Chester County agencies

Although there are numerous County agencies involved within the boundary of the watershed, the following is a list of those that were involved in the development of this Technical Compendium:

Chester County Water Resources Authority – Established in 1961 by the Chester County Board of Commissioners, CCWRA is now a line agency of the Chester County government through the Chester County Planning Commission. The role of CCWRA is to provide the basic science, analyses and planning that are necessary to protect public safety, to preserve the integrity of the County's natural water resources and watershed systems, and to balance the needs of all water users in support of planned growth for the County.

Chester County Planning Commission – The Chester County Planning Commission is an advisory board of nine citizens appointed by the Board of County Commissioners with a staff of professional planners and support staff. Program activities include the collection, analysis and dissemination of data; coordination and education; technical assistance to municipalities and other County departments; county-wide planning; and coordination with regional, state and federal agencies.

Chester County Conservation District – The Conservation District administers programs to conserve natural resources within the County. Programs include Erosion and Sediment Control permits, National Pollutant Discharge Elimination System (NPDES) permits (relating specifically to the discharge of stormwater from construction activities), and agricultural soil and water conservation programs.

Valley Creek Restoration Partnership

The Valley Creek Restoration Partnership is a partnership of 4 principle environmental organizations in the watershed: Valley Forge Chapter of Trout Unlimited, Open Lands Conservancy, West Chester Fish, Game and Wildlife, and Green Valleys Association. The partnership was formed in 2003 in order to coordinate and advocate efforts to plan, design and implement watershed-based restoration in the Valley Creek watershed. In addition to the members of the Partnership described above, other agencies and organizations coordinate efforts with the Partnership. Some of the governmental agencies include the Valley Forge National Historical Park, Pennsylvania Department of Environmental Protection, Chester County Conservation District, and Chester County Water Resources Authority.

The Valley Creek Restoration Partnership is still in the early stages of developing a work plan and finalizing their organizational structure. The Partnership hosted the first Valley Creek Summit in April

2004 with the purpose of having researchers and watershed stakeholders, including municipalities, discuss the issues and threats facing the watershed.

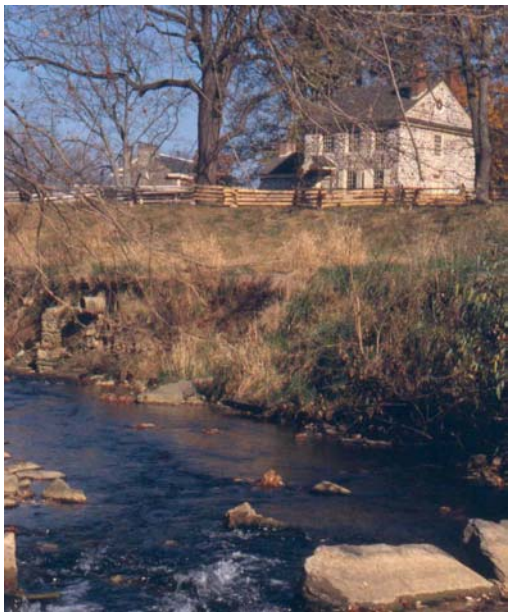
Valley Creek Coalition
The Valley Creek Coalition was originally formed in 1979 to fight for the closing of the Knickerbocker Landfill. The original Coalition included 9 organizations, with 7 organizations currently active in the Coalition. Currently, the Valley Creek Coalition is composed of the Green Valleys Association of Southeastern Pennsylvania, Open Lands Conservancy of Chester County, Pennsylvania Environmental Defense Fund, Raymond Proffitt Foundation, Schuylkill River Keeper, Valley Forge Chapter of Trout Unlimited, and West Chester Fish, Game and Wildlife Association.

Recently, the Coalition sued the PADEP over the issuance of stormwater discharge permits within the Valley Creek watershed. The parties reached an agreement that resulted in PADEP developing "Requirements for Post-Construction Storm Water Control in the Valley Creek Exceptional Value Watershed".

Valley Creek Trustee Council
In response to the need for governmental oversight on the planning and spending of monies collected as part of the Paoli Rail Yard Superfund Site settlement, the Valley Creek Trustee Council was formed between the Commonwealth of Pennsylvania and the Federal government. There are two members of the Council, the Pennsylvania Fish and Boat Commission (representing the state) and the National Park Service (representing the Department of the Interior).

The Valley Creek Trustee Council has recently released their Valley Creek Draft Restoration Plan/Environmental Assessment (2004). This *Valley Creek Draft Restoration Plan / Environmental Assessment* presents restoration strategies and projects that could be implemented in the Valley Creek watershed and an analysis of effects from implementing those projects. The two primary objectives of the proposed restoration efforts are to enhance the Valley Creek fishery and restore the natural resources in the watershed.

Valley Forge National Historical Park (VFNHP)
Valley Forge National Historical Park includes approximately 1.3 square miles of the watershed located within Chester and Montgomery Counties. Valley Forge is perhaps the best-known place name associated with the American Revolution, and the Park attracts over 1 million visitors each year to enjoy the Park and learn about the history of our Country. Park staff have been very active in the management of the Valley Creek watershed and responsible for natural resources management and resource protection within the Park boundary. The VFNHP serves as the National Park Service representative on the Valley Creek Trustee Council described above.



Valley Creek, in the foreground, as it flows past Washington's Headquarters in Valley Forge National Historical Park.

Universities

Drexel University—A team of researchers, including professors, graduate students and undergraduate students, conducted a series of inter-related studies on the Valley Creek watershed over the past few years. These studies included investigations into the ground water system, aquatic species diversity, stormwater management basins, and political/social decision making.

Villanova University—Research and investigations to quantify impacts of stormwater management are also underway at Villanova University through the Villanova Urban Stormwater Partnership. The mission of the Villanova Urban Stormwater Partnership is to advance the evolving comprehensive stormwater management field and to foster the development of public and private partnerships through research on innovative Best Management Practices, Directed Studies, Technology Transfer and Education.

University Of Maryland, Baltimore County (UMBC)—UMBC and Drexel University have begun a study that is measuring sediment erosion and deposition volumes and rates in the portion of Valley Creek that flows through the National Park. Published materials from the Drexel University and University of Maryland, Baltimore County studies in the Valley Creek watershed can be found at http://userpages.umbc.edu/~weltyc/wws.html.

Utilities

Aqua Pennsylvania—Aqua Pennsylvania, formerly Philadelphia Suburban Water Co, is the largest water supply utility in the watershed. The utility is an investor-owned company that provides service for nearly the entire watershed. Although most of the watershed is within the service area of Aqua Pennsylvania, there are some residential homes and mobile home parks that rely on individual wells. There are two public water supply wells owned by Aqua Pennsylvania within the watershed, the Great Valley well and the Tredyffrin well.

Valley Forge Sewer Authority—The Valley Forge Sewer Authority provides wastewater service for nearly two-thirds of the watershed, principally in the upper portion of the watershed, and in the southern portion of the watershed along the Route 30 corridor. The Sewer Authority treatment plant is located outside of the watershed (near Phoenixville) and discharges to the Schuylkill River.

State Agencies

Pennsylvania Department Of Environmental Protection (PADEP)—The Pennsylvania Department of Environmental Protection is the state agency largely responsible for administering Pennsylvania's environmental laws and regulations. Its responsibilities include air quality; drinking water quality; water quality in rivers and streams; waste management; and mineral management. Funding from the PADEP Growing Greener Grant program has been used to conduct this watershed assessment.

Pennsylvania Fish And Boat Commission (PAFBC)—The Pennsylvania Fish and Boat Commission is responsible for protecting and managing Pennsylvania’s fishery resources and regulating recreational fishing and boating on Pennsylvania waters. The PAFBC is also a member of the Valley Creek Trustee Council described above.

Pennsylvania Department Of Transportation (PennDOT)—The Pennsylvania Department of Transportation is responsible for the construction, maintenance, repairs and associated management of state roads. There are numerous state roads within the watershed that are managed by PennDOT. The Route 202 expansion project includes constructing additional lanes within Sections 400 and 300 that are both within the watershed. Section 400 has been completed and included only a small portion of the Valley Creek watershed in the northeastern portion of the watershed. Section 300 is entirely within the Valley Creek watershed and is currently in the planning and design phase (including the stormwater management systems).

Pennsylvania Turnpike Commission—The Pennsylvania Turnpike Commission is responsible for the operation and management on the Pennsylvania Turnpike. There are roughly 6.9 linear miles of the east-west Turnpike within the Valley Creek watershed.

Federal Agencies

U.S. Geological Survey (USGS)—The USGS is the principle science agency for the U. S. Department of the Interior, conducting data collection, research and interpretation on a wide-range of issues, including water resources, geology and biological resources. Within the Valley Creek watershed, the USGS has conducted numerous water resources and geologic investigations and, in cooperation with Chester County, they operate and maintain the stream gage.

U.S. Environmental Protection Agency (EPA)—EPA works to develop and enforce federal regulations that implement environmental laws enacted by Congress. EPA is responsible for researching and setting national standards for a variety of environ-mental programs. Within the Valley Creek watershed, EPA is the lead agency responsible for the control and remediation of the three designated Superfund sites within the watershed. Currently, EPA is overseeing the remediation of the Paoli Rail Yard superfund site, as well as the planning/remediation of the Malvern TCE and Foote Mineral superfund sites.

Watershed characteristics

Hydrologic Cycle Components

The Valley Creek watershed encompasses 23.3 square miles (mi^2). Valley Creek watershed is a carbonate watershed located in the Piedmont physiographic province. The watershed is characterized by steep valley walls with a broad, relatively flat valley floor. The stream system contains approximately 34 miles of perennial streams with other intermittent and ephemeral drainage swales. In the Valley Creek watershed, the ground water and surface water divides do not coincide, as the ground water divide is a few miles west of the surface water divide. The carbonate geology, which runs in an east-west band across the watershed, allows deep ground water movement from the eastern portion of the Brandywine Creek watershed to the Valley Creek watershed, and from the Valley Creek watershed to the Schuylkill River watershed east of the Valley Creek confluence with the Schuylkill River (Sloto, 1990).

Water Budget

Based on data collected from 1983 through 1987, the USGS has developed a water budget for the Valley Creek watershed for those years. As stated by Sloto (1994), "A water budget is an estimate of water entering and leaving a basin plus or minus changes in storage for a given time period. For a basin where ground-water divides and surface-water divides do not coincide, water also enters and (or) leaves a basin as ground-water underflow. Water also is taken into or released from ground-water and soil-moisture storage." (Sloto, 1994)

The key components of the water budget for Valley Creek watershed developed by the USGS are presented below. The water budget is based on data collected from 1983 – 1987 (Sloto, 1994):

Valley Creek Watershed Water Budget (1983-1987)
Precipitation = 47.3 inches
Runoff = 5.3 inches
Recharge = 21.0 inches
Of which … Baseflow = 13.0 inches
Evapotranspiration = 23.0 inches

Surface Waters

There are approximately 34 stream miles within the watershed . Valley Creek and its tributaries be-gin in the western hills of the watershed and flow in an eastern direction to its confluence with the Schuylkill River in the Valley Forge National Historical Park. Little Valley Creek, the major tributary of Valley Creek, begins in the south-central portion of the watershed, and confluences with Valley Creek about 1 mile west of the National Historical Park. Approximately 56 percent of stream miles in Valley Creek are first order streams. Figure A-2 shows the first order streams displayed on the topographic relief of the watershed that is shown in the form of a digital elevation model (DEM). First order streams are highly vulnerable to impacts of pollutants, stormwater flow, and ground water withdrawals.

The average width of Valley Creek after the confluence with its major tributary, Little Valley Creek, ranges from about 20 feet to 50 feet at bank full level. The average width of Valley Creek above the confluence with Little Valley Creek, ranges from 13 feet to 26 feet. The average width of Little Valley Creek is from 7 feet to 16 feet. The width of the other tributaries that make up the surface water system range form 1 to 3 feet (VCTC, 2004). With respect to width/depth ratios, at 8 of the 10 stable sites evaluated during the fluvial geomorphology assessment, the width/depth ratios ranged from 15.2 to 18.1, while the other 2 sites had ratios of 25.5 and 50.8. Additional information on bankfull channel characteristics is provided in Part C: Fluvial Geomorphology Assessment and Appendix B.

There are no major impoundments that would significantly affect the hydrology of the watershed, however, there are several historic mill dams which impact stream flows and the stream channel of the creek. There is one working limestone quarry (Catanach Quarry), and 2 closed limestone quarries (Cedar Hollow which has been converted to a lake and office park and a small former quarry in the southern portion of the watershed that has also been allowed to fill with water). The pumping operations from these quarries have affect low streamflow conditions as well as the ground water table.

Valley Creek has a typical streambed slope of 0.36 percent, while Little Valley Creek has a typical slope of 0.75 percent. The hydraulic grade line (slope) is, however, influenced by several instream low head dams. By contrast, a typical side tributary, Wilson Run for example, has a channel slope of approximately 4.6 percent.

Low head dam on Valley Creek just upstream of the confluence with Little Valley Creek.

Figure A-2 – First Order Streams on DEM

Stream Classification

Valley Creek is designated as an Exceptional Value (EV) stream by the Commonwealth of Pennsylvania (PA Code, 2004). Valley Creek and Little Valley Creek are both listed in the Pennsylvania Fish and Boat Commission's "List of Pennsylvania Class A Wild Trout Streams" (PAFBC, 2003). Both Valley Creek and Little Valley Creek are also listed as "Surveyed Streams Having Verified Trout Reproduction" by the PAFBC. Additional discussion of the Exceptional Value designation is provided in the Water Quality Assessment, which provides context of the Exceptional Value designation and water quality within the watershed.

Growth and development patterns

Population

As previously discussed, the watershed experienced a boom in population and associated development (i.e. roads, businesses, shopping and other commercial areas) during the 1950's and 1960's. During those two decades, the population within East Whiteland and Tredyffrin Townships (considered the most representative of the watershed as a whole, see Table A-1, note 2 below) more than tripled from 9,576 residents to 30,579 residents, as shown in Table A-1.

Table A-1 presents the U.S. Census population data, and Chester County Planning Commission population projections (CCPC, 2002) within the watershed. Based on the Year 2000 Census, it is estimated that there were 23,187 residents within the watershed in 2000. Based on the projected growth rate of East Whiteland and Tredyffrin Townships, it is estimated that the watershed will experience an increase of approximately 3,200 residents (or 13%) over the next 30 years.

Table A-1: Population Trends

	Six (6) Chester County Municipalities[1]		East Whiteland and Tredyffrin Townships[2]		Valley Creek Watershed[3]	
Census Year	Population	% Growth from prev. decade	Population	% Growth from prev. decade	Population	% Growth from prev. decade
1940	13,694		7,550			
1950	18,738	37%	9,576	27%		
1960	35,234	88%	21,082	120%		
1970	51,597	46%	30,579	45%		
1980	51,533	0%	31,487	3%		
1990	57,042	11%	36,426	16%	20,785	
2000	62,476	10%	38,395	5%	23,187	12%
2010[4]	65,420	5%	39,470	3%	23,836	3%
2020[4]	69,190	6%	41,480	5%	25,050	5%
2030[4]	73,400	6%	43,810	6%	26,457	6%

Notes:

1: Although there are 7 municipalities within the watershed, the portion of Upper Merion Township (Montgomery County) that is within the watershed lies entirely within the Valley Forge National Historical Park. It was assumed that the population, and change in population, within the Park boundary was negligible compared to the other 6 municipalities. Therefore, growth and development elsewhere

within Upper Merion Township was not considered to reflect the changes that would occur within the watershed.
2: East Whiteland and Tredyffrin Townships account for roughly 87% of the land area within the watershed. It is assumed that trends of growth and development within those municipalities most accurately reflect the trends within the Valley Creek watershed.
3: Valley Creek watershed population estimates for 1990 and 2000 are based on area weighted Census block data. The Census blocks were 'intersected' with the watershed boundary using GIS. For census blocks that were completely within the watershed, the population was totaled. For Census blocks that were partially within and partially outside of the watershed, the population for that block was area weighted based on the percentage of the block within the watershed. For example, if a census block with 45 people had 15% of the block within the watershed, then it was estimated that 7 people within that block lived within the Valley Creek watershed.
4: The projected population estimates for 2010, 2020, and 2030 are taken from Population Projections 2005 to 2030, Chester County Planning Commission Planning Bulletin #55, November 2002 (CCPC, 2002). Valley Creek watershed population estimates for 2010, 2020, and 2030 were extrapolated following the same projected rate of growth as those expected for East Whiteland and Tredyffrin Townships.

Land Use

All streams and watersheds are dynamic and ever-changing systems; stream channels change based on changes within the watershed, on the surface of the land or the ground water system. Pennsylvania was an area filled with mature woodlands when European settlers arrived in the 1600's and 1700's. During those centuries, tremendous changes took place to the landscape as much of Pennsylvania, including the Valley Creek watershed, was cleared of woodlands for agricultural uses. This change, in addition to the use of streams for mills, has a continued impact on the watershed today. The clearing of lands for timber harvesting and agricultural uses resulted in tremendous sediments being washed from the uplands and into the stream valleys. These sediments settled into the stream channels and are often still a factor in stream channel evolution and fluvial geomorphology processes. (Gutshall, 2004)

Over the past 60 years, the Valley Creek watershed, like most of eastern Chester County, has trans-formed from a watershed that was predominantly in woodland and agricultural land uses to a water-shed that is a mix of suburban and urban land uses today. However, even as the watershed has developed, a considerable amount of wooded land (approximately 28% of the watershed) remains within the watershed. Much of that land is within the Valley Forge National Historical Park, however, there are also tracts of woodlands within the floodplains of Valley and Little Valley Creeks that provide many benefits to the stream system.

Another land use category which is worthy of notation is the fact that 'Parking' facilities account for 9% of the land area within the watershed and is the third highest land use by area. This is an indication of the number of office parks, corporate and educational campuses, retail and shopping centers, etc. within the watershed. These land uses are not represented in the residential population Census figures, however the resulting impervious cover from these areas needs to be considered during stormwater management and watershed restoration planning.

Figure A-3 and Tables A-2 and A-3 present the land use within the watershed from the Delaware Valley Regional Planning Commission (DVRPC, 2003), which is based on year 2000 aerial photography.

Figure A-3 – Existing Land Use

Table A-2: Land Use within Valley Creek watershed (Year 2000)

Land Use (DVRPC, 2003)	Area (square miles)	Percent of total area
Wooded	6.76	29%
Residential: Single-Family Detached	6.51	28%
Parking	1.99	9%
Commercial	1.87	8%
Vacant	1.29	6%
Agriculture	1.17	5%
Recreation	0.99	4%
Mining	0.72	3%
Residential: Multi-Family	0.62	3%
Community Services	0.47	2%
Manufacturing: Light Industrial	0.42	2%
Utility	0.35	2%
Water	0.10	<1%
Manufacturing: Heavy Industrial	0.07	<1%
Residential: Mobile Home	0.03	<1%
Total	23.3	100%

While the table presented above indicates that 'wooded' is the largest land use within the Valley Creek watershed, it is important to note that many of the categories could be grouped under the category 'Development'. If this were done, the breakdown of land uses within the watershed could be de-scribed by Table A-3.

Table A-3: Grouped Land Uses (Year 2000)

Land Use (DVRPC, 2003)	Area (square miles)	Percent of total area
Development[1]	11.98	51%
Wooded	6.76	29%
Vacant	1.29	6%
Agriculture	1.17	5%
Recreation	0.99	4%
Mining	0.72	3%
Utility	0.35	2%
Water	0.1	<1%
Total	23.3	100%

1: Residential (all types), Parking, Commercial, Community Services, and Manufacturing (all types).

Impervious Cover

Substantial research has documented the often unnecessary impacts of the growth of traditional development on watershed "health." One of the primary indicators of stream health is the percent of impervious cover in the watershed that is directly connected to a stream via overland runoff or stormwater collection and conveyance systems. The following table summarizes the impacts on stream health from increasing amounts of directly connected impervious cover (CCWRA, 2001).

Table A-4: Impact from Impervious Cover

Characteristic	*Sensitive*	*Impacted*	*Impaired*
Impervious Cover %	0% to 10%	11% to 25%	26% to 100%
Channel Stability	Stable	Unstable	Highly Unstable
Water Quality	Good to Excellent	Fair to Good	Fair to Poor
Stream Biodiversity	Good to Excellent	Fair to Good	Poor
Pollutants of Concern	Sediment and temperature only	Also nutrients and metals	Also bacteria

The Valley Creek watershed is currently estimated to have an impervious cover of 18 percent of the total watershed (Steffy, 2003). This estimate is based on GIS layers provided to Drexel University by Cahill Associates from 1995 aerials, updated using year 2000 aerials photos by Drexel University researchers. The Valley Creek Watershed Action Plan (CCWRA, 2002) states that the impervious cover for the watershed is estimated at 24.3%. This estimate was based on interpretation of 1995 land use data for the watershed.

The Route 30 corridor, east of Route 202, in the headwaters of Valley Creek watershed.

The distribution of the impervious surfaces in the watershed primarily follows the Route 30, Route 29 and Route 202 corridors, with substantial blocks of impervious surfaces at the 'intersections' of Route 202 and Route 29, and Route 202 and Route 252. With an estimate of 18% impervious surface coverage in the watershed, Valley Creek watershed is at a very vulnerable stage in its evolution.

Geology

Ground water movement, the interaction of ground water with surface waters, and the quality of the ground water are dependent on the underlying geology of the Valley Creek watershed. The Valley Creek watershed is considered a carbonate watershed, with the valley floor underlain by carbonate rocks, however the ridges of the watershed are primarily crystalline rocks. The valley floor, which includes the majority of the stream miles and land area, is principally comprised of the following geologic formations: Elbrook formation, Conestoga Limestone, and Ledger Dolomite, as shown in Figure A-4. The valley walls are principally comprised of Octoraro Schist/Gneiss in the southern walls and Chickies Quartzite in the northern walls. (Sloto, 1990) Other geologic formations are present within the watershed, however the spatial area of these other formations are not as sizable as the formations listed above. Several faults exist in the watershed that have influenced its geology, hydrology and hydrogeology.

Within typical carbonate watersheds, ground water moves through solution channels, with the watershed characterized by sinkholes, dry valleys, and underground drainage to a regional ground water network. However, the ground water system in the Valley Creek watershed is closer to typical fractured rock watersheds than to the classic carbonate watersheds. While Valley Creek watershed does exhibit numerous characteristics of carbonate watersheds, such as sinkholes, springs, and losing/gaining stream reaches, the ground water flow in the watershed generally follows the topography and is more localized with discharge to nearby streams. (Sloto, 1990)

Field investigations conducted by USGS staff in the 1980's found that ground water movement with the Valley Creek watershed was principally through a "network of interconnected secondary openings - fractures, joints, faults, parting planes, and bedding planes. Some of these openings have been enlarged by solution. Most openings enlarged by solution are only a fraction of an inch wide, but they are capable of transmitting large quantities of water." (Sloto, 1990) As part of the Drexel University studies conducted in the watershed, a total of 172 springs were located within the watershed. Of these, 110 had a flow rates large enough to allow sampling. (McGinty, 2003)

Permeability depends on the degree of solution that has occurred. Where fractures are enlarged, permeability can be very high; elsewhere, they can be very low. The most active zone of solution is near the water table. Most of the ground water system is under water table conditions, however local areas of confined flow can be found. Like sedimentary rocks, ground water flow in the carbonate rocks has both local and regional components. Locally, ground water discharges to gaining reaches of streams, however, regional flow components can result in underflow from one surface water basin to another.

The solution channels can transmit not only large quantities of water, but also transmit water over large distances, especially when interconnected with the geologic faults in the watershed. Mapped fault lines for the Valley Creek watershed are found particularly in the western half of the watershed, and the faults typically are oriented parallel to the geologic contacts and the main stem Valley Creek, or from southwest to northeast.

Similarly, surface water pollutants can enter the ground water system through the stream and ground water interconnection. The most common interface where streams lose flow to the ground water system is when the streams flow from crystalline geologic rocks to carbonate rocks. However, as the streams in the crystalline rocks are headwater streams, and therefore small in size, the flow lost to the ground water system is not very large at these interfaces. (Sloto, 1990)

In crystalline rocks like those found in the northern and southern hills of the Valley Creek watershed, ground water moves through intergranular openings in the weathered zone and through a network of interconnecting secondary openings (fractures and joints) in the unweathered rock. Permeability of the unweathered rock depends on the number and size of the fractures, as well as how well interconnected they are. The ground water table reflects the topography of the land, and the ground water flow is usually local, with streams acting as the discharge points. Usually the ground water and surface water divides coincide. (Sloto, 1990)

Soils

The soils within the watershed play a very important role in the health and integrity of the watershed. The erodibility and infiltration potential of the soils in the watershed have a significant effect on the ground and surface water system of the watershed.

The soils in the Valley Creek watershed are arranged into four groups, or associations, based on the general patterns and characteristics of the major soil types as shown in Figure A-5. The general soil groups were delineated and published by the U.S. Department of Agriculture in the 1963 Soil Survey, Chester and Delaware Counties, Pennsylvania (USDA, 1963). Since that time, the names of the general soil groups have been changed but the delineated patterns are the same. Below are the general characteristics of the four soil groups within the watershed taken from the 1963 General Soil Map, Chester and Delaware Counties, Pennsylvania. For detailed soil characteristics, the information regarding the individual soil units should be examined.

The current soil group names and the map unit identification numbers (in brackets preceding the name) are provided along with the previous soil association names that are in parentheses. The characteristics described are from the 1963 soil survey.

[PA061] Unger-Penn-Klinesville (Penn-Croton-Bucks) – "The Penn soils are moderately deep. The Croton soils are deep and poorly drained. The Bucks soils are similar to the Penn soils but are deeper. Inmost places they are gently or moderately sloping. The sloping soils are likely to erode and require protection to help control erosion."

[PA066] Edgemont-Highfield-Buchanan (Edgemont Association) - "The soils are mostly on ridges and on the upper parts of slopes."

[PA058] Chester-Glenelg-Manor (Glenelg-Manor-Chester) – "The Chester soils are deep and well drained. The Gleneg soils are similar to the Chester soils but are shallower over parent material. The Manor soils … are shallow to partly weathered schist and are well drained. The sloping soils are likely to erode and require protection to help control erosion."

[PA063] Hagerstown-Duffield-Clarksburg (Hagerstown-Conestoga-Guthrie) – "The soils are level to moderately sloping, but most are gently sloping." The various soils series that make up this association include well-drained Hagerstown and Conestoga soils, the poorer draining Guthrie, Lawrence, and Bedford soils, and the Lindside and Melvin soils, which are found on floodplains.

Figure A-4 - Geology

Figure A-5 – Generalized Soils

The two predominant soil groups within the watershed (Chester-Glenelg-Manor and Unger-Penn-Kinesville) are characterized as "likely to erode". Physical properties of soils affect the infiltration capacity and the extent to which particles can be detached and transported. The corresponding soil characteristics that describe the ease with which soil particles may be eroded are soil detachability and soil transportability. In general, soil detachability increases as the size of the soil particles or aggregates increase, and soil transportability increases with a decrease in the particle or aggregate size. That is, clay particles are more difficult to detach than sand, but clay is more easily transported. (Schwab, 1993)

Exposed, vertical banks are found throughout the watershed, allowing instream erosion to mobilize and transport soils from the stream banks.

Within the stream corridors of the Valley Creek watershed, the principle soil types mapped by the Soil Survey Geographic Database for Chester County, Pa, (USDA, 1997) are silt loam soils. Silt particles are smaller than sand particles. Predominantly silty soils feel powdery (like flour) and do not hold together well when wet, though they are more cohesive than sandy soils. Loams are medium-textured soils and have properties in between those of coarse and fine texture. Silty loams to sandy-clay loams have a good capacity to retain water without becoming waterlogged.

The soils that make up the stream banks and stream channels of Valley Creek are often silt loams that indicates that they were transported via overland runoff and deposited in the stream channel and floodplain. Since they have already been shifted from their source, the soils along the stream channels throughout Valley Creek are susceptible to being eroded or scoured by stream flows.

Topography:

The Valley Creek watershed lies within the Piedmont Physiographic Province of Pennsylvania. The Piedmont Province is characterized by folded and altered rocks. The topography of the watershed is characterized by a relatively flat to gently rolling hills stream valley with steep side slopes up to the watershed divide. The highest point in the watershed is close to the Union Chapel located in the northwest corner of East Whiteland Township with an elevation of 716 feet above sea level. The lowest point (65 feet above mean sea level) is at the confluence point where Valley Creek flows into Schuylkill River between Schuylkill Township in Chester County and Upper Merion Township in Montgomery County. The problems in the Valley Creek watershed are not only caused by the increased runoff from developed areas, but the fact that the side slopes of the watershed are steep as shown in Figure A-6, while the valley floor has a relatively gently slope.

Conclusions

Influences on the surface of the land and the ground water system have altered the natural hydrologic regime and stream evolution process within the Valley Creek watershed. These changes have resulted in increased flooding and stormwater related problems, surface and ground water quality problems, and increased streambank instability. The Valley Creek watershed is over 50% developed based on year 2000 land use analysis and is estimated to have between 18 and 24% impervious cover.

The steepest natural slopes within the watershed are predominantly associated with the relatively more resistant geologic formations of the Octoraro Schist/Gneiss (along the southern rim) and the highly resistant Chickies Quartzite (along the northern rim). As the Valley Creek nears its confluence with the Schuylkill River, the stream channel and floodplain narrow as the stream follows the geologic contact and flows through a constricted reach between the Chickies Quartzite and the Antietam and Harpers Quartzite/Quartz Schist; both units have relatively high resistance to weathering and erosion, particularly compared to the limestone units. The stream then re-emerges into a short, wider reach passing by Washington's Headquarters, before encountering the constriction at the railroad overpass and the confluence with the Schuylkill River. The steep slopes along the northern and southern rims of the watershed are overlain by the two soil groups characterized as "likely to erode" (Unger-Penn-Kinesville and Chester-Glenelg-Manor soil groups). These characteristics demonstrate the close relationships between geology, topography, erosion and runoff within the watershed Valley Creek.

Figure A-6 - Slopes