

Final Report In Accordance With Agreement No. IA4000-7-8015

June 1995

Biological Survey and Management Plan for Valley Creek

Valley Forge National Historical Park

Martin Gutowski
Research Assistant
School of Forest Resources
The Pennsylvania State University
University Park, PA 16802

Jay Stauffer, Jr.
Professor, Ichthyology
School of Forest Resources
The Pennsylvania State University
University Park, PA 16802

Robert Carline
Leader, PA Cooperative Fish and
Wildlife Research Unit
Adjunct Professor, Fishery Science
The Pennsylvania State University
University Park, PA 16802

Table of Contents

Description of Valley Creek Basin	1
Location, Size, and Physical Description	1
Geology	1
Climate	1
Land Use	3
Water Resource Use and Development	3
Recreation	4
Valley Creek Water Use and Management - Authority and Responsibilities	5
Water Quality Standards and Monitoring	5
Sewage Facilities	6
Permit Programs	7
Valley Creek Management - Valley Forge National Historical Park	8
Valley Creek Management Zoning	8
Relationship to Applicable Legislation and NPS Planning Documents	8
Valley Creek NPS Management Objectives	10
Valley Creek Resources - Description and Condition	11
Water Resources	11
Quantity	11
Quality - Chemical and Bacteriological	11
Biological Resources	15
Aquatic Resources	15
Terrestrial (riparian) Fauna/Flora	18
Rare, Endangered, and Threatened Species	19
Stream Channel Characteristics	19
Identification of VAFO Valley Creek Management Concerns and Issues	28
Water Quantity	28
Acid Rain	29
Urbanization	29
Warner Quarry	30
Knickerbocker Landfill	31
Paoli Railyard	35
Persistent Pesticides	38
Chemclene	38
National Rolling Mills	39
Reconstructed Mill Dam	41

Table of Contents (continued)

State Route 252	41
Sewage and Coliform Contamination	42
Erosion and Sedimentation	43
Indicators and Standards of Resource Conditions	46
Water Resources	46
Biological Resources	46
Calculation of Inertia Indices	46
Calculation of Elasticity Indices	48
Comparisons of Standards and Existing Resource Status	50
VAFO Valley Creek Management Alternatives	54
Water Quantity	54
A. Problem statement and background	54
B. Current management actions and results	54
C. Alternative actions and probable effects	54
D. Recommended actions	55
Water Quality	56
A. Problem statement and background	56
B. Current management actions and results	56
C. Alternative actions and probable effects	56
D. Recommended actions	60
PCB Contamination	61
A. Problem statement and background	61
B. Current management actions and results	61
C. Alternative actions and probable effects	61
D. Recommended actions	62
Recreational Fishing	63
A. Problem statement and background	63
B. Current management actions and results	63
C. Alternative actions and probable effects	63
D. Recommended actions	64
Erosion and Stream Bank Stabilization	65
A. Problem statement and background	65
B. Current management actions and results	65
C. Alternative actions and probable effects	65
D. Recommended actions	67

Table of Contents (continued)

Cultural Resources	68
A. Problem statement and background	68
B. Current management actions and results	68
C. Alternative actions and probable effects	68
D. Recommended actions	69
Literature Cited	70

List of Tables

Table 1. Water discharge in Valley Creek at Pennsylvania Turnpike, U.S.G.S. station number 01473169, mean monthly values (cubic feet per second). . .	12
Table 2. Water discharge in Valley Creek at Pennsylvania Turnpike, U.S.G.S. station number 01473169, mean daily values (cubic feet per second, cfs) . .	13
Table 3. Valley Creek Stream Profile on 27-28 August 1987 from left to right bank looking upstream	20
Table 4. Valley Creek Stream Profile Means for each section from left to right bank looking upstream	23
Table 5. Laboratory Results from Pennsylvania Fish Commission	32
Table 6. Water chemistry of Valley Creek from the Knickerbocker Landfill area from fall, 1978 (Heister 1979). Some units are expressed differently than Heister (1979) to be comparable to DER standards	34
Table 7. PCB Analysis from the Pennsylvania DER (Knorr 1986, interagency memo) Fish flesh analysis for PCBs from Little Valley Creek (all collected at Mill Rd.)	36

List of Figures

- Figure 1: Map of the Valley Creek Drainage, emphasizing water quality impact sites. Numbers are sites collected for fishes and macroinvertebrates in this study 2
- Figure 2: Map of Valley Creek and nearby point-source/non point-source pollution and hazardous waste sites 25
- Figure 3: Map of the Washington's headquarters of Valley Forge National Historical Park with 100- and 500-year floodplains for Valley Creek indicated, adapted from flood preparedness plan outline developed by the U. S. Army Corps of Engineers. The inset shows the upper forge area. Some important cultural resources are indicated by the following numbers: 1 - Washington's HQ (extant), 2 - Stables (extant), 3 - Barn (extant), 4 - Grist mill (archaeological site), 5 - Saw mill (archaeological site), 6 - Potts/DeWees House (extant), 7 - Lower Forge (archaeological site), and 8 - Upper Forge (archaeological site) 26

List of Appendices

- Appendix A: Chapters 16 and 93. Water Quality Standards from the Pennsylvania DER (coldwater fishery)
- Appendix B: Map of Regional Sewer Systems - Valley Forge Sewer Authority, Chester County, Pennsylvania
- Appendix C: Pennsylvania Department of Environmental Resources National Pollutant Discharge Elimination System Application
- Appendix D: List of NPDES Permit Holders discharging into the Valley Creek Drainage-PA DER Computer File
- Appendix E: Valley Creek Station Descriptions, at the time of fish collections done by Penn State personnel
- Appendix F: Water quality data from selected stations collected 14 July 1987 by Penn State personnel
- Appendix G: Results of coliform testing completed by the Chester County Health Department on 21 August 1987 from samples collected by Penn State personnel
- Appendix H: Water quality data collected by the Chester County Health Department, legend
- Appendix I: Macroinvertebrates collected on 17 November 1987 by Penn State personnel
- Appendix J: Fishes collected July 1987 by Penn State personnel
- Appendix K: Field Measurements of Gamefishes collected July 1987 by Penn State personnel
- Appendix L: Jaccard Similarity Coefficients for macroinvertebrates collected by PSU personnel
- Appendix M: Jaccard Similarity Coefficients for fishes collected by PSU personnel

Appendices (continued)

- Appendix N: Historical fish collections currently catalogued in The Pennsylvania State University Fish Museum, collected by Dr. E. L. Cooper, Professor Emeritus of Zoology at Penn State
- Appendix O: Common names of the fishes collected and listed in historical collections
- Appendix P: Results of small mammal trapping done by Penn State personnel on 16-17 July 1987
- Appendix Q: Woody vegetation identified by Penn State personnel during summer 1987
- Appendix R: Data taken from National Park Service files in Valley Forge National Historical Park
- Appendix S: Reprint of Buikema, A. L., Jr., K. E. Schwaab, and J. Cairns, Jr. 1980. Pollution assessment: a training manual. UNESCO's Man and the Biosphere, U.S. MAB Handbook No. 1
- Appendix T: A copy of Reed (1990), Qualitative evaluation of the effects of changing watershed land uses on the hydrology, channel morphology, and historical uses of Valley Creek, Valley Forge National Historical Park, Pennsylvania

I. Description of Valley Creek Basin

Location, Size, and Physical Description

Valley Creek is a third order stream that drains a 23.4 mi.² (60.6 km²) area. The population of the Valley Creek drainage (within Chester County) was approximately 15,600 in 1980 (Chester County Planning Commission 1982). Figure 1 is a map of the Valley Creek drainage taken from United States Geological Survey (U.S.G.S.) (1988) quadrangle maps. Most of the basin is located in Chester County, more specifically in Tredyffrin and East Whiteland townships and the Malvern Borough. A small portion of the basin lies in Upper Marian Township, in Montgomery County. The population of Chester County is increasing. Below are population numbers from the 1980 census and projected population numbers for the county and some municipalities (Chester County Planning Commission 1988). The numbers are given in thousands.

	<u>1980</u>	<u>1990</u>	<u>2000</u>	<u>2010</u>
Chester County	317.0	359.0	396.0	420.0
Tredyffrin Township	23.0	26.7	28.5	29.8
East Whiteland Township	8.5	9.3	10.3	10.9
Malvern Borough	3.0	3.4	3.8	4.0

Tredyffrin Township has a population density of 1164 persons per square mile, East Whiteland has 782, and the borough of Malvern has 2608 (Chester County Planning Commission 1982).

Geology

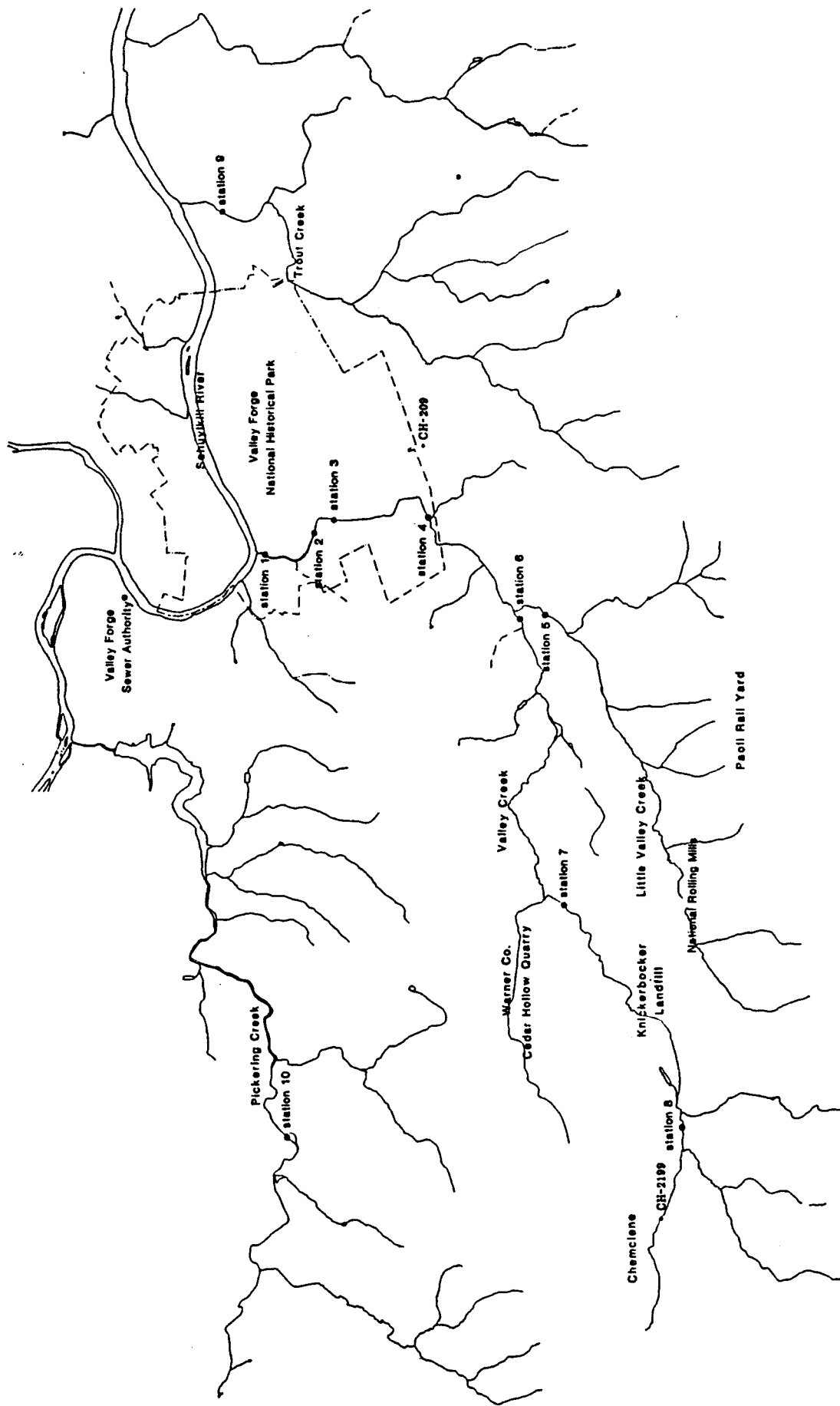
A major portion of the drainage consists of a valley of carbonate rocks such as limestones and dolomites. Chester Valley is flanked by hills of crystalline rock (mostly quartzite, schist, and gneiss) less likely to erode than carbonate rocks (Sloto 1987b). The limestones and dolomites are important for water retention (aquifers) and mineral content; both resources are exploited in the basin (Knorr 1985). These formations are 435 - 570 million years old (Sloto 1987a). The highest point in the drainage is Diamond Rock Hill on the northern slope at 668 ft. (203.6 m). Valley Creek enters the Schuylkill at 75 ft. (22.9 m). Altitudes are based on the National Geodetic Vertical Datum of 1929. The average channel slope for Valley Creek is 1.2% (Reed 1990). The upper part of the watershed, from the highest point to Church Rd., has a slope of 2.0% while the lower part has a 0.4% slope (Reed 1990).

Climate

The climate is a modified humid continental. A National Oceanic and Atmospheric Administration (NOAA) precipitation station is located in the basin at Devault, Pennsylvania.

[Map on file at Valley Forge National Historical Park]

Figure 1: Map of the Valley Creek Drainage, emphasizing water quality impact sites. Numbers are sites collected for fishes and macroinvertebrates in this study.



• High Capacity Well



VALLEY CREEK DRAINAGE MAP
with collection stations and threats indicated

Using their data, Sloto (1987b) estimated the average annual precipitation between the years 1951-1980 to be 1211.8 mm (46.92 inches).

Land Use

Changes in land use have been similar in the three municipalities drained by Valley Creek. These changes (by area, measured in acres) are documented below (Delaware Valley Regional Planning Commission 1984 from Sloto 1987a):

	Residential		Industrial		Commercial		Agricultural and Open Space	
	<u>1970</u>	<u>1980</u>	<u>1970</u>	<u>1980</u>	<u>1970</u>	<u>1980</u>	<u>1970</u>	<u>1980</u>
East Whiteland	1129	1422	396	505	1723	1932	3770	3165
Malvern	189	209	20	21	181	192	424	397
Tredyffrin	4228	4917	100	191	2404	2994	6009	4641

In East Whiteland and Tredyffrin townships land use for residential, industrial, and commercial purposes increased between 1970-1980 while agricultural and open space land use decreased (Sloto 1987b). The same was true for Malvern Borough. The immediate effect is an increase in peak discharge and runoff volume in Valley Creek. This is related to the growth of impervious areas (i.e., parking lots, roads, and roofs) which allow precipitation to flow quickly to streams. As of 1987, impervious areas covered approximately 9% of the Chester Valley (Sloto 1987b).

Water Resource Use and Development

In eastern Chester County approximately 62% of the population depends on ground water as their primary water source (Sloto 1987a). The Delaware River Basin Commission (DRBC) (1980), a cooperative body comprised of representatives from New York, New Jersey, Pennsylvania, Delaware and the federal government, has determined that all of the Valley Creek basin should be in a ground water protected area. As a result the DRBC set up specific guidelines governing ground water removal by persons, firms, or corporations. Guidelines were needed because of the increased growth in this area and the potential for the loss of ground water reserves during a drought. The mission of the DRBC is to maintain stream flows, ground water levels, and to protect overall quality of the water (DRBC, Groundwater Protected Area Regulations, Southeastern Pennsylvania 1980).

Reed (1990) discussed the historical conditions of the Valley Creek watershed. He found five phases. The first phase existed prior to settlement by colonists (pre-1700s). The condition of the watershed at this point was termed "excellent" because of the presumed large amount of vegetation and greater importance of groundwater to the flow of Valley Creek (Reed 1990). The next phase involved small amounts of clearing on the valley floor for agriculture and village sites. This period lasted from around 1700 until the American Revolution and the stream conditions would have been "good" to

"excellent" depending on the amount of the increase of sediment load to the stream (Reed 1990). Further deforestation occurred in the 3rd phase of the watershed's history. Up to 50% of the land had been denuded by the end of the 1800s and significant increases in sediment load and the concomitant increase in peak flows would have widened the stream channel (Reed 1990). Stream conditions would have been "good" to "fair" in phase 3. The effects of the industrial revolution began to appear in phase 4 of Valley Creek's history. More land was cleared and marginal agricultural land was converted to residential, commercial and industrial areas. Up to 60% of the watershed was now deforested and condition was probably "fair" to "poor" (Reed 1990). Presently, phase 5, the watershed is "poor" with the potential to become "fair". Peak flows may actually decrease with the conversion of marginal and prime agricultural lands to corporate centers. The channel conditions will continue to worsen because it is still adjusting to past changes in peak flows (Reed 1990).

Recreation

In the past, fishing for stocked trout in Valley Creek was very popular. Stocking and harvesting of trout was halted in 1984 when fishes in the stream were found to have high levels of PCBs, a carcinogenic chemical. When stocking ceased, fishing activity decreased dramatically but, as the wild trout population increased and the creek was designated a Class A Trout Fishery, the number of fishermen on the creek steadily rose until the number of fishermen now is about what it was prior to 1984. Valley Creek contains one of the few naturally reproducing populations of brown trout near a concentrated urban area (Philadelphia). Fishing remains a valuable resource.

Fishing is not the only recreational benefit of Valley Creek. The natural beauty of the stream and surrounding woodlands makes it popular among hikers, joggers, and picnickers. Besides Valley Forge National Historical Park there are other parks along Valley Creek and Little Valley Creek, including Mill Road Park and Valley Creek Park. Little Valley Creek flows through Mill Road Park. Valley Creek Park is located just downstream of the intersection of Valley Creek and Route 29 and is operated by East Whiteland Township.

II. Valley Creek Water Use and Management - Authority and Responsibilities

Water Quality Standards and Monitoring

The United States Environmental Protection Agency (USEPA) is obligated by the Clean Water Act to periodically publish and update water quality criteria. The publication, Quality Criteria for Water 1986 (USEPA 440/5-86-001), is a selective listing of literature concerning environmental contaminants and their effects on selected organisms. This list recommends levels that will have minimal adverse effects on aquatic life according to the most recent literature. These guidelines are not enforced. Water quality regulations are under total control of the state unless the USEPA determines that the state is not executing the task properly. The USEPA would then take direct actions to meet water quality standards until the state were able to enforce these standards.

The Pennsylvania Department of Environmental Resources (PADER) has water quality standards which list acceptable levels for those variables and pollutants it chooses to regulate. These can be found in Water Quality Standard of Chapter 93 of Article II (Rules and Regulations), subpart C (Protection of Natural Resources), Part I (Department of Environmental Resources) of Title 25 (Rules and Regulations) for the state of Pennsylvania. Sewage treatment plants are regulated in Chapter 94, industrial wastewater in Chapters 95 and 97, and phosphorus in Chapter 101 (Knorr 1988). These levels are based on information from the USEPA in part. The DER also considers different use classifications for each water supply and assigns criteria levels accordingly. For instance, surface waters used for drinking water have more stringent (safer) standards than one used for recreational purposes (e.g., a warmwater fishery). The designation for Valley Creek was recently changed from a coldwater fishery to Exceptional Value Waters. Discharge of industrial wastewater and sewage effluent into an EV stream cannot degrade "existing water quality" even for social and economic reasons. As an EV stream, the water quality criteria for Valley Creek are pegged to "existing water quality" conditions. There are no absolute numerical values. Because standards can vary from EV stream to EV stream, depending on each stream's "existing water quality", there is some difficulty in establishing measurable, quantifiable water quality standards for Valley Creek. Currently, the quality of water in Valley Creek equals or exceeds the water quality criteria for a cold water fishery, which is the designation it had before being upgraded to EV. CWF water quality criteria are listed in Appendix A. As a practical matter, when assessing stream conditions in Valley Creek, it is the CWF standards that will be used for establishing "existing water quality" conditions. Although some of these are values must not be surpassed (e.g., arsenic, copper, pH, etc.), many are based on daily, weekly, or monthly averages that involve several testing days (e.g., bacteria).

These values are designed to be used in detection of point-source pollution, which can be traced. Tracing organic pollutants such as pesticides, which lack a point-source, is very difficult because of rapid degradation of pesticides in the aquatic environment.

The only agency regularly monitoring Valley Creek is the Chester County Health Department (CCHD). They monitor quarterly but not on any set date. These data are public information and are available at the CCHD in West Chester. The PADER had monitored Valley Creek quarterly as part of its water quality network (WQN). Valley Creek was discontinued as station #157 of this network in 1987. The Pennsylvania Fish Commission only investigates if a fisheries management question is involved. Another group that monitors Valley Creek, though not on a regular basis, is the advanced biology class of Conestoga High School. They are led by Dr. Ralph Heister and did biological and chemical testing in 1972, 1978, 1983, 1986, and 1989. Data collected by the aforementioned groups are listed and discussed in section IV.

Sewage Facilities

The Valley Forge Sewer Authority (VFSA) began operation in 1978. The treatment plant, located on Pawlings Road in Phoenixville, discharges its effluent into the Schuylkill River. It serves the following townships: Tredyffrin, Easttown, East Whiteland, Malvern (borough), Willistown, East Pikeland, Charlestown, and Schuylkill. A map of this system is located in Appendix B. A pumping station is located on Wilson Road just outside of park boundaries. It is fed sewage by gravity through underground pipes. The sewage is then pumped under great pressure through a force main that parallels the creek. Where it crosses the stream it is buried beneath it. The sewer main exits from beneath Valley Creek at its confluence with the Schuylkill River. Here it crosses the river and continues until it reaches Pawlings Road where it again crosses the river enroute to the VFSA treatment plant. The large pipe visible in the creek at Washington's Headquarter is a water main operated by the Philadelphia Suburban Water Company (PSWC).

The Valley Forge National Historical Park uses partially its own sewage systems. The overall trend in the park is conversion from cesspools to leach fields. Those structures with leach fields include:

- Stirling's Quarters
- Rose Cottage
- Knox's Quarters
- Maxwell's Quarter
- Concession at Washington's Headquarters
- Valley Forge Railroad Station

The three structures with cesspools are Lafayette's Quarters, Frank Whittle house, and the Knox-Tindle house, while Dewees' house has a cesspool connected to a leach field. All the buildings in Valley Forge Village are connected to the Valley Forge Sewer Authority (Lambert 1988). In addition, the eastern portion of the park is connected to the Montgomery County sewer system.

Permit Programs

The goal of the Clean Water Act of 1975 was to eliminate the release of effluent to surface waters. The National Pollutant Distribution Elimination System (NPDES) was implemented to achieve this goal. The NPDES created a master list of all those who discharge waste into surface waters. State agencies under direction of the USEPA issue permits for the purpose of regulating discharge of effluents into surface waters. In Pennsylvania, the DER issues these permits. A sample application is located in Appendix C. Those NPDES permit holders currently discharging into Valley Creek or Little Valley Creek are listed in Appendix D. Many of these deal with discharge of treated sewage.

These discharge permits are specific in listing what chemicals a permit holder may release in its discharge, the quantity it may discharge, and the point of discharge. Through the permit process the DER tries to maintain receiving waters at state clean water standards (as described in section II).

Based on information supplied by the applicant, the DER proposes a draft permit and holds a public hearing to allow citizens to express opinions based on the draft. Hearings are also held at the time the permits are reissued, which occurs every 5 years. Compliance with the permit is monitored and reported by the permit holder although the DER may do spot testing to verify compliance. The permit holder is also required to notify the DER if violations of the permit occur.

III. Valley Creek Management - Valley Forge National Historical Park

Valley Creek Management Zoning

Valley Creek has various uses according to the management zoning as defined by the Park Service's General Management Plan (GMP) for the park. The entire stream is located in a historic zone, as is most of the park. Three major sections of the stream are in different subzones of the historic zone. A map of the management zones, not reproduced here, is found in the GMP.

From the mouth to the Knox covered bridge the creek is in a preservation subzone. This subzone emphasizes restoration, preservation, protection, and interpretation of cultural resources and their settings. Included in this area are Washington's Headquarters, several historic mill dam sites, one reconstructed dam at the site of the lower forge, and remnants of the upper and lower forge sites which gave the area its name. This section of Valley Creek will be managed to preserve these important historic features. The major activity in this subzone will be interpretation of the cultural resources and other quiet activities such as hiking, bicycling, picnicking, and fishing.

From the covered bridge upstream approximately 1900 stream feet (580 m) Valley Creek lies in a subzone for preservation, adaptive use, and park operations. The historic buildings are adapted for various park purposes and the natural resources are managed to complement these historic resources.

The remaining 2800 stream feet (853 m) of Valley Creek extending to the park boundary is in a preservation/public use subzone. Areas and structures of historic significance in this subzone are to be preserved and made available for public use. Spontaneous and light recreation will be allowed and natural systems will be preserved in a historic context. Activities in this area include horseback riding, fishing, picnicking, and hiking.

There are only two small portions within the close vicinity of Valley Creek that are not in the historic zone. For about 300 stream feet (91 m) below Wilson Rd. Valley Creek borders an institutional/private use subzone. This is a private use zone because of life tenants occupying some buildings, however the park owns the land and buildings. Beginning at Wilson Rd. and continuing approximately 400 stream feet (122 m) upstream, Valley Creek is bordered by a active recreation zone that is used mostly by fishermen. For a better graphical representation of these management zones see the management zone map in the General Management Plan.

Relationship to Applicable Legislation and NPS Planning Documents

Public Law 94-337 is the authorizing legislation for Valley Forge National Historical Park (VAFO) and it states that the park was established to:

"preserve and commemorate for the people of the United States the area associated with the heroic suffering, hardship, and determination and resolve of General George Washington's Continental Army during the winter of 1777-1778 at Valley Forge."

Valley Creek is an important part of the history of the encampment period. Since before the time of the encampment, human influence has degraded the stream. The Park Service will monitor water quality and quantity in the park and will work with other agencies and interests to prevent deterioration, in accordance with the GMP. The Valley Forge area is to be preserved for its historical significance. In historic zones natural resources will be managed primarily to complement historic resources. In recreational zones the available resources will be managed for the benefit of recreation. Management policies vary within each management zone. The GMP refers to the brown trout as a native which it is not. It was brought into North America from Europe in the 1800s.

The GMP directs NPS to preserve and maintain the historic setting and remnants from the encampment period. Objectives include the "protection and management of natural resources through research, surveys, and other means." Valley Creek is to be managed as a "natural stream associated with the historic encampment." More detailed goals for Valley Creek management are included in the natural resources section of the Resource Management Plan (RMP). Most of these concerns are addressed in section VIII, Valley Creek Management Alternatives.

The U.S. Department of the Interior, National Park Service, Management Policies (1988) set some management strategies for national parks in general that can be applied to VAFO in particular. These include:

- All water withdrawn from a park for domestic use will be returned to the park watershed system. Interbasin transfer will be avoided (Chap 4:15)
- The NPS will seek to restore, maintain, or enhance the quality of all surface and ground waters within the parks consistent with the Clean Water Act and other applicable federal, state, and local laws and regulations (Chap 4:15)
- Human activities will be managed to control erosion (Chap. 4:16)
- The NPS will enter into agreements or compacts with other agencies and governing bodies to secure their cooperation in avoiding water pollution (Chap. 4:5)
- Consistent with the rights of others, the Park Service will maintain a continuous vigilance by observing and monitoring upstream diversions, adjacent uses, and groundwater withdrawals and their effects on the occurrence, quantity, and quality of water necessary for the continued preservation of park biota and ecosystems (Chap. 4:16)

-management of populations of exotic plant and animal species, up to and including eradication, will be undertaken wherever such species threaten park resources or public health and when control is prudent and feasible (Chap. 4:12)

When considering the effects of any management action on Valley Creek, certain laws and regulations should be reviewed. Of particular importance to park managers are those laws that pertain to wetlands. These include the National Environmental Policy Act of 1969 (NEPA), The Clean Water Act of 1972, Executive Order 11990 (protection of wetlands), Executive Order 11988 (floodplain management), and the Rivers and Harbors Appropriation Act of 1899. These are discussed in detail in the NPS document, Wetlands Regulatory Compliance: A Guidance Manual for the National Park Service, Mid-Atlantic Region (1989). Other acts of importance to VAFO include the National Historic Preservation Act, the Archeological Protection Act, and section 4f of the National Transportation Act.

Valley Creek NPS Management Objectives

1. Manage Valley Creek as a natural stream in accordance with the General Management Plan;
2. Meet or exceed Pennsylvania DER standards for a coldwater fishery;
3. Meet or exceed USEPA standards for appropriate water quality variables;
4. Develop alternative management strategies for all significant threats and issues, and select recommended actions;
5. Establish a system for monitoring selected variables and all significant threats and issues;
6. Coordinate efforts with state and local government agencies, schools, and conservation groups which are involved in monitoring or managing Valley Creek;
7. Provide for suitable recreational activities in accordance with the GMP;
8. Protect and preserve cultural sites;
9. Identify, review, and evaluate current baseline data and collect additional data if existing baseline is deficient.

Recommendations for Valley Creek management activities to achieve these goals will be discussed more extensively in section VIII, Valley Creek Management Alternatives.

IV. Valley Creek Resources - Description and Condition

Water Resources

Quantity

Heister (1986) claimed excessive water withdrawal from the Valley Creek basin was a result of the installation of the Valley Forge Sewer System. The system takes water from Valley Creek (and other drainages) and sends it to the Schuylkill River as treated wastewater. Knorr (1985) listed water use for quarry operations and groundwater removal for public water supplies as other reasons for the loss of groundwater. The growth of impervious areas, which reduces the amount of rain reaching aquifers, can also affect water levels. The urbanization of the Valley Creek basin is accompanied by the growth of impervious areas, such as rooftops and parking lots. These factors are all discussed more fully in section V, Valley Creek Management Concerns and Issues. The Delaware River Basin Commission (1980) has limited the amount of groundwater a person, firm, corporation, or other entity can withdraw to 10,000 gallons (37,850 liters) per day under its Groundwater Protected Area Regulations (DRBC, Groundwater Protected Area Regulations, Southeastern Pennsylvania 1980). There are several exemptions to this rule, however. One organization that is exempted from the DRBC rules is the Philadelphia Suburban Water Company. The Warner Quarry is also exempted and is under the jurisdiction of the DER Bureau of Mines.

If the water level in Valley Creek decreases many negative events can happen. Fishes and other aquatic animals lose habitat necessary for reproduction and survival. Summer water temperatures would increase with the reduced influence of cold spring water. Concentration of many pollutants, from road salt to PCBs, would increase, and their effects on aquatic life would be amplified.

A United States Geological Survey continuous recording station located approximately 0.1 mi. (0.16 km) upstream from the boundary of the Valley Forge National Historical Park monitors stream discharge in the upper 20.8 mi.² (53.9 km²) of the Valley Creek drainage, whereas the lower 2.6 mi.² (6.7 km²) is not gauged. Baseline water flow data from this station appear in Tables 1 and 2. Table 2 isolates the months of July and August 1987 because that is the time of lowest flow. Without information on precipitation these data explain little about the flow patterns of Valley Creek. A complete water budget analysis by a hydrologist would find any trends in stream flow.

Quality - Chemical and Bacteriological

Although Valley Creek has had many problems with water quality in the recent past, there are some positive points to report. Knorr (1985) found no violations of the DER chapter 93 water quality criteria on upper Valley Creek, in a study done in the fall of 1984. However, groundwater contamination is more likely in the limestone/dolomite

Table 1. Water discharge in Valley Creek at Pennsylvania Turnpike, U.S.G.S. station number 01473169, mean monthly values (cubic feet per second).

<u>Month</u>	<u>1982</u>	<u>1983</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>
January		26.0	28.8	16.8	39.0	39.5	27.7
February		30.6	53.5	31.1	43.8	34.0	37.5
March		65.5	60.4	17.9	37.1	40.3	30.0
April		98.8	84.9	18.1	36.6	43.5	28.5
May		60.1	77.5	25.4	26.4	32.8	39.2
June		40.9	49.9	16.9	18.2	26.5	23.4
July		24.5	46.4	18.5	29.4	28.4	28.6
August		19.1	28.7	23.5	22.7	23.3	
September		18.9	23.6	38.1	15.4	24.6	
October	17.6	21.4	27.4	19.3	15.0	21.4	
November	24.7	29.2	22.7	32.8	48.8	30.6	
December	22.4	60.8	20.7	28.3	44.9	22.9	

Table 2. Water discharge in Valley Creek at Pennsylvania Turnpike, U.S.G.S. station number 01473169, mean daily values (cubic feet per second, cfs)

<u>Date</u>	Discharge (cfs)	
	<u>July 1987</u>	<u>August 1987</u>
1	80	19
2	74	18
3	28	18
4	25	18
5	24	35
6	23	48
7	26	20
8	23	19
9	28	29
10	25	84
11	25	22
12	33	20
13	24	19
14	85	19
15	34	19
16	24	18
17	23	18
18	22	18
19	21	18
20	21	17
21	20	17
22	20	20
23	19	18
24	19	17
25	19	17
26	20	17
27	19	27
28	19	33
29	18	24
30	19	18
31	20	18

formations found in the Valley Creek basin because of underground solution channels. Contaminants that enter these channels can move rapidly underground to distances far from the source. Sloto (1987a) lists additional information on the geology of limestone/dolomite formations.

Fourteen sites were sampled in this study. Sites 1 through 8 were located on Valley Creek to characterize all parts of the stream. Water quality was assessed using chemical testing and faunal surveys. One site each from Pickering Creek, Trout Creek, French Creek, the east branch of Perkiomen Creek, Swamp Creek, and Ridge Valley Creek was chosen for comparison purposes (stations 9 through 14, respectively). These sites are described in Appendix E. (The site numbers in Appendix E correspond to the site numbers in Appendix F, G, I, J, L, M, N, O, P, and Q.) Data in these tables were collected and analyzed by the authors of this report and/or Pennsylvania State University personnel unless otherwise noted in the text or table heading.

The results of the water quality testing done on 14 July 1987 at a portion of these sites are in Appendix F. Variables were recommended by VAFO personnel. These were analyzed by the Land and Water Research Institute at The Pennsylvania State University. None of the values reported in Appendix F exceed DER standards or USEPA recommended criteria. Nitrogen as nitrate (NO_3^- -N) values are all below the DER standard of 10 mg/l. Copper (Cu) levels are below 0.1 mg/l and manganese (Mn) levels are below 1.0 mg/l, both DER standards. The measurements of nickel (Ni) and lead (Pb) are less than the chronic damage levels suggested by USEPA, 0.19 mg/l and 0.01 mg/l, respectively. This means 95% of all aquatic animals are protected from harm if measurements stay at or below this level. Concentrations for nickel and lead are also below the human health criteria suggested by USEPA. When factoring in the water temperature and pH recorded the day these samples were collected (Appendix A) the levels of nitrogen as ammonia (NH_3 -N) were below the suggested USEPA hourly concentrations (USEPA 1986b). These values correspond closely with DER standards. There is no standard for total phosphates but eutrophication (a result of high concentrations of phosphates) was not noted.

The CCHD completed coliform testing at each site (Appendix G) from samples collected by Pennsylvania State University personnel. The results indicate a possible human fecal contamination. However, these data cannot be compared to DER standards because they were not collected in the same manner that the standards dictate, five consecutive samples over at least as many days.

Water quality data collected by the CCHD from 1981 to 1985 are listed in Appendix H. Data similar to this are readily available from the CCHD from their open files. These data should be viewed as baseline data. Since flow data were not collected, information on the most obvious form of variation is absent. We must also make the assumption-a reasonable one-that those who collected the data did so correctly and the instruments

were sufficiently sophisticated. Comparison of these data with standards is included in section VI.

Biological Resources

Aquatic Resources

Macroinvertebrates were collected at stations 1 through 10 on 17 November 1987 using D-frame kick nets (Appendix I). Nine 20-second kick sub-samples were made (Frost et al. 1971). All habitats (pool, riffle, run) were sampled, however, emphasis was placed on riffle areas and those areas with vegetation because these habitat types are commonly known to be the most productive with regard to macroinvertebrates (Rabeni and Minshall 1976). Samples were preserved in 70% isopropanol and 5% formalin and transported to the laboratory for sorting and identification. Specimens were identified to the lowest practical taxon (usually genus). Identifications were based on the following keys: Pennak (1953), Wiggins (1977), and Merrit and Cummins (1984).

On 8, 9, 13, and 14 July 1987, seines and DC electrofishing gear were used to collect fishes at each station (Appendix J). All existing habitats at a site were thoroughly sampled to obtain a representative qualitative collection (Hocutt et al. 1974). Fishes were tentatively identified in the field (gamefishes at sites on Valley Creek were weighed, measured and released, Appendix K) and sampling continued at each station until it was thought that further efforts would yield no additional species. Samples of fishes were preserved in 10% formalin, returned to the laboratory for positive identification, and permanently stored in 50% isopropyl alcohol. All specimens were catalogued into The Pennsylvania State University Fish Museum. Temperature, substrate type, and habitat were recorded at each station.

Diversity indices were calculated using Brillouin's (1960) formula which is based on information theory:

$$H = (1 / N) \times (N! / N_1!N_2!\dots N_s!)$$

where H is equal to diversity; N is the total number of individuals in the sample; N_1, N_2 , etc., are the number of individuals in species 1, 2, etc.; and s the total number of species in the sample. This index is preferred for most problems in applied aquatic ecology (Pielou 1966, Kaesler et al. 1978) because it is a measure of the diversity of the sample, which is the working unit of the investigator rather than a statistical estimate. The index was calculated using the computer program of Stauffer et al. (1980) which eliminated the need for an approximation of factorials. The diversity index used here incorporates the number of species present and the number of individuals of each species. If a collection consists of twenty species all represented by a comparable number of individuals a relatively high diversity index will be calculated. Conversely, if twenty species are collected and only one or two species comprise the majority of individuals collected, a

lower diversity index will be calculated. Thus, while a higher diversity index is usually calculated when there is a high number of species present, this is not always the case.

Similarity coefficients for all stations were calculated using the formula of Jaccard (Sneath and Sokal 1973):

$$S_j = (a / (a + u))$$

where S_j is the Similarity Coefficient; a is the number of species which were present at both stations; and u is the number of mismatches.

The Jaccard similarity coefficient used in this report measures only the presence or absence of a taxa. In other words, if sample one consists of 20 specimens of species A, 30 specimens of species B, and one specimen of species C, and sample two consists of 1 specimen of species A, 5 specimens of species B, and 30 specimens of species C, the similarity coefficient between sample 1 and sample 2 will be 1. They will be 100% similar since they both contain taxa A, B, and C, even though the numbers of each taxa are not the same. Similarity coefficients are included for macroinvertebrates (Appendix L) and for fishes (Appendix M).

The survey of fishes included eight stations (stations 1 through 8) in the Valley Creek drainage with four located in the park. Existing ichthyofauna of Valley Creek was compared to the fauna in six comparable streams (stations 9 through 14). For eastern Pennsylvania (and most localities in the U.S.) there is a historical record for fishes but none for insects. That is, past collections of fishes were done, these fishes are housed in museums, and comparisons can be made. Past collections of fishes by E. L. Cooper, presently professor emeritus of Fisheries at Pennsylvania State University, are listed in Appendix N. Extensive collections of insects are not available. The macroinvertebrate sampling is done primarily to determine within-stream differences in the Valley Creek drainage. This helps to isolate pollution effects and their possible point of origin. A substantial drop in diversity from one station to the next would indicate a toxic event may have occurred between the two stations.

A total of 17 fish species was captured in the Valley Creek drainage basin (Appendix J). Common names of fishes for these and historical collections are located in Appendix O. Fishes were also collected at six stations outside the Valley Creek drainage but in the Schuylkill River basin. Station 9 was Trout Creek which is the next tributary to the Schuylkill River downstream of Valley Creek. Station 10, Pickering Creek, and station 11, French Creek, are both relatively large tributaries to the Schuylkill River. Stations 12 through 14 (East Branch of Perkiomen Creek, Swamp Creek, and Ridge Valley Creek, respectively) are tributaries to Perkiomen Creek with the same relative size as Valley Creek. The Trout Creek station was characterized by extremely low flows and was littered with garbage and trash, hence the low number of both species and individuals present at this site.

When the stations located in Valley Creek are compared with the remainder of the stations located outside the basin (stations 10-14) it is obvious that Valley Creek harbors a depauperate ichthyofauna. Valley Creek has fewer fish species than one would expect for a healthy stream in this biogeographic area.

Two species of fishes were captured in the Valley Creek watershed which were not present at the stations outside of this drainage. One species, *Pimephales promelas*, is a common baitfish which may have been introduced into Valley Creek. Of particular interest is the presence of *Margariscus margarita*, the pearl dace, at station 8 in Valley Creek. *Margariscus margarita* is a relatively uncommon species in the southeastern portion of Pennsylvania and efforts should be made to protect this population by protecting the habitat. Conversely, there were 13 species which occurred at the stations outside of the Valley Creek watershed, which were not present at any of the eight stations located in the Valley Creek basin.

The depauperate ichthyofauna of Valley Creek is reflected by the diversity indices (0.62 - 1.57) and higher number of species (13-20) present at stations 10-14 than at Valley Creek (3-9) (Appendix J). Valley Creek would have a higher diversity of fishes if not for perturbations over, presumably, the last few hundreds of years. This condition is further reflected by the similarity coefficients (Appendix M) which are low when the Valley Creek stations are compared with the stations 10-14.

That Valley Creek has been influenced by perturbations is further supported by the macroinvertebrate collections (Appendix I), which show that station 10 had a substantially higher number of taxa present (47) and a higher diversity index (2.83) when compared to stations 1 - 8 (diversity indices 0.98 - 2.26; number of taxa 17 - 24). There was a greater number of individuals collected at the Valley Creek stations than at Pickering Creek. These higher numbers were usually due to the abundance of chironomids (midges), tipulids (crane flies), nematodes (roundworms), isopods (sow bugs), and amphipods (scuds) at the Valley Creek sites. A high number of individuals of a few species is usually indicative of a toxic stress. Such a stress eliminates some species, which in turn reduces competition for those taxa still present in the system and permits them to maintain high population numbers.

Based on extensive surveys of the Atlantic Coastal streams (streams that eventually flow into the Atlantic Ocean) in Pennsylvania, the fish fauna found at stations other than Valley and Trout creeks is indicative of good water quality. The fauna at the Valley Creek stations is indicative of a stressed ecosystem.

Sloto (1987a) reported that trends of diversity indices are increasing on stations on Valley Creek near Valley Forge and Little Valley Creek near Howellville. He thought the overall increase in diversity since 1973 may be due to the banning of persistent insecticides, which usually accumulate in the stream bottom. Indices continued to increase when the Valley Forge Sewer System was installed in 1977 (Sloto 1987a). It

essentially closed smaller plants that operated along these two streams. Our survey cannot dispute this trend although our diversity indices for 1987 were lower (Appendix I) than Moore's values of greater than 3 for Valley Creek at Valley Forge (Sloto 1987a). This could be explained by different sampling methods. The exact method by which the macroinvertebrates are collected must be identical to compare diversity indices. The method of calculation of the diversity index is also crucial. If one uses an approximation of a factorial the index would be an estimate rather than a precise calculation. If the park uses the techniques described in this report, comparisons with data collected at a later date can be made.

Another aquatic resource that was not systematically studied was the plant community in Valley Creek. The large beds of *Elodea* found in Valley Creek are very common in limestone-rich streams. They are important fish habitat especially for juveniles for species such as brown trout and the sunfishes.

Terrestrial (riparian) Flora/Fauna

Eight sampling locations (sites 1 through 8) in and upstream of VAFO were trapped to identify small mammals present in the riparian zones along Valley Creek. Five Sherman live-traps were baited and placed at 10 meter intervals parallel to the stream at each location. Attempts were made to place traps in riparian vegetation "typical" of each sampling location and concealed so as to prevent human disturbance. Any mammals captured were identified to species with the aid of Burt and Grossenheider (1976), and released. The results of two nights of trapping are given in Appendix P.

The live-trapping method employed for this survey does not lend itself to complete determination of local small mammal fauna. *Peromyscus leucopus*, *Peromyscus maniculatus*, and *Microtus pennsylvanicus*, all captured during this survey, are three of the most common species found in Pennsylvania. Their habitat requirements are quite general and are met by numerous different vegetative communities. Other common animals were white-tailed deer, muskrats, raccoons, and the northern water snake, *Nerodia sipedon*.

A visual survey of woody vegetation at each sampling location (same as above) was accomplished by walking parallel to the stream for approximately 25m and identifying all woody vegetation observed within approximately 30m of the stream bank (Appendix Q). Any plants that could not be positively identified in the field with the aid of Petrides (1972) were collected for subsequent identification by Pennsylvania State University faculty. While every effort was made to identify all woody vegetation present, the resulting species list should not be considered a comprehensive inventory.

Stream bank vegetation serves numerous functions in both the aquatic and terrestrial communities. It provides a source of shade which helps keep stream temperature low and decreases the chance of summer fishkills of coldwater fishes such as trout. It also

contributes to bank stabilization which protects adjacent man-made development because a wandering stream channel can have devastating effects on roads and other man-made structures. Root systems or limbs that may reach out into the stream provide shelter for fish, especially young fish which are more vulnerable to predation. Likewise, when trees fall into the stream they also provide habitat and sanctuary for aquatic fauna. Logs and trees only become a problem when they change the current direction in such a way as to threaten the stability of a bank.

Rare, Endangered, and Threatened Species

Fishes: No federally endangered or threatened fishes were found in this study. The bridle shiner, *Notropis bifrenatus*, has a historical range which includes the Schuylkill River and may possibly be found here. It is listed as vulnerable to extinction by the Pennsylvania Biological Survey (Horwitz 1985). Listed as extirpated from Pennsylvania but historically found in the Valley Creek area is the ironcolor shiner, *Notropis chalybaeus* (Gilbert 1985). Extirpation is the loss of a species from a local geographic area.

Other Vertebrates: No federally endangered or threatened reptiles, amphibians, or mammals were found in our study. There is a possibility of finding the bog turtle, *Clemmys muhlenbergii*, which is listed as endangered by the Pennsylvania Fish Commission, in the Valley Forge area (Kulp 1987). The preferred habitat for this turtle is marshy meadows and sphagnum bogs (Ernst 1985). Threatened or endangered species may exist that were simply not found due to small sample size.

Plants: The only federally endangered plant to have a historical range within Pennsylvania is *Isotria medeoides*, the small whorled pogonia (U.S. Fish and Wildlife Service 1987). These were not found during our study.

Stream Channel Characteristics

Valley Creek was characterized in the following manner. Stream channel characteristics were measured on 27-28 August 1987 when the flow was at a typical summer level. Beginning at the mouth, random numbers ranging from 1 to 100 were used to pace off sections of the stream. As each random number of steps was walked, stream measurements were taken. First, stream width was measured with a tape measure. With the width information, water depth (at low summer flow) was measured with a meter stick at 1%, 10%, 33%, 50%, 66%, 90%, and 99% of the width, starting on the southern shore. This gave a stream profile of the entire stream without bias to any one section. This was done for the entire length of the stream in the park. Also, at each point substrate (silt, sand, gravel, cobble, rubble, boulder, or bedrock) and stream character (riffle, run, or pool) was noted. Eighty-four measurements were taken (Table 3). The mean values for certain sections of the stream are given in Table 4. The stream was divided into recognizable sections based on physical characteristics.

Table 3. Valley Creek Stream Profile on 27-28 August 1987 from left to right bank looking upstream.

Width (m)	Depths at percents of widths (cm)						
	<u>1%</u>	<u>10%</u>	<u>33%</u>	<u>50%</u>	<u>33%</u>	<u>10%</u>	<u>1%</u>
12.5	6	16	43	18	28	21	17
6.2	10	27	52	54	47	32	3
8.2	1	4	1	19	30	18	1
8.23	2	7	28	21	14	19	2
15.5	7	50	63	24	14	6	4
11.6	1	56	82	68	20	7	11
12.6	8	34	26	26	35	24	4
9.7	5	18	38	23	24	28	1
9.5	1	31	24	16	12	8	1
Rt. 23 Bridge**							
10.3	2	17	9	27	28	12	9
12.0	6	39	> 100	> 100	> 100	> 100	> 100
9.8	6	71	72	86	101	33	0.5
10.1	7	19	47	78	52	37	3
11.6	7	22	60	78	64	25	7
9.5	17	27	33	42	30	6	2
10.6	4	10	38	31	57	19	5
19.2	8	29	57	49	20	11	3
dam							
*17.1	130	130	130	130	130	130	130
10.0	> 150	> 150	112	110	93	40	10
15.5	47	82	73	49	32	6	1
13.7	26	35	76	76	56	10	1
14.7	8	85	72	63	36	21	4
15.4	8	77	72	56	40	30	15
14.0	7	81	65	49	39	23	10
16.0	3	78	51	68	87	> 100	14
14.4	8	61	43	42	53	58	15
12.3	14	41	47	51	64	60	11
12.3	26	48	60	51	47	31	3
10.9	10	74	79	54	38	26	7
end of slack water behind dam							
9.1	17	56	59	43	23	13	4
8.5	5	44	74	46	26	14	3
11.3	6	10	25	13	13	9	5
10.0	4	14	25	29	31	19	3
13.6	7	14	24	6	6	6	2
14.65	4	4	13	25	33	38	4
9.5	2	27	88	114	113	55	4
9.35	2	3	32	60	62	20	2

Table 3. (continued)

Width (m)	Depths at percents of widths (cm)						
	<u>1%</u>	<u>10%</u>	<u>33%</u>	<u>50%</u>	<u>33%</u>	<u>10%</u>	<u>1%</u>
				footbridge			
11.15	8	27	41	35	32	17	5
11.1	9	13	17	18	27	10	2
11.08	3	12	26	26	20	13	4
8.9	4	18	32	26	32	25	4
11.4	3	10	6	16	10	8	2
16.0	5	24	14	12	17	9	3
13.7	1	3	20	32	44	17	4
8.35	10	7	39	48	43	16	2
				covered bridge			
8.1	2	6	9	20	14	9	3
14.4	5	11	17	7	5	0	6
9.6	5	29	64	56	25	5	3
12.3	3	10	11	13	8	30	11
8.6	5	21	33	30	19	12	1
10.2	3	14	32	37	28	10	1
10.9	2	9	18	23	24	9	2
10.95	5	7	10	15	15	11	4
12.4	4	8	11	31	8	14	4
8.7	1	18	38	24	19	18	12
9.4	4	37	31	27	26	15	3
10.8	4	7	15	10	17	0	1
12.2	8	35	49	43	47	31	8
17.8	7	13	24	25	17	18	2
10.6	3	24	40	18	25	6	3
13.0	7	12	12	6	13	10	4
10.2	1	5	17	20	2	12	2
13.8	25	31	47	65	75	50	8
11.1	2	5	12	11	11	21	8
10.65	2	5	12	15	19	19	2
12.6	10	20	23	13	19	5	2
9.7	8	28	21	21	8	4	1
11.4	13	22	34	35	20	14	9
9.0	13	40	40	52	37	15	6
8.6	15	19	18	1	25	16	4
6.7	3	5	6	12	18	13	7
7.3	2	17	59	60	51	31	1
8.7	2	6	20	16	20	6	1
9.5	2	21	65	54	37	7	2
8.95	8	40	64	48	38	16	2

Table 3. (continued)

Width (m)	Depths at percents of widths (cm)						
	<u>1%</u>	<u>10%</u>	<u>33%</u>	<u>50%</u>	<u>33%</u>	<u>10%</u>	<u>1%</u>
			covered bridge (continued)				
6.4	13	44	53	65	82	20	2
11.4	10	16	21	23	18	13	2

*measured directly behind dam; **landmarks to denote stream sections

Table 4. Valley Creek Stream Profile Means for each section from left to right bank looking upstream

<u>Section</u>	<u>Width(m)</u>	<u>Depths at percents of widths (cm)</u>						
		<u>1%</u>	<u>10%</u>	<u>33%</u>	<u>50%</u>	<u>33%</u>	<u>10%</u>	<u>1%</u>
1	10.45	4.5	27.0	39.7	29.9	24.9	18.1	4.9
2	11.64	7.1	29.3	52.0	61.4	56.5	30.4	16.2
3	13.85	25.7	78.5	73.6	66.6	59.6	44.6	18.4
4	10.75	5.9	21.5	42.5	42.0	38.4	21.8	3.4
5	11.62	6.3	23.9	30.3	30.9	27.9	19.9	3.5
6	10.50	6.2	18.3	28.7	28.0	24.7	14.4	4.0
overall	11.30	8.9	30.2	40.1	38.8	34.6	22.3	7.2

Sections

- 1 Valley Creek mouth to Rt. 23 bridge
- 2 Rt. 23 bridge to historic mill dam
- 3 historic mill dam to end of slack water
- 4 end of slack water to footbridge
- 5 footbridge to covered bridge
- 6 covered bridge to park boundary

Riffles are shallow areas with higher gradients than pools and runs. Runs are deeper and are characterized by low level turbulence. Pools are deeper with slower current velocities and are termed depositional zones since stream sediments and detritus settle here. The exact determination of these stream habitats is very subjective. The ratio of riffles to runs to pools was 32:32:20. This shows the stream has a good gradient or vertical drop in water level per unit stream distance. Over 75% of the stream habitat is either runs or riffles. More than half of the pool sites were behind the reconstructed historic mill dam.

Throughout the entire stream the dominant substrate is cobble and gravel with sand and silt prevalent immediately upstream of the dam. Shallow riffles and runs with a cobble or gravel substrate make suitable spawning areas for brown trout. Valley Creek is therefore well-suited for brown trout reproduction (when other conditions such as temperature are suitable), except for the large pool behind the dam. Some small sections of Valley Creek flow over bedrock. The deepest water (up to 1.5 m) was located behind the dam.

The stream changes markedly in the vicinity of the covered bridge. Upstream of the bridge the land is relatively flat while below this area the stream is forced into a narrow gorge. Mount Joy and Mount Misery form the sides of this gorge. This difference in surrounding geomorphology could explain the difference in stream bank height in these two sections. The susceptibility to erosion of the banks below the covered bridge could also be explained by the large number of dams historically found there. The sediment deposits resulting from these dams, which form the present stream bank, are subject to erosion. A tributary flows down Mount Misery and enters Valley Creek approximately 150 feet (100 m) downstream of the reconstructed mill dam. A second tributary in the park is near the Wilson Rd. bridge. It is only intermittent and Reed (1990) used this fact as proof that the base flow of Valley Creek has decreased as a result of development. Other tributaries are indicated on Figure 1.

Beginning at the footbridge and extending approximately 200 feet, there are retaining walls that protect the road and the archaeological remains of the upper forge. The walls also force the creek into a narrow chute which increases the velocity of the water. The increased water velocity has scoured the substratum leaving only large rocks. This also occurs at bridges when water is forced through a narrow gap. The alteration of the stream bottom here is acceptable because of the importance of protecting the cultural landmarks of the old forge.

A map of the entire drainage is provided, showing all tributaries (Figure 1); some real and potential pollution impact sites are included. A more complete map of point/non point-source pollution and hazardous waste sites is given (Figure 2). Cultural sites and how they relate to Valley Creek are also an important part of the park's resources. Maps depicting the flood plains, in relation to cultural resources are also given. Figure 3

[Map on file at Valley Forge National Historical Park]

Figure 2: Map of Valley Creek and nearby point-source/non point-source pollution and hazardous waste sites.

[Map on file at Valley Forge National Historical Park]

Figure 3: Map of the Washington's headquarters of Valley Forge National Historical Park with 100- and 500-year floodplains for Valley Creek indicated, adapted from flood preparedness plan outline developed by the U. S. Army Corps of Engineers. The inset shows the upper forge area. Some important cultural resources are indicated by the following numbers: 1 - Washington's HQ (extant), 2 - Stables (extant), 3 - Barn (extant), 4 - Grist mill (archaeological site), 5 - Saw mill (archaeological site), 6 - Potts/DeWees House (extant), 7 - Lower Forge (archaeological site), and 8 - Upper Forge (archaeological site).

is a map of the area near Washington's headquarters with the 100 and 500 year floodplains indicated. An inset to this figure indicates the floodplain boundaries for that portion of Valley Creek near the upper forge. Further information regarding flood preparedness and Valley Creek along with additional information on hydrology, stream channel characteristics, and erosional processes can be found elsewhere (U.S. Army Corps of Engineers 1981).

V. Identification of VAFO Valley Creek Management Concerns and Issues

Water Quantity

The amount of water in Valley Creek basin may be decreasing for many reasons. Sloto (1987a) documents the loss of flow in different reaches of Valley Creek. Water may be depleted due to an increase in impervious areas which lowers the amount of water absorbed into underground aquifers. This process also increases discharges during periods of high rainfall (Sloto 1987b).

Another process that decreases water in a given drainage basin is interbasin exchange, where groundwater or surface water is transferred from one basin to another. The Valley Forge Sewer Authority facility takes wastewater from many smaller basins and empties it as treated wastewater into the Schuylkill River. The release results in a large loss of water in the Valley Creek basin.

Groundwater may also leave a basin through infiltration into sewage systems. This is related to the altitude of the sewer line relative to the altitude of the groundwater. Groundwater that is higher than a sewer line will lose water to it while lower (deeper) groundwater levels result in sewage infiltration of the groundwater (Sloto 1987a). Groundwater that is lost to the sewer system is not discharged into streams, resulting in lower flows (Sloto 1987a).

Groundwater removal by Warner Quarry has led to a depression of the water table in the immediate area and is limited to the quarry region because of the rock formations found nearby (Sloto 1987a). Removal by Warner Quarry averaged 5 million gallons/day (MGD, or 19 million liters, MLD) in 1984 (Sloto 1987a). Catanach Quarry is located just west of Warner Quarry. The groundwater it uses is put back into a closed depression that acts as a groundwater recharge area (Sloto 1987a) reducing the amount of groundwater lost.

The pumping of 2 high-capacity wells by the PSWC may have caused water depletion in some stretches of Valley Creek and totally dried some tributaries (Sloto 1987a). Well CH-2199 is located near State Route 401 and U.S. Route 202 and well CH-209 is at State Route 202 and the Pennsylvania turnpike. Their locations are shown in Figure 1. Another well is in the adjacent Trout Creek drainage. Combining the amount of water the PSWC pumps from wells, 552 MG (2.1 billion liters, BL) and commercial pumping, 78 MG (300 million liters, ML), the Valley Creek basin lost 630 MG (2.4 BL) in 1984 (Sloto 1987a).

The potential effects of these activities, as described in section V, include the loss of habitat for aquatic life and greater concentration of pollutants. Though these effects have not been observed, the data (Sloto 1987a) shows that the lower water table levels are a reality and these effects are likely to be in Valley Creek's future. Chester County

Board of Commissioners (Chester County Planning Commission 1979) discusses more long range problems associated with water loss. Heister's (1986) prediction that low flow could become Valley Creek's biggest problem may be realized in coming years.

Acid Rain

In a limestone stream such as Valley Creek acid rain would have very little, if any, effect. The high calcium carbonate concentrations found in water from limestone formations has a high chemical buffering capacity. The calcium carbonate neutralizes the acidic precipitation eliminating any effect.

Urbanization

The effects of urbanization in eastern Chester County are pronounced in the Chester Valley (Sloto 1987a). These effects (other than those concerning water quantity) include contamination of groundwater by organic chemicals. Volatile organic compounds move through limestone aquifers. They originate from many sources including industrial spills, leakage from storage tanks, and discharge from septic systems, lagoons and disposal sites (Sloto 1987a). As part of the mining process, water is pumped from quarries into settling ponds, allowing suspended solids to settle. This process allows some organic chemicals to volatilize (evaporate into the air) to below detectable limits. Sloto (1987a) found that pesticides did not pose a problem.

Human activity has had quite an effect on surface-water because of urbanization. One important consequence is the accumulation of organic compounds such as pesticides and polychlorinated biphenyls (PCBs) in stream sediments. Persistent chemicals such as these are not easily flushed from the system. Valley Creek and most creeks in eastern Chester County have measurable levels of PCBs, DDE, DDD, DDT, dieldrin, and chlordane in the sediment (Sloto 1987a). Persistent hydrocarbons are usually not found in the water column but accumulate in the sediments. There are presently no quality criteria for sediments to apply in this situation. The presence of these chemicals would indicate a contaminated benthic macroinvertebrate community which means higher order consumers, such as fishes, may have accumulated these chemicals (in tissues) at even higher concentrations than found in the benthos. For example, PCBs were measured at 18 ppb in the sediment in 1985 (Sloto 1987a) while whole fish analysis of brown trout and white suckers have ranged from 1.00 to 3.9 ppm (1000 to 3900 ppb) since 1985 (Knorr 1985, 1986).

Nine percent of Chester Valley is covered by impervious areas (Sloto 1987b). Besides limiting the amount of precipitation that soaks into groundwater reserves, these impervious areas increase the amount of water flowing into streams at peak flow, which in turn contributes to erosion and stream sedimentation. The Soil Erosion, Sedimentation, and Grading Control Ordinance was approved in 1975 by Tredyffrin Township. Also passed was the Flood Hazard District Ordinance. These two ordinances

protect land, water, and property resources of Tredyffrin Township. Reports recently have shown that many builders are not following the guidelines set by these laws (NPS files, see Appendix R). Eagles' Crest and Sym's Clothing Store have allegedly not been built to legal specifications while developments like Chesterbrook and Westlakes have followed the law (NPS files, see Appendix R). When major corporate complexes are built proper (lawful) precautions must be taken to stop sediment from entering streams. A design feature usually employed is the installation of retention areas in which rainwater collects. The water is slowly absorbed into the ground instead of rushing to the nearest stream, reducing sedimentation. When runoff from roads and parking lots drains into streams during storm events, contaminants may be carried into streams. The chemicals that drop from cars onto parking lots may be introduced into streams in this way.

Warner Quarry

The Cedar Hollow Plant of the Warner Company is a limestone mining operation. It is located on Yellow Springs Road near Pennsylvania Route 29 in Devault. The quarry removes large quantities of water and releases sediments and warm water effluent into Valley Creek. Knorr (1985) stated that the chemical quality of the water coming from the quarry was "good" and "not significantly different" from Valley Creek at the point at which the discharge was entering, but that a potential for problems exists. He did mention in a memo (1985b) that the effect may be "greater than the biological data indicated". Two points mentioned were the reassessment of the 30mg/L permit criteria for suspended solids (by DER) and whether the rechannelization of Cedar Hollow Creek was permissible.

The sediments in the discharge create several problems. The discharge streambed is chalky-white and a whitish cast is imparted to Valley Creek as the effluent enters it. We also noticed the striking difference in sediment load as the more clear Little Valley Creek entered the turbid Valley Creek approximately 4 stream miles (6.4 km) below the quarry discharge stream (3 August 1987). Sedimentation has caused changes in Valley Creek's aquatic life below the effluent. Lack of spawning habitat for brown trout is one of these results (Knorr 1985). There is also a decrease in species diversity in the reach below the quarry's discharge (between stations 6 and 7 in our study). Other warning signs besides suspended solids were magnesium, turbidity, and fecal coliforms.

John Arway (1987) of the Fisheries Environmental Services (FES) branch of the Pennsylvania Fish Commission (PFC) conducted a study of benthic macroinvertebrates on 10 February 1987, near the Warner Quarry discharge. He found a much lower number of individuals below the discharge compared to above. From this observation Arway (1987) advised the DER to require daily monitoring to check levels of suspended solids for compliance with average monthly levels. The DER investigated and found no standards have been violated. Further study is planned to determine if there are any

effects of suspended solids on trout reproduction by investigating egg survival (Knorr 1988).

Data collected by the PFC in 1987 reflect the effects of the discharge (Table 5). The effluent does not change appreciably from the outflow of the settling to the mouth of the discharge flume. This is to be expected as conditions would change very little in this short distance (less than 100 feet). As for the differences in Valley Creek upstream and downstream of the discharge, the variables that did not change appreciably are specific conductivity, pH, total alkalinity, total dissolved solids, nitrogen as nitrate, total phosphate, total hardness, calcium, magnesium, total sulfate, total iron, and total acidity (constant at zero). Nitrogen as ammonia and nitrogen as nitrate decreased, probably because of biological activity in the settling pond using the nitrogen. Turbidity increased because of the suspended solids coming from the quarry.

Heister (1986) warns that in a drought year like 1966 the 3-5 Mgal (11.4-17.5 MI) of water the quarry takes daily would be half the water available in the watershed. In 1988, Warner Quarry was granted an expansion by the Bureau of Mining and Reclamation, DER to expand its operation from 149 acres to 262 acres and to increase its discharge to 11.1 MGD (DER files). This compares to the base flow of Valley Creek of 14 MGD.

Knickerbocker Landfill

The Knickerbocker Sanitary Landfill (KSL) is located in East Whiteland Township, lying within a half-mile from Valley Creek. It opened in 1958 and was designed to prevent leachate contamination of groundwater. Violations of its 1974 landfill permit were reported to DER. These included leachate contamination, well contamination, excessive corrosion, and illegal dumping of hazardous chemicals. There are also reports of dumping liquid hazardous wastes from New Jersey. The landfill was forced to start closure procedures in 1979 (NPS files, see Appendix R). Tests were done on water samples in the fall of 1978 (Heister 1979) (Table 6). The leachate flowing into Valley Creek at that time was lethal to the common goldfish (*Carassius auratus*) in 30 minutes while a 10% solution was lethal within 2 hours (Heister 1979).

Knickerbocker began treating leachate in 1983 with plans to release it into the Valley Forge Sewer Authority (VFSA). They claimed at this time that VFSA was delaying the start of this procedure. Lawyers for KSL suggested the VFSA was making unreasonable demands when suggesting a holding lagoon be built. At that time KSL felt that the leachate was treated enough to be discharged into Valley Creek or sprayed as irrigation (McElrane 1983).

The response from the VFSA was that the leachate would be accepted as soon as it met the standards for industrial wastes. They further stated that each batch of leachate must be tested before it was released because of the likely variability of the batches. The

Table 5. Laboratory Results from Pennsylvania Fish Commission

Valley Creek upstream of confluence with Warner Quarry discharge, 11 Feb 1987

<u>Test</u>	<u>Result</u>
specific conductivity	740.00 umhos
pH (lab)	8.30
total alkalinity (CaCO ₃)	222.00 mg/l
total dissolved solids	396.00 mg/l
total NH ₃ -N	0.47 mg/l
total NO ₂ -N	0.43 mg/l
total NO ₃ -N	2.83 mg/l
total phosphate	0.05 mg/l
total hardness (CaCO ₃)	228.00 mg/l
calcium	56.58 mg/l
magnesium	31.06 mg/l
chloride	75.00 mg/l
total SO ₄	43.00 mg/l
total Fe	140.00 ug/l
total acidity	0.00 mg/l
turbidity	1.00 NTU

Warner Quarry Discharge at mouth, 11 Feb 1987

specific conductivity	460.00 umhos
pH (lab)	7.80
total alkalinity (CaCO ₃)	162.00 mg/l
total dissolved solids	244.00 mg/l
total NH ₃ -N	0.04 mg/l
total NO ₂ -N	0.008 mg/l
total NO ₃ -N	2.63 mg/l
total phosphate	0.02 mg/l
total hardness (CaCO ₃)	201.00 mg/l
calcium	43.42 mg/l
magnesium	30.80 mg/l
chloride	25.00 mg/l
total SO ₄	29.00 mg/l
total Fe	140.00 ug/l
total acidity	0.00 mg/l
turbidity	4.40 NTU

Table 5. (continued)

Warner Quarry discharge below settling pond, 11 Feb 1987

<u>Test</u>	<u>Result</u>
specific conductivity	460.00 umhos
pH (lab)	7.80
total alkalinity (CaCO ₃)	166.00 mg/l
total dissolved solids	258.00 mg/l
total NH ₃ -N	0.02 mg/l
total NO ₂ -N	0.006 mg/l
total NO ₃ -N	2.00 mg/l
total phosphate	0.02 mg/l
total hardness (CaCO ₃)	205.00 mg/l
calcium	45.12 mg/l
magnesium	30.84 mg/l
chloride	26.00 mg/l
total SO ₄	31.00 mg/l
total Fe	230.00 ug/l
total acidity	0.00 mg/l
turbidity	5.40 NTU

Site: Valley Creek below confluence with Warner Quarry discharge

Date: 11 February 1987

specific conductivity	620.00 umhos
pH (lab)	8.00
total alkalinity (CaCO ₃)	194.00 mg/l
total dissolved solids	360.00 mg/l
total NH ₃ -N	0.27 mg/l
total NO ₂ -N	0.022 mg/l
total NO ₃ -N	2.62 mg/l
total phosphate	0.04 mg/l
total hardness (CaCO ₃)	212.00 mg/l
calcium	53.89 mg/l
magnesium	31.29 mg/l
chloride	49.00 mg/l
total SO ₄	37.00 mg/l
total Fe	150.00 ug/l
total acidity	0.00 mg/l
turbidity	3.50 NTU

NTU = nephelometric turbidity units

Table 6. Water chemistry of Valley Creek from the Knickerbocker Landfill area from fall, 1978 (Heister 1979). Some units are expressed differently than Heister (1979) to be comparable to DER standards

	<u>#1</u>	<u>#2</u>	<u>#3</u>	<u>#4</u>
Manganese (mg/L)	0.016	0.104	---	0.050
Nickel (mg/L)	0.012	0.026	---	0.016
Lead (mg/L)	0.016	0.018	---	0.036
Copper (mg/L)	0.002	0.002	---	0.002
Iron (mg/L)	0.00014	0.0019	0.150	0.020
Mercury (ppm)	<0.001	<0.001	<0.001	<0.001
Broad spectrum pesticides, PBB & PCB (ppb)	<0.1	<0.1	<0.1	<0.1
Specific conductance (umhos/cm ³ @ 25°C)	650	800	1100	750
Total coliforms (#/100ml)	300	433	---	---
Fecal coliform/Fecal <u>Streptococcus</u> ratio	0.19	0.38	---	---

#1 immediately upstream from landfill

#2 immediately downstream from landfill

#3 groundwater near landfill

#4 groundwater 2000 yds. downstream from landfill

holding lagoons were to be for temporary storage during testing. Very specific variables were to be tested before anything could be released (Bateman 1984).

From data collected 19 September and 8 November 1984, Knorr (1985) found that below Knickerbocker Landfill there were elevated levels of alkalinity (which is usually antagonistic to other toxicants), dissolved solids, and ammonia nitrogen. This led him to state "concentrations on both dates...exceeded recommended 30-day averages, and may be high enough to induce chronic toxicity problems for some organisms, especially during lower stream flows" (Knorr 1985).

Paoli Railyard

The railyards at Paoli, an USEPA Superfund site, is operated by the Southeastern Pennsylvania Transportation Authority (SEPTA). The PCB contamination at the railyards has been called the worst ever by the National Institute for Occupational Safety and Health (Philadelphia Inquirer, 5 March 1987). The USEPA is cleaning the site and will sue SEPTA for the cost of the cleaning. Over the years PCBs have entered Valley Creek, via Little Valley Creek, contaminating both. The site lies a half a mile from Little Valley Creek.

The Pennsylvania Fish Commission had stocked trout in Valley Creek for harvest. Kaufman (1984) suggested harvest be discontinued because the FDA action level prior to 1984 (6.0 ppm) was too high and the PFC should have recognized 2.0 ppm as a dangerous level years before. Kaufman (1984) added that stopping harvest would also be an effective method of informing the public of the contamination in the wild fish in the stream. The recommendation was made to R. A. Snyder, Chief of the Fisheries Management Section of the PFC, to delete Valley Creek from the catchable trout program in 1985 by Marcinko (1985).

Valley Creek, and its entire drainage, supports wild trout, which live their entire life in PCB-contaminated waters. These fish might then be ingested by anglers who thought they were taking recently-stocked fish (Marcinko 1985). The PFC now has Valley Creek under its pollution program which means no fish may be taken (eaten) from Valley Creek (Marcinko 1988). Since 1984, when the stream was put under no-kill restrictions, the brown trout population has increased in biomass (Marcinko 1988).

The PADER periodically analyzes fish for PCB contamination (Table 7). Reports indicate dangerously high levels of the contaminant. The DER does not plan to run these tests in the next couple of years because the persistent nature of this class of chemicals assures their presence, at unhealthy levels, for years to come (Knorr 1988).

PCBs are known to be a health hazard. The USEPA has set water quality criteria for aquatic wildlife and humans. For protection of freshwater aquatic life, the USEPA

Table 7. PCB Analysis from the Pennsylvania DER (Knorr 1986, interagency memo)

Fish flesh analysis for PCBs from Little Valley Creek (all collected at Mill Rd.)

<u>Sample Date</u>	<u>Fish Species</u>	<u>PCBs (ppm)</u>
13 Dec 1979	white sucker (WF)	6.66
18 Feb 1981	white sucker (F)	2.65
	brown trout (F)	3.86
11 Mar 1982	brown trout (F)	2.30
3 Mar 1983	brown trout (WF)	5.28
9 Jan 1986	brown trout (WF)	4.50
	brown trout (F)	3.70

Fish flesh analysis for PCBs from Valley Creek

<u>Sample Date</u>	<u>Species</u>	<u>PCBs (ppm)</u>	<u>Location</u>
11 Mar 1980	WS (F)	0.70	Church Rd.*
	BT (F)	0.13	Church Rd.
	BT (F)	0.42	Wilson Rd., VAFO**
	WS (F)	1.00	Wilson Rd., VAFO
29 Jun 1981	BT, S (F)	<0.20	hatchery truck
11 Mar 1982	BT (F)	0.52	Wilson Rd., VAFO
	BT (F)	1.90	Rt. 29
13 Aug 1982	BT (WF)	1.62	Below Little Valley Ck.
3 Mar 1983	BT (F)	1.76	Wilson Rd., VAFO
28 Mar 1985	BT (F)	0.43	Wilson Rd., VAFO
	WS (F)	0.26	Wilson Rd., VAFO
9 Jan 1986	BT (WF)	2.80	Wilson Rd., VAFO
	BT (F)	2.70	Wilson Rd., VAFO

F=fillet, WF=whole fish, WS=white sucker, BT=brown trout, S=stocked

* Church Rd. is upstream of the confluence with Little Valley Creek

** Wilson Rd. is downstream of Little Valley Creek

note: PCBs are fat soluble and collect in fatty deposits and organs in the fish. Whole fish analysis gives higher levels of PCBs when compared to fillet analysis where only muscle tissue is used.

recommends that concentrations in surface waters not exceed 0.014 ppb (ug/L) as a 24 hour average and further states that acute toxicity will occur at levels of 2 ppb (ug/L).

To protect humans from contamination from the carcinogenic effects either by exposure to PCBs from drinking water or animal consumption, the USEPA recommends ambient water concentrations be zero (USEPA 1986a). There are no criteria set for PCB levels in sediments.

Since zero levels are sometimes unattainable, the Food and Drug Administration (FDA) sets action levels for poisonous and deleterious substances in human food and animal feed. These tolerances are based on the unavailability of the presence of the poisonous substance in the food. The purpose is not to allow contamination where it is avoidable. The levels set are those at which the FDA will take legal action to remove a given adulterated product from the market. The FDA action level for PCBs in fish fillets was lowered in 1984 to 2.0 ppm (Federal Register, Vol. 49, No. 100, p. 21514).

PCBs are very volatile (evaporate very quickly) in water. The evaporation time is lengthened by the presence of sediments (Oloffs et al. 1972 in USEPA 1980). This is likely occur in streams (USEPA 1980). In aquatic environments that PCBs are found in much higher concentrations in sediments than in the water column (Crump-Weisner et al. 1974 in USEPA 1980). Because of this low solubility, PCBs are not often acutely toxic to fish and invertebrates in static aquatic tests. A fate and transport study would indicate exactly where PCBs go in the food web.

PCBs are lipophilic, which means they are attracted to and concentrate in fatty tissue. Bioconcentration occurs when PCBs are brought into fat compounds of animals from the surrounding water. They often reach high concentrations in these tissues from water that has undetectable levels of the chemicals (USEPA 1980). If the sediment has PCBs then these are not only passed to other organisms in the food web but concentrations in these organisms will increase, by orders of magnitude, in higher levels of the food web. This can lead to human ingestion of PCBs. In many studies of PCBs in foodstuffs, contamination by tainted fish is by far the most common (USEPA 1980). Dermal contamination may occur but this is usually in an occupational setting near very high concentrations of PCBs. The general public is much more likely to obtain dietary PCBs from fish living in contaminated water (USEPA 1980). A wide range of ailments arise from direct PCB contamination. From studies of accidental poisoning of hundreds of people in Japan, it has been noted that many symptoms of PCB contamination mirror those found in laboratory studies of other mammals (USEPA 1980).

As long as the sediment is contaminated the trout and insects will also be contaminated. The sediments in Little Valley Creek near Howellville contained 15 ppm (mg/L) in 1980 (U.S.G.S. computer file). A more complete analysis for persistent chemicals showed PCBs to be 18 ppb (ug/L) in the stream bottom material near the Turnpike in 1985 (Sloto 1987a). The levels in Little Valley Creek are predictably higher because this is

where the PCBs enter the drainage. Some dilution would occur by the time they reached Valley Creek. Brown trout and white suckers throughout the Valley Creek watershed are contaminated at unhealthy levels (Table 7). Brown trout from as recently as 1986 had levels in fillets above 2.0 ppm. Fish in Little Valley Creek had 3.7 ppm and fish in Valley Creek had 2.7 ppm of PCBs. These are clearly unhealthy concentrations. Even if the fish were not over the action level, it would be prudent for park and the Pennsylvania Fish Commission to disallow harvest because the small number of fish sampled each time could theoretically be at the low end of the contamination continuum for fish in the watershed.

Persistent Pesticides

The following pesticides were found in stream bottom material in Valley Creek at levels ranging from 1 to 9 ppb (ug/kg) (Sloto 1987a). Since they are persistent (resistant to biological or chemical breakdown) they bioaccumulate in the higher predators (as do PCBs). The FDA action levels listed are for concentrations in fish fillets (Federal Register, Vol. 49, No. 100, p. 21514).

<u>Substance</u>	<u>FDA Action Level</u>
chlordane	0.3 ppm
DDD, DDE, DDT	5.0 ppm
dieldrin	no level set
heptachlor and heptachlor epoxide	0.3 ppm

Chemclene

The Chemclene Corporation, located near the intersection of Rt. 401 and the Phoenixville Pike, has handled hazardous wastes in the past. The company, which is currently known as Malvern TCE, is located within a mile of a small tributary of Valley Creek. Some of these chemicals, many of which are volatile organic carbons (VOC), have been found in nearby wells. These wells near Chemclene are sources of VOC, including PCE and TCE (NPS files, see Appendix R), which are probably migrating eastward through the aquifer and entering Valley Creek via the Warner Quarry. The Chemclene site was listed as a Superfund site by the USEPA. Following is a list of hazardous chemicals at Chemclene of which the USEPA is aware (Koltonuk 1987):

Hazardous Waste Number and Substance

U220	Methyl Benzene
U154	Methanol
U002	Acetone
U159	2-Butanone
U031	n-Butyl Alcohol
U112	Ethyl Acetate

K062	Spent pickle (ferrous chloride) liquor generated by steel finishing operations
U019	Benzene
U044	Chloroform
U140	2-methyl-1-propanol
U161	Methyl Isobutylketone
U239	Xylene
U080	Methylene Chloride (MeCl)
U210	Perchloroethylene (PCE)
U226	1,1,1-Trichloroethane
U228	Trichloroethylene (TCE)
F001	Spent halogenated solvents used in degreasing: TCE, PCE, MeCl, 1,1,1-T, Carbon Tetrachloride
F002	Spent halogenated solvents: PCE, MeCl, etc.

Chemclene in the final stages of cleaning the site. The company is now communicating with DER on the terms of closure of the site, and because of this completion of the cleaning has been delayed. Under current law Chemclene is responsible for the waste at its site for 30 years (NPS files, see Appendix R). Measurements of volatile organic chemicals found in a Chemclene sample are located in the Appendix R.

National Rolling Mills

National Rolling Mills (NRM) is a metal processing plant on the banks of Little Valley Creek. It is located at 45 Morehall Rd., Frazer, Pennsylvania, in East Whiteland Township. As early as 1974 it was implicated in causing adverse effects to the water quality and fauna of Little Valley Creek. Strekal (1974) conducted an investigation of Little Valley Creek at stations above and below NRM. There were increases in concentrations of iron, copper, zinc, and alkalinity. Pollution sensitive species of insects had disappeared from upstream stations and Strekal (1974) termed stream conditions marginal.

A fishkill (PFC #6484) occurred on 30 July 1974 below NRM and NRM and Bishop Tube were listed as possible sources of the spill (Mangialardi 1974). National Rolling Mills settled with the PFC for five-hundred dollars. Sixty trout, 20 suckers, and 1000 minnows were killed (Bednarchik 1974).

A study conducted by Knorr (1980) in 1979 showed poor stream conditions and high levels of toxic chemicals including cyanide. Levels of cyanides and fluorides below NRM caused the aquatic communities at two sites to be low in diversity and numbers of individuals. The Department of Environmental Resources knew of the high levels of cyanide in the groundwater and was planning action. A conference held in 1980 (Hinkle 1980) recommended the company (NRM) contract a consultant to develop a plan to study (1) groundwater recovery, (2) treatment of this contaminated groundwater, and (3)

recharge of treated groundwater back into the groundwater until it could be discharged into the municipal sewage system in East Whiteland. National Rolling Mills would also test and discuss the levels of cyanide in the water with the Valley Forge Sewer Authority and the East Whiteland Township Municipal Authority to be discharged into the respective systems (Hinkle 1980).

In 1983 a report was issued by Earth Data Inc. (1983) which described the progress of the groundwater recovery system instituted by NRM. The report noted an overall decrease of cyanide levels in local wells in the preceding four years. Little Valley Creek had cyanide concentrations low enough to dispel any concern. One conclusion was that the recovery program was successful with decreasing levels of cyanide in bedrock and the overlying weathered zone. The size of the zone of contamination had also decreased and levels were low enough for water to be discharged to the VFSA (below 0.2 mg/L). Recommendations include continuation of the recovery program, treatment system, disposal of treated water, and monitoring of wells to assure progress. Reports to the DER and other parties were also suggested (Earth Data Inc. 1983).

Spills of other materials occurred throughout the 1980s at NRM. Prompt action averted contamination of Little Valley Creek (LVC) as employees of NRM contained an oil spill of 180 gallons (680 l) on 31 January 1983 (Winters 1983a). Also, on 25 and 26 April 1983, approximately 100 gallons (380 l) of kerosene was spilled into LVC (Winters 1983b). A broken flange caused the spilling of pickle liquor (ferrous chloride), some of which went in LVC, on 30 July 1986 (Freda 1986). The acidic mixture lowered the pH in LVC from 7.6 to 6.5 for a total of 30 minutes. No report of fishkill was given. Winters (1986) reported a spill of 10-15 gallons of fuel oil on 8 September 1986. Employees flushed the spill into LVC not considering the consequences. Procedural changes were made.

A more serious incident occurred on 30 December 1986. Two 30-gallon (114 l) containers of sulfuric acid were dropped and spilled into LVC (Sinding 1986). A fishkill occurred as the pH dropped to 3.0 approximately 50 yards (46 m) below the spill. National Rolling Mills agreed to pay \$1140 to the Clean Stream Fund for violation of the Clean Streams Law and \$1000 to the Pennsylvania Fish Commission for violation of the Fish and Boat Code to avoid litigation (Sinding 1986).

A spill of 25-30 gallons (95-114 l) of #2 diesel fuel occurred on 18 February 1988 (van Veen 1988). An NRM employee left a truck while refueling and the fuel overflowed the tank. Appropriate persons were notified and no serious consequences were reported. Measures were taken to avoid a similar incident and the employee received a suspension (van Veen 1988).

A hazardous waste inspection of the NRM facility by the PADER was done on 4 February 1988 (Boyd 1988a). Numerous violations of the Pennsylvania Solid Waste

Management Act (Act 97) and the Rules and Regulations of the DER were cited, including:

- 1) improper notification of hazardous waste shipment;
- 2) failure to supply the proper reports to DER;
- 3) lack of inspection records;
- 4) inadequate training programs for hazardous waste management;
- 5) no contingency plan hazard abatement;
- 6) no site closure plan available for inspection;
- 7) failure to submit a groundwater quality assessment and abatement program to the DER;
- 8) hazardous waste containers not labeled.

An abatement schedule was to be submitted within 14 days (Boyd 1988a). A second notice was sent on 4 May 1988, and a compliance meeting was set (Boyd 1988b). The meeting was held with assurances by NRM that all violations will be corrected (Boyd 1988c).

In a recent survey of wells near NRM cyanide levels were measured (Freda 1988). The results are follow:

<u>Well</u>	<u>Replicates (ug/L)</u>			
MW-1	<0.03	<0.03	<0.03	<0.03
MW-2	0.07	0.08	0.08	0.08
MW-3	<0.03	<0.03	<0.03	<0.03
MW-4	0.04	0.04	0.04	0.04

These readings are all below the USEPA ambient water quality criteria for human health established by the USEPA (USEPA 1986b). The criteria of 200 ug/L for water protects humans from drinking water contamination and consumption of contaminated aquatic organisms. The PADER criteria (see Appendix A) is not to exceed 0.005 mg/L (5 ug/L) as free cyanide (HCN + CN). There is no FDA action level for cyanide.

Reconstructed Mill Dam

The historic mill dam limits the potential for brown trout reproduction by eliminating riffles, their preferred spawning habitat. The deep, slow water behind the dam increases the potential for reproduction of some sunfish species. There is danger of park visitors attempting to swim in this area because of the deep, slow water. This was definitely the most "unnatural" section of the stream. The dam also blocks migration for such species as American eels and white suckers.

State Route 252

Another disturbed area of Valley Creek is the stretch that flows closely between Rt. 252 and the hiking path, from the covered bridge to the footbridge. The Park Service has

decided the walking path on the north shore of the stream will remain. (It was built years ago when the area was under the control of the state park system.) The location of Rt. 252 constrains the stream on the other side. The stream may have been lowered by dredging that was done in 1931 to protect the site of the upper forge. A stream naturally meanders and cuts into banks making deeper runs and pools. When a stream is dredged and straightened it no longer meanders and water flows uniformly. Streams that are dredged usually are widened and are thus shallower.

Unless Rt. 252 can be relocated, compromises have to be made. The roadway is in danger of being eroded in a severe storm. Bank erosion is a problem in this area because the stream channel has no room to meander as banks erode. If there were no physical constraints the course of the stream would change over time as a result of erosion and sedimentation. With the road and the path this natural process cannot occur.

Sewage and Coliform Contamination

Sewer installations in the 1970s lowered organic enrichment and bacterial levels (Heister 1979). Sewer treatment did not extend to the upper reaches and there have been problems in this area with small sewage treatment plants (Knorr 1985). Problems have arisen with the sewage treatment plants of the Great Valley High School, Malvern Trailer Courts, Inc., Immaculata College, and Camilla Hall of Immaculata (Knorr 1985). According to Community Facilities Inventory for Chester County (Chester County Planning Commission 1985) all of the aforementioned smaller sewage facilities were given good ratings except for the Great Valley High School which was termed excellent. There are a total of 24 on-lot disposal systems in the Valley Forge and Malvern U.S.G.S. quadrangles which encompass all of the Valley Creek drainage. An on-lot system is one that does not connect to a larger sewage system but treats waste close to the source. They include septic systems, aerobic tanks, seepage bed, drainfields, aerated lagoon, leach fields, spray irrigation, cesspools, or tile fields. Although a force main for the Valley Forge Sewer Authority follows the Valley Creek streambed along its entire length in the park, it is not likely the causative factor in any existing problems. (This is a common practice.)

Few problems arise with sewage treatment system discharges when operated properly and monitored regularly. Large treatment systems with impaired culture processes will not operate effectively and this problem is experienced mainly during periods of low operation. During declined periods of sewage treatment no nutrients are being added so the large bacterial cultures that process waste may be lost. This lag time is used to replace the declined bacterial culture, and it is during these times that the operation may not meet the established criteria.

Coliform sources, which are widespread due to the ubiquitous nature of this bacterial group, have been identified in pasture environments. A coliform source suspected of

insufficient treatment must be investigated individually. High coliform counts, in addition to high levels of nitrogen, phosphorus, and chlorides, are indicative of sewage input. The chlorides are left from the treatment process while nitrogen and phosphorus are nutrients which remain from insufficient treatment. Coliforms are not intrinsically dangerous, but high levels indicate that raw sewage may be in the water. This suggests that dangerous pathogens may be in the water and a human hazard is impending.

The horses that graze along Valley Creek in the park and on private property upstream of the park are a potential source of coliforms. A suggestion of a 100 foot buffer zone is made by Kunkle et al. (1987). This allows bacteria and viruses to be filtered from water before it enters the stream.

Erosion and Sedimentation

Erosion is a problem at VAFO because of the past uses of Valley Creek. In the 1800s a two-story mill dam was constructed just upstream of the present location of the Rt. 23 bridge. The sediment that accumulated up behind this dam are now the unconsolidated, highly-erodible streambanks along Valley Creek up to 100 feet upstream of the covered bridge (Reed 1990). Officials at VAFO have already implemented steps to protect the walking path near the footbridge and Rt. 252 from erosion damage. In each circumstance where erosion becomes a problem alternative remedies must be evaluated. The mitigation of the deleterious effects of erosion will be discussed in section VIII. Reed (1990) postulates that since there has been a large amount of development in recent years the stream morphology may continue to adjust for another decade. He also concludes that the present land transformation to low-density residential areas and corporate centers might have less impact than the previous transition from agriculture to high-density residential areas and industrial parks. If this hypothesis is true the future shape of Valley Creek will deviate "very little from existing conditions" (Reed 1990). Because stream width will eventually increase due to expected increases in stream flow (which have occurred in the past), slope protection and erosion control must be designed using current streamflow conditions (Reed 1990). Reed (1990) has made extensive recommendation based on the above information. See Section VIII, Valley Creek Management Alternatives, Erosion and Bank Stabilization for further details. Also, the Pennsylvania Clean Stream Law states that contractors and developers implement county and municipal erosion and sediment control plans. The following information is a general account of the effects of increased suspended sediment to a stream.

The concentration of suspended sediment in streams is influenced by such factors as topography, geology, soil condition, intensity and duration of rainfall, and the amount and type of vegetation in the drainage basin. Suspended solids concentrations may vary quite dramatically. Most flowing waters have considerable variation in the suspended solid concentration from day to day and year to year. Substantial differences in suspended solids concentration in different sections of a stream may occur where

material carried as bed load is thrown into suspension at a narrows or falls where the velocity increases.

Most aquatic organisms have adequate means of protection against the mechanical effects of fairly high temporary concentrations of suspended solids as long as their action is uncomplicated by other pollutants. Fish and other aquatic organisms continuously secrete quantities of mucus (Cole 1935) or increase their ventilation rates (Horkel and Pearson 1976) to carry away particulate matter from the gills. As long as the mucus barrier remains operative, water containing considerable quantities of pulps, sawdust, and other suspended solids will cause little or no mechanical injury to the gills (Cole 1935); however, there will be a corresponding energy drain. The combined action of suspended solids with acids, chemical wastes, or other substances will increase the abrasive action on the gills or mat the gills with deposits which, under more favorable condition, would have been washed away by the mucus (Marsson 1911).

The ecological effects of suspended solids include: (1) mechanical or abrasive action; (2) blanketing action of sedimentation; (3) reduction of light penetration; (4) availability as a surface for growth of bacteria, fungi, etc.; and (5) adsorption and/or absorption of various chemicals; and (6) reduction of temperature fluctuations (Cairns 1968). Biologists generally agree that any of the above deleterious consequences can occur if large quantities of suspended solids are introduced into an aquatic system. However, as Hoak (1957) summarized, there is a lack of agreement as to the amount of particulate matter that can be assimilated, either in suspension or bottom accumulation, before threshold values are reached for biota. When significant quantities of precise experimental data are assembled, it will probably be found that various fishes can tolerate quite a wide range of suspended concentrations. Cairns (1968) reported 29 fish species existed with no evidence of gill clogging or other damage in a reach of the Kansas River in 1958 when turbidity measurements exceeded 72,000 mg/l.

Wallen (1951) found that 16 fish species did not react to elevated turbidity levels until 20,000 mg/l and that one species showed no reaction until levels reached 100,000 mg/l. Most individuals tested tolerated exposures more than 100,000 mg/l of turbidity for a week or longer, but succumbed at turbidity measurements of 175,000 to 225,000 mg/l. Wallen (1951) found no evidence of gill injury even though the gills were blanketed with a layer of silt and the opercular cavities were matted with the material. All organs appeared normal. Arteries and veins were not congested, and no unusual amount of mucus was secreted by the gills.

Ellis (1927) also examined fishes whose gills were coated with sediment. His description of the coating responsible for death agrees with that observed by Wallen (1951). Ellis (1927) pointed out that healthy and uninjured fish can move through very muddy water since the continuous secretion of mucus washes away the sediment particles. However, when toxic chemicals injure the gills or alter the flow of mucus, the addition of suspended silt may aggravate gill damage through increased abrasive or matting action.

In contrast to Wallen's (1951) work, other biologists concluded that lower turbidity concentrations had deleterious effects on fishes. Kemp (1949) attributed gill damage to various fish species at turbidity measurements up to 3,000 mg/l. As an example, he cited a flood in 1936 which created a turbidity of 6,000 mg/l in the Potomac River and lasted 15 days. The fish kill was large. Others supporting the thesis of comparatively low level turbidity measurements (100-6,000 mg/l) being limiting to fish populations are Scheberger and Jewell (1928), Ellis (1940), Doan (1942), and Munns (1948).

In summary, little sound experimental data exist and many authorities disagree on the tolerance limits of freshwater fishes to high concentrations of suspended solids. However, it is apparent that fish encounter, tolerate and perpetuate in waters where natural man-made influences result in high turbidity measurements. As Gammon (1970) surmises "It seems fairly clear...that while eggs and fry may be quite susceptible to the direct action of suspended sediment, fingerlings and adults are quite resistant and are capable of enduring temporary periods of high concentrations of suspended solids."

The harmful effects of siltation can be overcome with effort.

VI. Indicators and Standards of Resource Conditions

Water Resources

Valley Creek should at least meet the DER water quality standards for a coldwater fishery. These standards are listed in Appendix A. The USEPA mandates guidelines for each state to implement. These are the USEPA quality criteria (USEPA 440/5-86-001). Acute and chronic refer to toxicity levels for aquatic life (ug/L or ppb). The DER enumerates these criteria in chapters 93.8a and 16 of the Pennsylvania code. The USEPA sets criteria to protect 95% of all aquatic life. They are based on all available data from species toxicity testing. Chronic toxicity levels indicate that exposure to these levels would harm aquatic life over the life of the organism. The effect might be on survival, reproduction, or growth. Acute levels would bring immediate effects to organisms. Organisms tested range from algae to protozoans to trout. Human health criteria are set to avoid risks to humans. When the suggested criteria is zero, the USEPA estimates the risk of getting cancer associated with lifelong exposure of various concentrations of the contaminant.

Biological Resources

The assessment of ecosystems has evolved from the presentation of flora and fauna lists to a series of classification schemes which include: species-area curves (Gleason 1922), diversity indices (Shannon and Weaver 1949, Margalef 1958, Wilhm and Dorris 1968, Cairns 1977), autotrophic-heterotrophic ratios (Weber 1973), saprobian designations (Bick 1958, Cairns 1977), and biotic indices (Weber 1973, Karr et al. 1986, Ohio Environmental Protection Agency 1987). Many of these studies were initiated to determine the effects of organic pollution. Additionally, lotic, or stream, habitats have been classified on the basis of calcium content (Ohle 1937), distribution of fauna (Smith 1971, Thompson and Hunt 1930), water zones (Illies 1961), gradient (Trautman 1942), and stream order (Kuhne 1962). However, Platts (1974) suggested that these classification systems had limited value to the management of land and water systems. A more useful technique would center on variables which could predict the amount of stress a particular system could assimilate and the potential of a system to recover once a structural or functional change of the biota was effected. The concepts of inertia and elasticity (Cairns and Dickson 1977) appear to have great potential for use in a water resource classification system, as well as strong management implications. Stauffer et al. (1978) and Stauffer and Hocutt (1980) used existing information on the aquatic fauna to evaluate the inertia and elasticity of two lotic systems.

Calculation of Inertia Indices

Cairns and Dickson (1977) defined inertia as the capacity of a stream to withstand a particular stress without eliciting a structural or functional change, and stated that the inertia of a system is based on the following variables: 1) whether or not the indigenous

organisms are accustomed to highly variable environmental conditions; 2) the structural and functional redundancy of the stream; 3) stream order, flow dependability, flushing capacity, etc.; 4) the presence of well-buffered water antagonistic to toxic substances; 5) how close the system is to a major ecological transitional threshold; and, 6) the presence of a drainage basin management group with a water quality monitoring program.

An estimate of the value of parameter 1 would have to be made based on a comparison of the variability of flow, temperature, dissolved oxygen, ph, etc. of Valley Creek with other neighboring lotic systems. With a rating system of one to three, a one might be used to rate an ocean system, a two for a freshwater lake, and a three for an estuarine system. A freshwater lake is subject to more variable environmental conditions than an ocean, but subject to less variable environmental conditions than an estuary, whose organisms are subjected to freshwater, saline water, and dry conditions within a 24-hour period. The ratings given to each reflect these differences among the three. A similar type of analysis would have to be made for the Valley Creek watershed, when compared to other neighboring watersheds.

Parameter 2 is an evaluation of the structural and functional redundancy of the system. Since inertia is defined as the ability of a system to withstand a stress without eliciting a structural or functional change, it follows that the greater the redundancy in structure, the less chance a stress has of creating a measurable shift. Structural redundancy could be estimated by evaluating the number of species present in a particular genus or the number of genera in a particular family.

To calculate functional redundancy life history information on the aquatic fauna must be accumulated. Functional redundancy can then be calculated based on characteristics such as the amount of overlap in trophic-level interactions, habitat occupied, spawning sites utilized, etc. Again, these data must be compared to data from neighboring lotic systems.

The values for parameters 3 and 4 would have to be assigned after a comparison of flow data, flushing capacity, buffering capacity, etc. of the Valley Creek basin.

Parameter 5 could only be assigned after an evaluation of the use and purpose of the watershed is determined by Park personnel. For example if it is a goal of the Park to maintain the stream as a trout fishery, then a low value for this parameter must be assigned. Summer water temperatures approach the lethal threshold for brown trout; thus, the stream would have to be considered close to a major ecological transitional threshold. If, on the other hand, the goal is not to maintain the stream as a trout fishery, since brown trout are not native to the watershed, than a high value could be assigned to this category.

Category 6 would also have to be assigned after certain management decisions are made by the Park. If the Park is going to initiate a monitoring program either by themselves,

or in conjunction with a group such as Trout Unlimited, then a high value could be assigned to this parameter.

Calculation of Elasticity Indices

Cairns and Dickson (1977) define elasticity of a system as the capacity of a system to recover after a structural or functional displacement has occurred. The factors which they considered important in the development of an elasticity index follow: 1) existence of nearby epicenters for providing organisms to reinvade a damaged ecosystem; 2) mobility of any dispersal stages of the organisms present; 3) condition of habitat following the stress; 4) presence of residual toxicants; 5) chemical-physical environmental quality after pollutorial stress; and 6) management or organizational capabilities for immediate control of the damaged area.

Parameter 1 is a measure of nearby epicenters from which colonization can initiate should a stress occur. Relative to fishes, the only epicenter from which recolonization could occur is the Schuylkill River. Any of the other watersheds in the vicinity of Valley Creek could act as an epicenter for most aquatic invertebrates, since the majority of these forms have aerial stages in certain portions of their life history.

The values of parameter 2 would also be different depending upon whether the aquatic vertebrates or invertebrates are being classified. Life history information would have to be gathered for the dominant species present. For example, certain fishes, such as suckers (Catostomidae), migrate into streams to spawn, while others, such as darters (Percidae), are relatively sedentary.

A regular monitoring system would have to be established to determine both the condition of the habitat following the stress (parameter 3), the presence of residual toxicants (parameter 4), and the chemical-physical environmental quality after pollutorial stress (parameter 5). In fact, these three parameters may be grouped for the purposes of a management strategy.

The values for parameter 6 would have to be assigned depending on the commitment that the park makes to a monitoring program and/or the cooperation of various interest groups such as Trout Unlimited.

The concept of inertia and elasticity as conceived by Cairns and Dickson (1977) can be used to formulate a stream classification system, which can predict the amount of stress a particular system can assimilate and the potential of a system to recover if and when the assimilative capacity is exceeded. The main emphasis proposed centers on the monitoring of the biota of the system. While certain physical and chemical variables are needed, as discussed above, biological sampling may be the only method which will detect ecosystem change. Once a change in the ecosystem has been effected and

detected, then intensive chemical monitoring can be initiated to determine the source of the stress.

There is some debate as to whether fishes or macroinvertebrates should be used to monitor the biological community. Some investigators suggest that macroinvertebrates are more sensitive to pollutants at different stages of their life cycles than fishes, and that they are more sedentary than fishes. Fishes, on the other hand, 1) occupy the top of the food chain in most stream systems, and as such their presence implies the presence of many other phyletic groups; 2) throughout their development from larvae through adult they pass through most, if not all, trophic levels above the primary producer stage; 3) taxonomically, fishes have been well studied, hence, accurate identifications can be made easily and quickly without the aid of sophisticated equipment; and 4) there is generally more information available on their life history than is available for other groups.

VII. Comparisons of Standards and Existing Resource Status

Valley Creek has many environmental problems. One concern is the loss of surface and groundwater, as demonstrated by the water removal limitations imposed by the DRBC. Most of the loss of water can be attributed to increased commercial and residential development. There is some feeling that a potential for extremely low flows due to water removal is possible in the next decade (Chester County Water Resources Authority and Chester County Planning Commission 1979). Development and industry also contribute to the amount of pollution in Valley Creek.

The most dangerous pollutants are polychlorinated biphenyls, or PCBs. They have reached unhealthy levels in fish and have, most likely, severely effected the sediments. Other chemicals such as DDE, DDD, DDT, dieldrin, and chlordane (all pesticides or pesticide by-products) have also been found in the sediments of Valley Creek (Sloto 1987a). Other chemicals only reach harmful levels when a spill occurs; i.e., the various spills from National Rolling Mills. The threat of a devastating spill is constant.

The results of limited chemical testing listed in Appendix F do not show any high levels of variables tested. The nitrate levels are well below DER levels of 10 mg/l. Copper (Cu) and manganese (Mn) are many times lower than DER standards. The DER standards for lead (Pb) and nickel (Ni) both involve testing for specific organisms or site-specific bioassays. The USEPA, in contrast to the DER standards, lists levels for protection of all aquatic life. For both lead and nickel, these criteria are relative to the hardness of the water tested. Data from as far back as 1981 indicate that a suitable mean for the hardness of Valley Creek is 250 mg/l CaCO_3 (Appendix H). Incorporating this value into the USEPA criteria formulas for lead and nickel gives the appropriate standards. For nickel the acute value is 3.7 mg/l and chronic value is 0.19 mg/l. The acute value for lead is 0.262 mg/l and chronic value is 0.01 mg/l. The human health criteria for nickel and lead are 0.0134 and 0.050 mg/l, respectively. The levels to protect humans are the same as the drinking water standards. Neither lead nor nickel tested above 0.005 mg/l so both are within safe limits.

Ammonia as unionized ammonia (NH_3) has been found to be toxic to fishes and other aquatic life. It is more toxic than the ionized form (NH_4^+). The equilibrium of these two chemical species is dependent upon many factors including water temperature and pH. The DER standards use these two variables to predict this equilibrium. Ammonia standards can be set according to the known pH and temperature extremes. In Valley Creek the pH ranges from 7.0 to 8.5 and temperature ranges from 0°C to 25°C. The DER standards using these four values were calculated (Appendix A).

The USEPA has set criteria for total ammonia and un-ionized ammonia to protect aquatic organisms and their uses (Appendix A). One hour averages are to protect against acute effects and 4-day averages are to protect against chronic effects. They protect aquatic organisms and their uses if the criteria are not exceeded more than once

every three years. The three year time period is the best estimate for recovery time for an unstressed ecosystem (USEPA 1986b).

At the time of the collection of ammonia samples (Appendix F) the pH in Valley Creek approached 8.5 and the temperature was near 25°C at many sites. These values can be compared to the worst-case scenario for ammonia effects. The value for total ammonia recorded at station 6 (0.220 mg/l) exceeds the DER thirty day average of 0.16 mg/l (Tables 1 and 5). This value also approaches the USEPA 4-day average of 0.23 mg/l (Appendix A). None exceed the acute maximum. The chronic values are very important. While high acute values can cause fishkills, etc., the high chronic values indicate that serious long-term damage to the system may be occurring.

The concentration of coliforms in Valley Creek is very high. Appendix G shows a range of 9,000 - 40,000 most probable number (mpn) per 100 ml sample which gives a mean across stations of 25,000 mpn per 100 ml. Comparing this to the DER standard of 200 mpn per 100ml for a five day mean (for the swimming season, when these samples were collected) shows that Valley Creek has a serious coliform problem. Even though these data cannot be directly compared the levels indicated in Appendix G, they are alarming. The coliform sample taken at station 8 was split into 2 subsamples (above and below a small feeder stream) in an attempt to identify a potential source of sewage but the results were not conclusive.

The CCHD has collected extensive water quality data for Valley Creek (Appendix H). These values are compared to DER and USEPA standards. The pH varies but is consistently between the DER standard of 6.0 and 9.0. The pH fluctuates depending upon the amount of rainfall versus groundwater input. Dissolved oxygen levels are, for the most part, above the DER standard of 6 mg/l. If low dissolved oxygen levels were a limiting factor, trout would not be as plentiful (Appendix J).

Total dissolved solids are regulated monthly at a mean concentration of 500 mg/l while 750 mg/l is the highest any single measurement may be. Since the values in Appendix H are instantaneous measurements we can compare them to the acute standard of 750 mg/l and most are below by as much as 300 mg/l. Hardness and alkalinity are not regulated because they are entirely dependent upon on natural conditions in a system. The high levels in Valley Creek are usually associated with a productive biological community.

Many heavy metals were analyzed by the CCHD (Appendix H). Iron (Fe) should not exceed 1.5 mg/l as total and Valley Creek does not exceed this value. The values are also all below the USEPA criteria for the protection of aquatic life, which is 1.0 mg/l. The DER criteria for manganese (Mn) is 1.0 mg/l and no values approach this level. Most are below 0.05 mg/l. There is no standard for sodium (Na).

The zinc (Zn) standard set by the DER includes a bioassay (Appendix A). The USEPA states the zinc level should not reach 0.700 mg/l at any time or go above 0.047 mg/l as a 24-hour average (at a hardness of 250). Valley Creek is safe in that all measured values are below the detection limit of 0.02 mg/l. The DER has set no standard for cadmium. The USEPA states that aquatic life would not be affected if acute levels are below 0.0039 mg/l and chronic values are below 0.0011 mg/l. The cadmium collected by CCHD is difficult to interpret since the precision in their methods is lacking to compare results to the standard.

As mentioned in section IV, Valley Creek has less species of fishes than other streams in the area. Stations 9 through 14 (Trout Creek, Pickering Creek, French Creek, East Branch of Perkiomen Creek, Swamp Creek, and Ridge Valley Creek, respectively) have at least twice the number of species as Valley Creek stations (Appendix J). This could be related to the various fishkills in Valley Creek and the inability of the fishes to re-establish populations. Some of the more common species in the area (such as *Exoglossum maxillingua*, *Luxilus cornutus*, *Notropis hudsonius*, and *Ambloplites rupestris*) should be found throughout the Valley Creek drainage but were collected in only a few locations. The macroinvertebrate populations are also less diverse than nearby streams. This lower diversity indicates a stressed system though no one specific cause is indicated.

Table 5 lists the results of a study near the Warner Quarry to assess its effects on Valley Creek. A comparison of the samples on Valley Creek above and below the quarry discharge showed that only turbidity changed appreciably. Other changes are mainly due to the dilution effect of the quarry water and the binding of calcium carbonate to other molecules. Stream temperature measurements would have shown thermal effects of the quarry but were not taken.

Heister (1979) attempted to demonstrate the effects of Knickerbocker Sanitary Landfill on Valley Creek (Table 6) by analyzing the water chemistry of the creek and nearby groundwater above and below the landfill. The manganese level was raised below the landfill but remained below the standard of 1.0 mg/l set by DER. The concentration of nickel, 0.026 mg/l below the landfill, is below the USEPA suggested 24-hour average of 0.19 mg/l. Copper and iron levels are both orders of magnitude below their standards. Heister (1979) measured mercury in the water but the USEPA suggests mercury be monitored via the FDA action level (1.0 ppm) in fishes (USEPA 1986b). Since mercury bioaccumulates, the best test is on harvested fish. The increase in conductance is probably due to the ions entering from the landfill. The coliform levels are low for the non-swimming season with its higher DER standard than during the swimming season (Appendix A). These tests were completed ten years ago and may not reflect current conditions.

The most alarming problem in Valley Creek is the PCB contamination. Fish collected from Little Valley Creek as far back as 1981 have concentrations in muscle tissue higher than the FDA action level of 2.0 ppm (Table 7). The fish should not be eaten.

In summary, Valley Creek has at least one serious problem (PCBs) and could potentially have many more. Coliform levels are a concern also. The threat of lower flow levels increases the chances that pollutants that are close to toxic levels may soon reach these levels. Continued accidental spills of various chemicals are likely with all the industry in the Valley Creek basin.

VIII. VAFO Valley Creek Management Alternatives

Water Quantity

A. Problem statement and background

Perhaps the most serious threat to Valley Creek's existence as a quality stream is the loss of water for base flow. Flows have been lowered because of interbasin transfer, quarry use, pumping of high-capacity wells, and the increase in impervious areas. All of these factors are related to urbanization or development of the land. Sloto fully documents these effects to Valley Creek in a U.S.G.S. report: *Effect of Urbanization on the Water Resources of Eastern Chester County, Pennsylvania* (Sloto 1987a). As stream flows decrease, the habitat quality degrades and pollutants become more concentrated.

B. Current management actions and results

There is currently no management action employed by the park.

C. Alternative actions and probable effects

1. **Continue current action:** The Park Service currently has no management plan for water loss. The effects of this are difficult to predict. The loss of water is directly tied to the continued development in the Chester Valley. Since development is certain to increase, the situation can only worsen through inactivity.
2. **Become more involved in the decision-making process:** It is assumed that the activities that are leading to lower water levels in Valley Creek follow DER, DRBC, and USEPA guidelines. These development projects usually have public meetings associated with permit-granting process. At these meetings, the NPS (VAFO) officials could act as a watch-dog to make certain that any development follow accepted guidelines, such as the construction of well-designed storm water retention basins. The NPS would be made aware of these meetings through contacts with organizations such as Trout Unlimited, Sierra Club, Green Valleys Association, and the Tredyffrin Township Environmental Advisory Council. The NPS could also designate an employee, or obtain a volunteer, to act as a liaison to the Chester County Planning Commission to be aware of public meetings concerning issues of concern to VAFO.
3. **Fund more scientific study:** The NPS may be instrumental, through its own monitoring program or through funding of scientific research, in collecting the data necessary to support the claims of environmental harm to Valley Creek

and the surrounding area due to base flow decreases. As the nation's primary conservation agency it may be the only recourse to avoid the loss of more natural areas.

D. Recommended actions

The recommended action is to coordinate with other groups to become more involved in the land development process throughout the watershed (Alternative 2).

Water Quality

A. Problem statement and background

Valley Creek has several water quality problems. These include high fecal coliforms, groundwater contamination, and sites of possible toxic leachate introduction, such as Knickerbocker Sanitary Landfill and the Chemclene Corporation. (The PCB contamination at Paoli Railyards will be addressed separately.) Most of these sites are being monitored by other agencies. The USEPA is involved with the Chemclene Corporation and the DER is monitoring National Rolling Mills and Knickerbocker Sanitary Landfill. Most of Valley Creek's problems arise because it is surrounded by a rapidly expanding industrial and residential community.

B. Current management actions and results

The CCHD samples Valley Creek three times a year and measures many water quality variables (Appendix H lists these variables and the sampling locations). This information is easily attainable. The U.S.G.S. takes annual samplings for basic water quality variables at the turnpike flow gauge. The NPS can access this information simply by contacting the U.S.G.S. office in Malvern, Pennsylvania.

C. Alternative actions and probable effects

1. Continue current actions: If current actions were not changed, the park would have no input on which variables were chosen for study and no direct access to the data. This is undesirable as the park would have little information on water quality and whether conditions were improving.
2. Institute an extensive chemical/physical testing program: The park could start a wide ranging chemical analysis of park waters. One to four times per year the park could arrange for extensive chemical and physical testing of Valley Creek through its own employees or contracting (the type of data shown in Appendix H). Park personnel or consultants could evaluate and look for trends that indicate changing water quality. The drawbacks to this plan include high cost and some duplication of testing that is already being performed by other agencies. A wide variety of tests would cost at least \$1000 per sample (times the number of stations). The cost for sampling quarterly, if stations (approximately 8) were chosen to cover the entire drainage, could rise as high as \$30,000 per year with possibly no foreseeable management benefit.

Regardless of how extensive the testing is, the source of many problems may still go undetected. The only type of pollution a monitoring program could hope to find is a continuous point-source. All standards are based on

"discharge pipe" levels. A chemical monitoring program, e.g., an exhaustive survey of many variables, would very rarely catch a short-term (pulse) pollution event.

3. Institute a Limited Chemical/Physical Water Sampling Program:

Phase I: The park could undertake coliform monitoring in accordance with DER testing procedures so if levels are too high the data would force DER to take action. (The Chester County Health Department may provide free laboratory service as they did for this study.) As for other water quality variables, the park could monitor pH, dissolved oxygen, and conductivity. Conductivity often correlates with total dissolved solids and levels of major cations. Because of their effects on conductivity, these ions can indicate changes in different pollutant levels. Examples are road salts, nitrates and phosphates in manure and sewage, and heavy metals. Conductivity differences could also help pinpoint the source of these pollutants by finding differences between stations with more precision. Like conductivity, pH can act as an index of water quality. It frequently correlates closely to nitrate, sulfate and chloride measurements and will obviously indicate acid spills like those that have occurred in the past. The sampling could occur four times a year at the Valley Creek locations listed in Appendix E.

Phase II: If a marked change of any of these aforementioned three variables (e.g., pH out of normal range of 6-9) would occur, it would indicate a shift in the ionic composition of the water and the following set of chemicals could immediately be further analyzed by laboratory analysis. The chemicals listed have either state standards listed in Appendix A or USEPA criteria listed in Section VI of this report.

<u>Parameter</u>	<u>Rationale for Testing</u>
-cyanide -iron -lead	tested because of a history of spills from National Rolling Mills. These three chemicals are listed as detected in at least 75% of samples in National Urban Runoff Program, NURP (Kunkle et al. 1987)
-copper -zinc	these two chemicals are listed as detected in at least 50% of samples in NURP (Kunkle et al. 1987)

<u>Parameter</u>	<u>Rationale for Testing</u>
------------------	------------------------------

-chromium	
-arsenic	
-chloride	
-ammonia-nitrogen	
-nitrate-nitrogen	

Note: When sampling for ammonia, pH and temperature must be recorded at each collection.

These analyses could be done at a DER-certified laboratory. Correct procedures for collecting water samples could be set prior to testing in order to attain reliable data. Kunkle et al. (1987) have suggestions specifically for park personnel regarding sample collections and choosing proper laboratory facilities.

Phase III: Should a fishkill occur, those variables listed above and the following could be immediately investigated:

-dissolved oxygen

-temperature (should always be taken when sampling but rapid changes can cause fishkills)

-pH

For all phases of action the selection of sites is critical. As mentioned above, stations 1 through 8 (Appendix E) could be tested for routine management. When a pollution event occurs different stations are chosen. For example, if dead fish are found at the park boundary at the Pennsylvania turnpike, the spill occurred somewhere upstream of park land. Further sampling should take place only upstream of the park to avoid collecting extraneous data and wasting time. Using the map of the drainage (Figure 1) park personnel could select sites that encompass all potential polluters to try to narrow the search for the source.

In collecting water samples to be sent to outside laboratories two one-liter plastic bottles could be filled with water (to ensure an adequate supply for testing) and stored in a refrigerator until shipped to the testing site. The appropriate enforcement agencies could then be notified regarding the fishkill and data to back up the complaint could be available.

High flow could have an effect on sampling results, such as diluting toxicants in the stream. A pH or conductivity reading taken on a day of high flow could be skewed toward the values of the precipitation and away from the ambient values of the stream. Any effect of dilution on the monitoring program can be avoided by taking regular samples of pH, conductivity, and dissolved oxygen only after precipitation effects have had sufficient time to dissipate. This could be determined by visual inspection by an employee familiar with normal Valley Creek water levels.

4. Calculate Inertia and Elasticity Indices: Inertia and elasticity indices could be calculated as described earlier in Section VI for the Valley Creek watershed. The resultant index could provide a starting point to which indices in subsequent years could be compared. It is suggested that an inertia and elasticity index be calculated for a similar-sized stream within the drainage basin that is considered "pristine" either by the Pennsylvania DER, Trout Unlimited, or the PFC. This regimen could provide reference numbers to which the values obtained for Valley Creek could be compared. A management decision could then be made to try to improve the quality of Valley Creek to within some range of these indices. This system could have to be evaluated for a two or three year period so that natural variance could be determined. Once this baseline is established, the yearly values determined for Valley Creek could be compared to this suite of indices. Such a protocol could be relatively expensive (i.e., \$20,000/year for the first two years; ca. \$4000-5000/year subsequently).
5. Develop a biological monitoring program using the Sequential Comparison Index: This monitoring scheme involves the use of VAFO personnel and could be relatively inexpensive. The biological monitoring program could employ the Sequential Comparison Index for macroinvertebrates developed by Cairns (1968) to monitor the health of biological communities. The sequential comparison index follows the basic idea that a healthy system has higher faunal diversity than a disturbed one. This procedure has been described in Buikema et al. (1980) which is located in Appendix S. A baseline could be built through data collected each season. A decline in number of individuals or taxa could indicate a decline in biological health. Collections could be made in each season, December to February, March to May, June to August, and September to November. Comparisons are only made between collections done at the same time of the year because populations of a given species change seasonally due to reproductive cycles. With this method, VAFO could have an in-house procedure of assessing the biological health of their waterway. The macroinvertebrates could be collected by park personnel quarterly at stations 1 through 8 described in Appendix E using the collection techniques described in Section V. B. 1.

6. Develop a biological monitoring program using outside consultants to monitor the biological community: In this method consultants could be hired to identify the macroinvertebrates and fishes which could be collected by park personnel in the manner described in Alternative 5. For each collection, total numbers and number of taxa could be computed. (The same methods as outlined in this report in Section V. B. 1. could be followed.) A baseline could be built of data collected each season of the year. A decline in number of individuals or taxa could indicate a decline in biological health. Collections could be made in each season as in the previous alternative. Different data could be generated with this method than in method 4 which uses inertia and elasticity indices. In this alternative simple species lists and diversity could be obtained, not an in-depth analysis of the community taking into account the structural and functional redundancy of some members of the community as in alternative 4.

D. Recommended actions

The recommended management action is to use chemical/physical testing and monitoring program described in Alternative 3 and the Sequential Comparison Index biological monitoring approach discussed in Alternative 5. There are various reasons why biological monitoring is suggested. As Cairns (1968) stated, "physical and chemical parameters...give the conditions existing only at the time of the test, whereas biological parameters represent a summation of the past and present environmental circumstances." Since the purpose of water quality testing is to protect the biological community it logically follows that the park should monitor its health.

PCB Contamination

A. Problem statement and background

Polychlorinated biphenyls (PCBs) have infiltrated the Valley Creek system. They are persistent hydrocarbons that were once used in railroad transformers at Paoli Railyards. The soils in the immediate area are contaminated and the PCBs leach into Little Valley Creek which flows into Valley Creek. PCBs will likely be in Valley Creek for many years because of the soil contamination. Whereas the exact amount of PCB's that can be absorbed via skin is relative to the surface area of skin in contact with the sediment and the duration and frequency of contact, the USEPA has estimated the absorption rate at 5% for PCB-contaminated sediments (USEPA 1986a). Most of the data available describes the high levels of PCBs associated with contact in a occupational environment (Idler 1986, Safe 1988). Safe (1988) indicates that the general public is not at risk to environmental uptake of PCBs but that "individuals who consume relatively large amounts of fish...[acquire]...elevated serum PCB concentrations". There does seem to be a higher blood pressure associated with these higher blood concentrations of PCBs (Kreiss 1985). PCB levels in the fish in Valley Creek have exceeded FDA standards and cannot be eaten. The Pennsylvania Fish Commission (PFC) has discontinued stocking and halted harvest.

B. Current management actions and results

The Park Service currently enforces the PFC no-harvest rule and discourages wading in Valley Creek. No monitoring is done by the park. With current management procedures, the public is protected from eating contaminated fish and swimming in contaminated water. The DER has stated it will sample fish for PCBs less frequently because of the persistence of the chemicals.

C. Alternative actions and probable effects

1. Continue current action: The public could continue to be protected from eating contaminated fish and swimming in contaminated water. There are still high levels of PCBs in the fishes and the sediment (Table 7). Testing of the fish flesh is done on a semi-regular basis by the DER.
2. Remove the PCBs: The park could attempt to remove the PCBs from the stream system. This could be impractical, for many reasons, and probably impossible. It could include, at the very least, removal of the stream substrate. This could take away the entire food base for the fishes in the stream and release large amounts of sediment which could effectively kill the stream. The condition of the stream after a procedure like this could be much less desirable than the present condition. Even if this could be

accomplished, PCBs could still be leaching into the stream from its origin at Paoli Railyards and the problem could remain.

3. **Increase Public Awareness:** The park could alert the public to the PCB problems, by increasing the number of warning signs against wading. If, in the future, conditions improve at Paoli Railyards, the park could order sediment sampling in the streambed. This is the only way to be sure the PCBs are out of the system. Fish harvest could depend on PCB levels in their flesh.

D. Recommended actions

A combination of alternative 1 and alternative 3 is recommended. Public awareness will be heightened because some portions of the stream can be reached without seeing signs concerning the dangers of eating the fish and someone could unknowingly eat the fish. Otherwise, the Park should just remain aware of any sampling done by holding regular discussions with the DER and the PFC. This is sufficient because the PCBs will remain in Valley Creek as long the contamination exists in the watershed.

Recreational Fishing

A. Problem statement and background

Fishing in Valley Creek is regulated by state law. In the past, when the stream was stocked annually with brown trout, many fishermen came to Valley Creek. Since catch-and-release was instituted by the PFC because of PCB contamination the number of fishermen visiting Valley Creek has declined dramatically. The PFC has placed the stream in its pollution program which stops harvest but allows all types of fishing (e.g., flyfishing, artificial lures, bait).

B. Current management actions and results

Fishing laws of Pennsylvania are enforced. There are PFC signs that warn against eating the fish.

C. Alternative actions and probable effects

1. Continue current action: Fishing could continue as it has with no tackle restrictions.
2. Remove brown trout and replace with brook trout: The park could make an effort to rid the stream of exotic (introduced from other continents) brown trout and replace them with native brook trout. Historically, the brook trout could have been in the stream (perhaps eliminated before the time of the encampment because of deforestation and pollution). Electrofishing could be done to eliminate brown trout and wild strains (not from hatcheries) of brook trout could be introduced.

This alternative would likely fail for several reasons. The PFC may not allow this action and the public could certainly be outraged. Brown trout are more popular because they attain a much larger average size than do brook trout. Also, total elimination of brown trout is probably an unattainable goal, because more could migrate back into the park from upstream tributaries. There is also no guarantee the brook trout could be able to reproduce in waters as deteriorated as Valley Creek because brook trout are less pollution-tolerant than brown trout. It is not against Park Service policy to allow the exotic fish (brown trout) to remain since the native brook trout can no longer exist in these waters.

3. Restrict tackle to artificial lures only: Only artificial lures could be used on Valley Creek (no bait allowed). Fish caught on live bait are more susceptible to hooking mortality than those caught with artificial lures. Hooking mortality (fish death caused by a hook injury) could then become the most

significant cause of death (other than natural mortality) for fishes in Valley Creek. Implementing a plan of artificial lures-only fishing could lower the number of fish lost through hooking mortality, preserving this resource.

4. Free license system: The park could institute a free license system in which anyone wishing to fish in the park could first need to obtain a license at the visitors' center. (A valid Pennsylvania fishing license could still be necessary.) The anglers' names and addresses could be taken along with other information park personnel might deem appropriate. Survey cards could be distributed for anglers to return (by mail or in person) so the park could have an estimate of fishing pressure, type of fishing done, sizes and numbers of fishes caught, and locations in the park fished. Information on contamination in the stream could also be given to the anglers. These same anglers could be helpful in the future as a means of collecting fishes for PCB analysis.

D. Recommended actions

The recommended action is a combination of restricting fishing to artificial lures only (alternative 3) and implementation of a free license system (alternative 4). The former could preserve a valuable resource that is accessible to many people and the latter could gather information on angler use patterns and the condition of the fish community.

Erosion and Stream Bank Stabilization

A. Problem statement and background

Erosion is a problem along Valley Creek where it closely borders Rt. 252 and the hiking path. In other parts of the stream, erosion occurs but is of minor consequence. In VAFO erosion is only a problem when it threatens a man-made structure (historical or modern) or a substantial aquatic habitat alteration is likely. Along Rt. 252 as the stream cuts away the bank the road becomes susceptible to collapse. The gabions opposite the road, however unattractive, protect the hiking path from destabilization. The road is vulnerable to stream channel changes. During periods of high flow the bank slowly erodes. Trout Unlimited has expressed interest in "improving" habitat for brown trout in this section to increase trout densities, citing their success in other nearby streams.

B. Current management actions and results

The most recent action was the installation of the gabions along the bank opposite Rt. 252. There is a second set of gabions on the road side of the stream further downstream that are so well-covered with soil and plants that they are not conspicuous. The guard rails, telephone poles, and trees in some areas are leaning toward the creek. The Pennsylvania Department of Transportation (PennDOT) has repaired the guard rails in the past.

C. Alternative actions and probable effects

1. Continue current action: If no additional action is taken the bank erosion along Rt. 252 will surely worsen. The increased flow from precipitation will scour the bank and could eventually force PennDOT to reinforce it. PennDOT's primary concern is road maintenance. As the bank erodes the probability increases that DOT will dump large rock (rip-rap) to stabilize it.
2. Stream habitat improvement: The park could restructure the stream in the problem area to improve habitat for brown trout, with possible assistance from Trout Unlimited (TU). TU has been successful in many other stream improvement projects. Not only do they have a supply of enthusiastic volunteers, but their members have been successful in acquiring donations of materials from business and state/federal agencies for their projects. In Centre County, Pennsylvania they have worked with Penn State University, the Pennsylvania Fish Commission, and various area businesses to achieve significant improvements to stream quality for Spring Creek, a stream very similar in geology and fauna to Valley Creek. Activities included tree planting and construction of jackdams to control stream bank erosion (Anonymous 1993).

3. **Protect road, engineering solution:** The restructuring of the bank could employ engineering/construction solutions with the emphasis being on saving the roadway only. More gabions could likely be used in this alternative causing further adverse effects on the natural/cultural scene.
4. **Protect road, cover gabions:** The park could investigate ways with the help of TU or outside consultants to reinforce the eastern bank of Valley Creek with standard engineering approaches. Rocks covered with soil and native plants might offer the necessary protection without losing the natural stream appearance. Soils with rooted plants could also reduce the effects that water runoff from the road has on eroding the stream bank and polluting the stream. Riparian zones are wetlands and can have a filtering and cleansing effect. The same soil/plant combination could also be used to cover the present gabions.
5. **Soil and plants only:** Instead of using soil-covered rocks, the park could just use soil and plants to strengthen the bank. The bank may be too steep for this to be effective. An expert in soil engineering should be consulted if any work of this type is considered.
6. **Problem Evaluation:** This approach could postpone any work on the stream until a separate study is done to evaluate the likelihood of success of the various approaches to bank/road stabilization. A study has already been done by W. B. Reed of the NPS Water Resources Division (Reed 1990; see Appendix T). In it he addresses recommendations for the Valley Creek from the upper forge site to the covered bridge. Reed (1990) suggests conceptual designs for two portions of Valley Creek: the site of the upper forge and the stream reach from the upper forge site to the covered bridge.

The plans could try to protect slopes and control erosion in these two locations. At the upper forge five steps are proposed. The first is to repair the right retaining wall that collapsed. This has already been done. The next three steps involve the area behind the left retention wall, the site of the historic upper forge. The wall could be lowered (step 2) and the floodplain behind it could be re-shaped to the same level as the floodplain downstream of the forge (3). Soil and vegetation could then be added to this site (4) to stabilize in high water times. Finally, the right-bank bridge abutment could be moved towards the road to increase bridge span. Water velocities could be decreased with the lessening of the constriction of the retention walls.

Between the upper forge and the covered bridge Reed (1990) suggests a 3-phase approach. The right bank could be protected using soil bioengineering techniques. Secondly, the gabions could be removed from the left bank and the footpath could be lowered 3 feet. The channel could

become more stable and a more natural scene would result. Lastly, as priorities evolve, the remaining stream segments along this stretch could receive the same treatments. Alternatively the work could commence from the covered bridge toward the lower end of this reach.

D. Recommended actions

As Reed's (1990) suggestions seem to be the most sensible from the standpoint of bank stability and aesthetics they could be best course to take. Also, the Pennsylvania Clean Stream Law states that contractors and developers must implement county and municipal erosion and sediment control plans. These laws could be used as a standard for comparisons to park work.

Cultural Resources

A. Problem statement and background

Valley Forge is part of the national park system because of its historic significance. Valley Creek is an integral part of the park because it includes the location of the forges that gave Valley Forge its name, were located. These forges, and others like them in southeastern Pennsylvania, were sources of weapons for George Washington's Continental Army. Any management plan implemented on Valley Creek must take into account the cultural resources that might be affected. The cultural resources most closely associated with Valley Creek are the upper and lower forge sites and the historic mill dam. The mill dam was recreated by the state in the 1930s to mark the location of an original mill dam. It can be argued that the mill dam should be removed to create a more natural appearance.

B. Current management actions and results

The upper forge near the footbridge is protected from high waters by retaining walls. These walls could protect it from all but the worst of storms. While there are no physical structures to protect the lower forge it is currently not threatened. The current management position on the mill dam is that it will stay because of its historic significance.

C. Alternative actions and probable effects

1. Continue current action: The park could leave the retaining walls and the dam standing. No additional monitoring could be done. The retaining wall is sufficient to protect the upper forge. The dam prevents upstream fish travel and probably inhibits brown trout reproduction in the slack water area. It is certainly the more historic alternative to leave the dam intact but there are adverse visual effects on the natural scene.
2. Remove the dam: The dam could be removed to allow a natural stream flow. (Engineers could suggest the best method of removal.) The fish assemblage in this portion of the creek could change from pool to riffle species. The removal could not occur during spawning periods for fishes or macroinvertebrates to avoid affecting their populations. If the removal were scheduled during high water most of the sediment could likely be flushed out of the system. Pennsylvania Fish Commission, Department of Environmental Resources, Corps of Engineers, and Environmental Protection Agency officials could have to be consulted before removal was undertaken.
3. Monitor: Park personnel could visually monitor (monthly and after serious rains) cultural resources to document stream erosion effects. This systematic

approach would evaluate the state of vulnerable cultural resources near Valley Creek. The monitoring program could include effects of the public on the cultural resources. The program could be expanded when further archeological information is available.

D. Recommended actions

Alternative 1 and alternative 3 are recommended. The removal of the dam could be positive from a natural resources aspect while leaving it could serve a historical purpose. Cultural resources are not in any immediate threat and visual monitoring is sufficient.

Literature Cited

- Anonymous. 1993. A brief history of the Spring Creek chapter of Trout Unlimited.
- Arway, J. A. 1987. Memorandum to William Peppard, Bureau of Mining and Reclamation, Pennsylvania Department of Environmental Resources. Fisheries Environmental Service Station, Pennsylvania Fish Commission.
- Bateman, J. S. 1984. Letter to F. Williams, Media Engineering Associates. General manager, Valley Forge Sewer Authority.
- Bednarchik, R. A. 1974. Interagency water pollution report. Pennsylvania Fish Commission.
- Bick, H. 1958. Oklogishe Untersuchungen an Ciliaten Fallanbreicher Kleingewasser. Arch. Hydrobiol. 54:506-542.
- Boyd, B. K. 1988a. Letter to M. Winters, National Rolling Mills, Inc. Waste management specialist, Pennsylvania Department of Environmental Resources.
- _____. 1988b. Letter to M. Winters and P. Freda, National Rolling Mills, Inc. Waste management specialist, Pennsylvania Department of Environmental Resources.
- Brillouin, L. 1960. Science and information theory, 2nd ed. Academic Press, New York, New York.
- Buikema, A. L., Jr., K. E. Schwaab, and J. Cairns, Jr. 1980. Pollution assessment: a training manual. UNESCO's man and the biosphere, U.S. MAB Handbook No. 1.
- Burt, W. H. and R. P. Grossenheider. 1976. A field guide to the mammals. Houghton Mifflin Company. 289p.
- Cairns, J., Jr. 1968. Suspended solids standards for the protection of aquatic organisms. Purdue Univ. Eng. Bull. 129:16-27.
- _____. 1977. Aquatic ecosystem assimilative capacity. Fisheries 2:5-7.
- _____. and K. L. Dickson. 1977. Recovery of streams from spills of hazardous materials. *In* Recovery and restoration of damaged ecosystems. J. Cairns, Jr., K. L. Dickson, and E. E. Herricks (eds.). Univ. Virginia Press, Charlottesville, Virginia. pp. 24-42.
- Chester County Water Resources Authority and Chester County Planning Commission. 1979. Water resources inventory study, Vol. 2 Schuylkill Sub-basin, Chester County, Pennsylvania.

- Chester County Planning Commission. 1982. Population density, Pennsylvania: West Chester, Pennsylvania, Data Series 80, Map 2-7.
- _____. 1985. Community facilities inventory, Chester County, Pennsylvania. Vol. 1 Sewer Facilities.
- _____. 1988. Planning Bulletin #35: Population projections, 1990-2010, West Chester, Pennsylvania.
- Cole, A. E. 1935. Water pollution studies in Wisconsin. Effects of industrial (pulp and paper mill) wastes on fish. *Sewage Works Journal* 7:280-302.
- Crump-Weisner, H. J., et al. 1974. Pesticides in water: a study of the distribution of polychlorinated biphenyls in the aquatic environment. *Pestic. Monitor. J.* 8:157.
- Delaware River Basin Commission. 1980. Groundwater protected area regulations, Southeastern Pennsylvania, as amended in 1986.
- Delaware Valley Regional Planning Commission. 1984. Land use in the Delaware Valley, 1970-1980, municipal data in 12 categories: Philadelphia. 25p.
- Doan, K. H. 1942. Some meteorological and limnological conditions as factors in the abundance of certain fishes in Lake Erie. *Ecol. Monogr.* 12:293-314.
- Earth Data Inc. 1983. A report on recovery, treatment, and disposal of contaminated ground water at National Rolling Mills, East Whiteland Township, Chester County, Pennsylvania. Report to National Rolling Mills, Inc.
- Ellis, M. M. 1927. Detection and measurement of stream pollution. U.S. Dept. Commerce, Bur. Fish. Bull. 48(22):365-437.
- _____. 1940. Water conditions affecting aquatic life in Elephant Butte Reservoir. U.S. Bur. Fish. Bull. 49:257-304.
- Ernst, C. H. 1985. Bog turtle *Clemmys muhlenbergii* (Schoepff). Pages 270-273 in H. H. Genoways and R. J. Brenner (eds.). *Species of special concern in Pennsylvania*. Carnegie Museum of Natural History Special Publication No. 11. Pittsburgh, Pennsylvania.
- Freda, P. G. 1986. Letter to M. Shup, Pennsylvania Department of Environmental Resources. Chief engineer, National Rolling Mills, Inc.
- Frost, S., A. Huni, and W. E. Kershaw. 1971. Evaluation of a kicking technique for sampling stream bottom fauna. *Can. J. Zool.* 49:167-173.

- Gammon, J. R. 1970. The effects of inorganic sediment on stream biota. USEPA. Water Quality Off., Publ. 18050DWCIZ:1-141.
- Gilbert, C. R. 1985. Blackchin shiner *Notropis heterodon* (Cope). Pages 240-242 in H. H. Genoways and R. J. Brenner (eds.). Species of special concern in Pennsylvania. Carnegie Museum of Natural History Special Publication No. 11. Pittsburgh, Pennsylvania.
- Gleason, H. A. 1922. On the relation between species and area. Ecology 3:158-162.
- Heister, R. D. 1979. The impact of the installation of sewers on Valley Creek and its surrounding watershed. Conestoga Senior High School, Tredyffrin-Easttown School District, Berwyn, Pennsylvania.
- _____. 1986. Valley Creek watershed revisited. Conestoga Senior High School, Tredyffrin-Easttown School District, Berwyn, Pennsylvania.
- Hinkle, R. L. 1980. File memorandum. Chief, facilities section, Pennsylvania Department of Environmental Resources.
- Hoak, R. D. 1957. Effects of suspended matter in waste water. Pap. 4th Ont. Indust. Waste Conf. pp. 45-49.
- Hocutt, C. H., R. L. Kaesler, M. T. Masnik, and J. Cairns, Jr. 1974. Biological assessment of water quality in a large river system: an evaluation of a method of fishes. Arch. Hydrobiol. 74(4):448-462.
- Horkel, J. D. and W. D. Pearson. 1976. Effects of turbidity on ventilation rates and oxygen consumption of green sunfish, *Lepomis cyanellus*. Trans. Am. Fish. Soc. 105:107-113.
- Horwitz, R. J. 1985. Bridle shiner *Notropis bifrenatus* (Cope). Pages 190-193 in H. H. Genoways and R. J. Brenner (eds.). Species of special concern in Pennsylvania. Carnegie Museum of Natural History Special Publ. No. 11. Pittsburgh, Pennsylvania.
- Idler, K. L. 1986. PCBs: the current situation. Canadian Centre for Occupational Health and Safety, Hamilton, Ontario, Canada.
- Illies, J. 1961. Versuch Einer all Beneinen Biozonatischen Gliederung der Fliessegewasser. International Review. Hydrology 45:205-213.

- Kaesler, R. L., E. E. Herricks, and J. S. Crossman. 1978. Use of indices of diversity and hierarchical diversity in stream surveys. Pages 91-112 *in* K. L. Dickson, J. Cairns, Jr., and R. J. Livingston (eds.). Biological data in water pollution assessment: quantitative and statistical analysis. Amer. Soc. for Testing and Materials. Spec. Publ. 652.
- Karr, J. R., K. D. Fausch, P. L. Angermier, P. R. Yant, and I. J. Schlosser. 1986. Assessing biological integrity in running water: a method and its rationale. Illinois Nat. Hist. Surv. Spec. Publ. 5. 28p.
- Kaufman, 1984. No reference available.
- Kemp, H. A. 1949. Soil pollution in the Potomac River Basin. Amer. Wat. Works Assoc. J. 41:792-796.
- Knorr, D. F. 1980. Memorandum to W. Stanley, Jr., chief, operations section, Pennsylvania Department of Environmental Resources. Water pollution biologist II, Pennsylvania Department of Environmental Resources.
- _____. 1985. Aquatic biology investigations-streams Valley Creek (trib. to Schuylkill River) 1.15.0 report to Pennsylvania Department of Environmental Resources.
- _____. 1986. Memorandum. Aquatic biologist, Pennsylvania Department of Environmental Resources. Norristown Regional Office.
- _____. 1988. Personal communication. Aquatic biologist Pennsylvania Department of Environmental Resources, Norristown Regional Office.
- Koltonuk, G. 1987. Letter to Brian Lambert, resource manager, Valley Forge National Historical Park. U.S. Environmental Protection Agency.
- Kreiss, K. 1985. Studies on populations exposed to polychlorinated biphenyls. Environ. Health Perspect. 60:193.
- Kuhne, R. A. 1962. A classification of streams illustrated by fish distributed in an eastern Kentucky creek. Ecology 43:608-614.
- Kulp, C. J. 1987. Letter to J. Karish, regional chief scientist, National Park Service. Field supervisor, U.S. Fish and Wildlife Service.
- Kunkle, S., W. S. Johnson, and M. Flora. 1987. Monitoring stream water for land-use impacts: a training manual for natural resource management specialists. National Park Service, Water Resources Division.

- Lambert, B. 1988. Personal communication. Natural resources specialist, Valley Forge National Historical Park, National Park Service.
- Mangialardi, D. 1974. Memorandum to J. Toothaker, chief, Division of Management Services. Pennsylvania Department of Environmental Resources. Environmental protection technician III, Pennsylvania Department of Environmental Resources.
- Marcinko, M. 1985. Memorandum to R. Snyder, chief, Fisheries Management Section. Coldwater unit leader, Pennsylvania Fish Commission.
- _____. 1988. Personal communication. State coldwater fisheries manager, Pennsylvania Fish Commission.
- Margelef, D. R. 1958. Information theory in ecology. *Gen. Syst.* 3:36-71.
- Marsson, M. 1911. The significance of floral and fauna in maintaining the purity of natural waters, and how they are affected by domestic sewage and industrial waters. (English translation by E. Kuichling)
- McErlane, J. E. 1983. Letter to L. Thompson, Pennsylvania Department of Environmental Resources. Legal counsel, Knickerbocker Sanitary Landfill Corporation.
- Merrit, R. W. and K. W. Cummins. 1984. An introduction to the aquatic insects of North America. Kendall/Hunt Publ. Co., Dubuque, Iowa. 722p.
- Munns, E. N. 1948. Our forests and watersheds. *Sci. Monthly* 67:346-354.
- Ohio Environmental Protection Agency. 1987. Biological criteria for the protection of aquatic life: Vol. III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Division of Water Quality Monitoring and Assessment, Columbus, Ohio.
- Ohle, W. 1937. Kalksystematik Canserer Binnengewasser und der Kalgehalt Rugener Bache. *Biology Neece Binneweg.* 1:291-316.
- Oloffs, P. C., et al. 1972. Fate and behavior of five chlorinated hydrocarbons in three natural waters. *Can. J. Microbiol.* 18:1393.
- Pennak, R. W. 1953. Freshwater invertebrates of the United States. Ronald Press Co., New York. 769p.
- Petrides, G. A. 1972. A field guide to the trees and shrubs. Houghton Mifflin Company. 428p.

- Pielou, R. C. 1966. The measurement of diversity in different types of biological collections. *J. Theoret. Biol.* 13:131-144.
- Platts, W. S. 1974. Geomorphic and aquatic conditions influencing salmonids and stream classification. *Surface Environment and Mining Programs.* 199p.
- Rabeni, C. F. and G. W. Minshall. 1976. Factors affecting the micro-distribution of benthic insects. *Oikos* 29:33-43.
- Reed, B. R. 1990. Qualitative evaluation of the effects of changing watershed land uses on the hydrology, channel morphology, and historical uses of Valley Creek, Valley Forge National Historical Park, Pennsylvania. National Park Service, Water Resource Division, Fort Collins, Colorado. 48p.
- Safe, S. 1988. Polychlorinated biphenyls: human health effects. *In Hazards, decontamination, and replacement of PCB: a comprehensive guide* (ed.). J. Crine. Plenum. New York.
- Shannon, C. E. and W. Weaver. 1949. The mathematical theory of communication. Univ. of Illinois Press, Urbana, Illinois.
- Scheberger, E. and M. E. Jewell. 1928. Factors affecting pond fish production. *Kan. Forestry, Fish and Game Comm. Bull. No.* 9:5-14.
- Sinding, S. 1986. Letter to M. Civatello, vice president of operations, National Rolling Mills, Inc. Water quality compliance specialist.
- Sloto, R. A. 1987a. Effect of urbanization on the water resources of Eastern Chester County, Pennsylvania. U.S. Geological Survey Water-Resources Investigations Report 87-4098. Harrisburg, Pennsylvania.
- _____. 1987b. Effect of urbanization on storm runoff volume and peak discharge of Valley Creek, Eastern Chester County, Pennsylvania. U.S. Geological Survey Water-Resources Investigations Report 87-4196. Harrisburg, Pennsylvania.
- Smith, D. W. 1971. Illinois streams: a classification based on their fishes and an analysis of factors responsible for disappearance of native species. *Biological Notes* 76. *Illinois Nat. Hist. Sur.* 14p.
- Sneath, P. H. A. and R. R. Sokal. 1973. Numerical Taxonomy. W. H. Freeman and Company, San Francisco, California. 573p.

Stauffer, J. R., Jr. and C. H. Hocutt. 1980. Inertia and recovery: an approach to stream classification and stress evaluation. *Water Res. Bull.* 16:72-78.

_____, C. H. Hocutt, M. L. Hendricks, and S. L. Markham. 1978. Inertia and elasticity as a stream classification system: Youghiogheny River case history evaluation. *In* D. E. Samuel, J. R. Stauffer, Jr., C. H. Hocutt, and W. T. Mason, Jr. (eds.). *Surface mining and fish/wildlife needs in the eastern United States. Proceedings of a symposium U.S. Fish and Wildlife, December 1978. FWS/OBS-78/81, Morgantown, West Virginia.* 386p.

_____, R. L. Reish, and W. F. Calhoun. 1980. A FORTRAN program for calculating Brillouin's species diversity index. *Prog. Fish. Cult.* 42(3):185-187.

Strekal, T. A. 1974. Memorandum to W. Stanley, chief, operations section, Pennsylvania Department of Environmental Resources, biologist II, Pennsylvania Department of Environmental Resources.

Thompson, D. W. and F. O. Hunt. 1930. The fishes of Champaign County. *Illinois Nat. Hist. Sur. Bull.* 19:5-101.

Trautman, M. B. 1942. Fish distribution and abundance correlated with stream gradients as a consideration in stocking programs. *Trans. Seventh N. A. Wildlife Conf.* 7:221-224.

U.S. Army Corps of Engineers. 1981. Flood preparedness plan outline, George Washington's headquarters, Valley Forge National Historical Park.

U.S. Department of the Interior, National Park Service. 1988. General management plan for Valley Forge National Historical Park.

_____. 1988. Management policies

U.S. Environmental Protection Agency, Office of Water Regulations and Standards. 1980. Ambient water quality criteria for Polychlorinated Biphenyls, USEPA 440/5-80-068, Washington D.C.

U.S. Environmental Protection Agency. 1986a. Development of advisory levels for Polychlorinated Biphenyls (PCBs) Cleanup (OHEA-E-187). Office of Health Effects Assessments, U.S. Environmental Protection Agency, Washington D.C.

_____. 1986b. Quality Criteria for Water, USEPA 440/5-86-01, Washington D.C.

U.S. Fish and Wildlife Service. 1987. Endangered and threatened wildlife and plants, 10 April 1987, 50 CFR 17.11 and 17.12. U.S. Government Printing Office.

- U.S. Geological Survey. 1988. Computer database of stream discharge information for Pennsylvania.
- van Veen, P. A. 1988. Letter to R. Bauer, water quality specialist, Pennsylvania Department of Environmental Resources. Facility emergency coordinator, National Rollings Mills, Inc.
- Wallen, E. I. 1951. The direct effect of turbidity on fishes. Okla. Agric. and Mech. Col. Biol. Ser. 48:27 pp.
- Weber, C. I. 1973. Recent developments in the measurement of the response of phytoplankton and periphyton to changes in their environment. *In* Bioassay Techniques and Environmental Chemistry, G. E. Glass (ed.). Ann Arbor Science, Ann Arbor, Michigan. pp. 119-138.
- Wiggins, G. B. 1977. Larvae of the North American caddisfly genera (Trichoptera). Univ. Toronto Press, Toronto, Canada. 401p.
- Wilhm, J. L. and T. C. Dorris. 1968. Biological parameters for water quality criteria. BioScience 18:477-481.
- Winters, M. 1983a. Letter to M. Shup, Pennsylvania Department of Environmental Resources. Superintendent of buildings and grounds, National Rolling Mills, Inc.
- _____. 1983b. Letter to M. Shup, Pennsylvania Department of Environmental Resources. Superintendent of buildings and grounds, National Rolling Mills, Inc.
- _____. 1986. Letter to M. Shup, Pennsylvania Department of Environmental Resources. Superintendent of buildings and grounds, National Rolling Mills, Inc.

Appendices

Appendix A: Chapters 16 and 93. Water Quality Standards from the Pennsylvania DER (coldwater fishery).

<u>Parameter</u>	<u>Criteria</u>
Aluminum	Not to exceed 0.1 of the 96-hour LC50 for representative important species as determined through substantial available literature data or bioassay test tailored to the ambient quality of the receiving waters.
Alkalinity	Equal to or greater than 20 mg/l as CaCO ₃ , except where natural conditions are less. Where discharges are to waters with 20 mg/l or less alkalinity, the discharge should not further reduce the alkalinity of the receiving waters.
Ammonia-Nitrogen	The maximum total ammonia nitrogen concentration at all times shall be less than or equal to the numerical value given by: un-ionized ammonia nitrogen $(\text{NH}_3\text{-N}) \times (\log^{-1}(\text{pK}_T\text{-pH}) + 1), \text{ where:}$ $\text{un-ionized ammonia nitrogen} = 0.12 \times f(T)/f(\text{pH})$ $f(\text{pH}) = 1 + 10^{1.03(7.32\text{-pH})}$ $f(T) = 1, \text{ if } T \geq 10^\circ\text{C}$ $f(T) = \frac{1 + 10^{(9.73\text{-pH})}}{1 + 10^{(\text{pK}_T\text{-pH})}}, \text{ if } T < 10^\circ\text{C}$ and $\text{pK}_T = 0.090 + 2730/(T + 273.2), \text{ the dissociation constant for ammonia in water.}$ The average total ammonia nitrogen concentration over any 30 consecutive days shall be less than or equal to the numerical value given by: $\text{un-ionized ammonia nitrogen} (\text{NH}_3\text{-N}) \times (\log^{-1}(\text{pK}_T\text{-pH}) + 1), \text{ where:}$ $\text{un-ionized ammonia nitrogen} = 0.025 \times f(T)/f(\text{pH})$ $f(\text{pH}) = 1, \text{ pH} \geq 7.7$ $f(\text{pH}) = 10^{0.74(7.7\text{-pH})}, \text{ pH} < 7.7$

Appendix A: (continued, page 2 of 5)

$$f(T) = 1, \text{ if } T \geq 10^{\circ}\text{C}$$

$$f(T) = \frac{1 + 10^{(9.73 - \text{pH})}}{1 + 10^{(\text{pK}_T - \text{pH})}}, \text{ if } T < 10^{\circ}\text{C}$$

The pH and temperature used to derive the appropriate ammonia criteria shall be determined by one of the following methods:

- 1) Instream measurements, representative of median pH and temperature-July through September.
- 2) Estimates of median pH and temperature-July through September-based upon available data or values determined by the Department.

For purposes of calculating effluent limitations based on this value the accepted design stream flow shall be the actual or estimated lowest 30-consecutive-day average flow that occurs once in 10 years.

Arsenic	Not to exceed 0.05 mg/l
Bacteria	During the swimming season (May 1 through September 30), the fecal coliform level shall not exceed a geometric mean of 200 per 100 milliliters (ml) based on five consecutive samples each sample collected on different days; for the remainder of the year, the fecal coliforms level shall not exceed a geometric mean of 2,000 per ml based on five consecutive samples collected on different days.
Chromium	Not to exceed 0.05 mg/l as hexavalent chromium
Copper	Not to exceed 0.1 mg/l
Cyanide	Not to exceed 0.005 mg/l as free cyanide (HCN + CN ⁻)
Dissolved Oxygen	Minimum daily average 6.0 mg/l; no values less than 5.0 mg/l. For lakes, ponds and impoundments only, no value less than 5.0 mg/l at any point.
Fluoride	Not to exceed 2.0 mg/l.
Iron	Not exceed 1.5 mg/l as total iron; not to exceed 0.3 mg/l as dissolved iron.

Appendix A: (continued, page 3 of 5)

Lead	Not to exceed the lesser of 0.05 mg/l or 0.01 of the 96-hour LC ₅₀ for representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving waters.
Manganese	Not to exceed 1.0 mg/l.
Nickel	Not to exceed 0.01 of the 96-hour LC ₅₀ for representative important species as determined through substantial available literature data or bioassay test tailored to the ambient quality of the receiving waters.
Nitrite plus nitrate	Not exceed 10 mg/l as nitrogen.
Osmotic Pressure	Not to exceed 50 milliosmoles per kg or criteria developed using Section 93.5 (d)
pH	Not less than 6.0 and not more than 9.0.
Phenolics	Not to exceed 0.005 mg/l. Four-day average 0.02 mg/l; one-hour average 0.1 mg/l.
Temperature	Maximum temperatures in the receiving water body resulting from heated waste sources regulated under Chapter 97 (relating to Industrial Wastes), and any other sources where the Department determines that temperature limits are necessary to protect designated uses, are as follows. Additionally, these wastes may not result in a change by more than 2°F during any 1-hour period.

<u>Period</u>	<u>Temperature °F</u>
January 1-31	38
February 1-29	38
March 1-31	42
April 1-15	48
April 16-30	52
May 1-15	54
May 16-31	58
June 1-15	60
June 16-30	64
July 1-30	66
August 1-30	66
September 1-15	64
September 16-30	60
October 1-15	54

Appendix A: (continued, page 4 of 5)

<u>Period</u>	<u>Temperature °F</u>
October 16-31	50
November 1-15	46
November 16-30	42
December 1-31	40

Turbidity	Maximum monthly mean of 10 NTU, maximum 150 NTU.
Total Dissolved	Not more than 500 mg/l as a monthly average Solids value; not more than 750 mg/l at any time.
Zinc	Not to exceed 0.01 of the 96-hour LC ₅₀ nor the representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving waters.

Sample standards for ammonia set by the DER and the EPA

DER maximum acute concentrations of total ammonia (mg/l):

<u>Temperature</u>	<u>pH</u>	
	<u>7.0</u>	<u>8.5</u>
0°C	20.59	2.03
25°C	6.76	0.74

DER maximum thirty day averages for total ammonia (mg/l):

<u>Temperature</u>	<u>pH</u>	
	<u>7.0</u>	<u>8.5</u>
0°C	3.5	0.45
25°C	1.15	0.16

Appendix A: (continued, page 5 of 5)

EPA one hour average criteria: Total ammonia (mg/l NH₃)

Temperature	pH	
	<u>7.0</u>	<u>8.5</u>
0°C	28.0	2.6
25°C	16.4	1.71

EPA one hour average criteria: Un-ionized ammonia (mg/l NH₃)

Temperature	pH	
	<u>7.0</u>	<u>8.5</u>
0°C	0.023	0.065
25°C	0.093	0.26

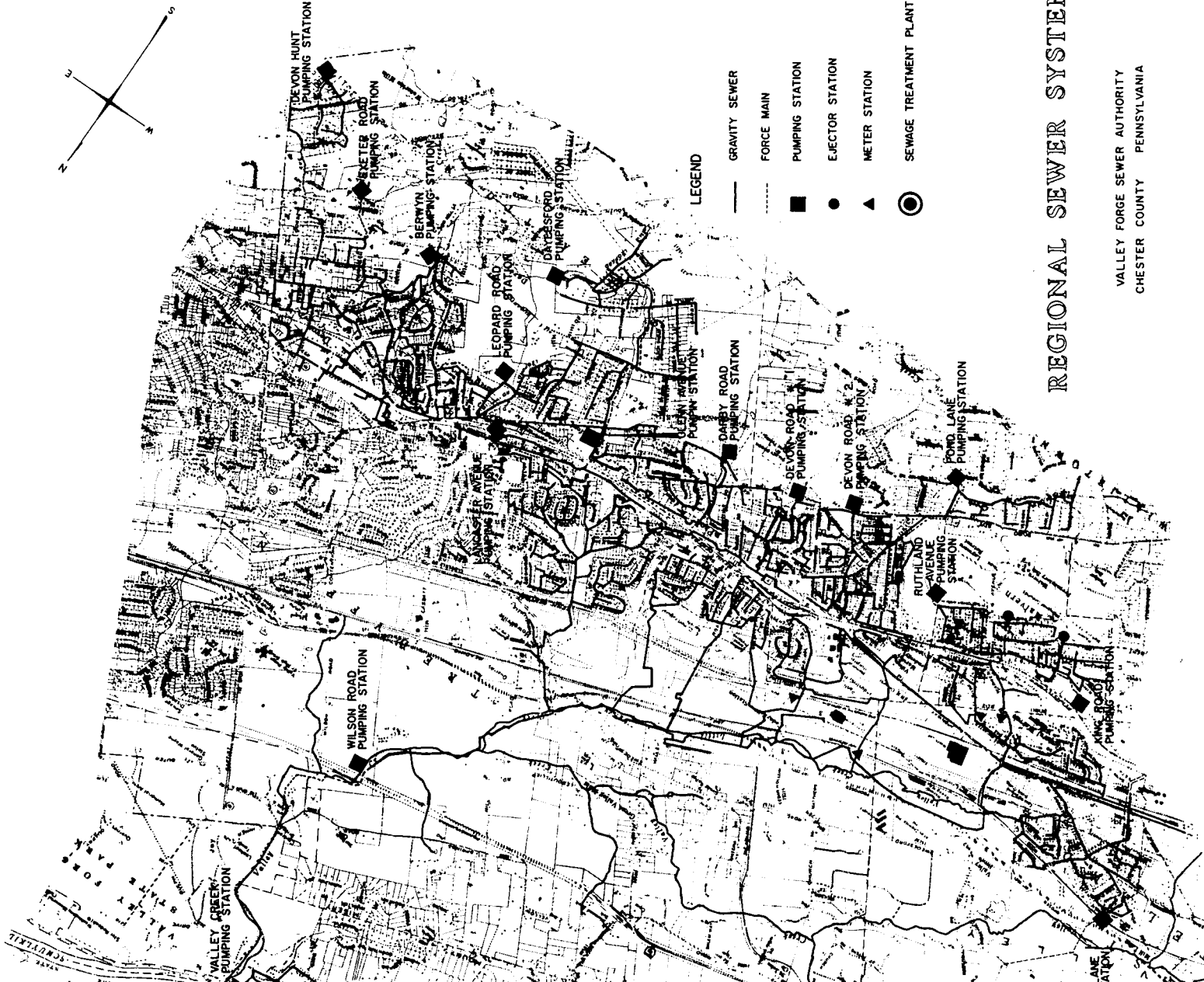
EPA 4-day average criteria: Total ammonia (mg/l NH₃)

Temperature	pH	
	<u>7.0</u>	<u>8.5</u>
0°C	2.5	0.49
25°C	1.04	0.23

EPA 4-day average criteria: Un-ionized ammonia (mg/l NH₃)

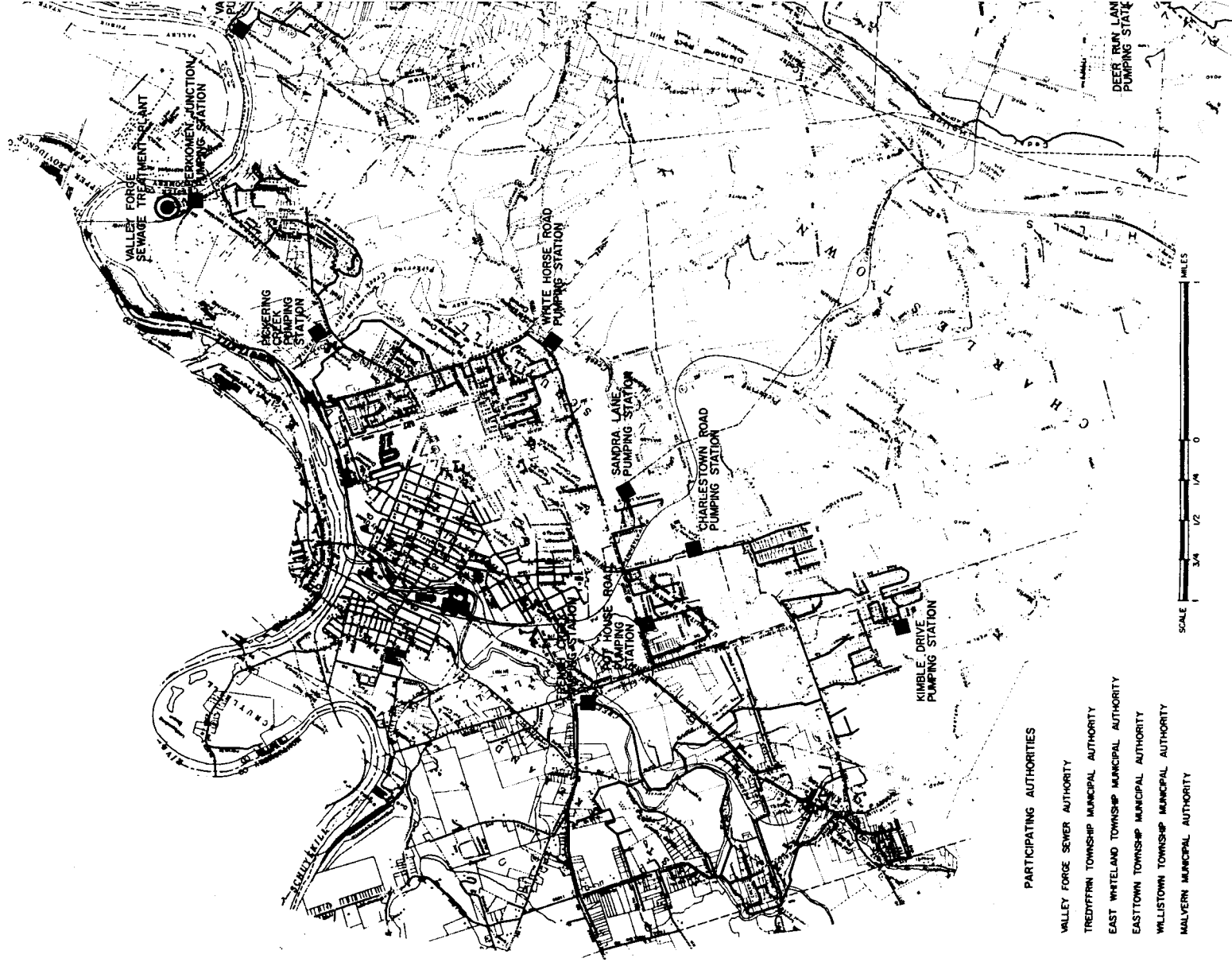
Temperature	pH	
	<u>7.0</u>	<u>8.5</u>
0°C	0.0021	0.0216
25°C	0.0059	0.035

**Appendix B: Map of Regional Sewer Systems - Valley Forge Sewer Authority,
Chester County, Pennsylvania.**



REGIONAL SEWER SYSTEMS

VALLEY FORGE SEWER AUTHORITY
CHESTER COUNTY PENNSYLVANIA



PARTICIPATING AUTHORITIES

- VALLEY FORGE SEWER AUTHORITY
- TREDYFFRIN TOWNSHIP MUNICIPAL AUTHORITY
- EAST WHITELAND TOWNSHIP MUNICIPAL AUTHORITY
- EAST TOWN TOWNSHIP MUNICIPAL AUTHORITY
- WALLISTOWN TOWNSHIP MUNICIPAL AUTHORITY
- MALVERN MUNICIPAL AUTHORITY

**Appendix C: Pennsylvania Department of Environmental Resources
National Pollutant Discharge Elimination System Application.**

**Appendix D: List of NPDES Permit Holders discharging into the
Valley Creek Drainage - PA DER Computer File.**

Appendix E: Valley Creek Station Descriptions, at the time of fish collections done by Penn State personnel.

Station No. 1--Valley Creek 300m above the mouth (VAFO)

Date	13 July 1987
Water	slightly turbid
Vegetation	none
Width	8-10m
Bottom	boulder-rubble-cobble-some gravel
Current	riffle-run-pool
Shore	open
Depth of capture*	0-1.5m
Depth of water	0-1.5m
Method of capture	10' x 5' x 1/8" seine
Time of effort	1125-1205
Dissolved Oxygen	riffle 10 mg/l, pool 9.2 mg/l
Temperature	21.7°C
pH	8.35
Gradient	6.25m/km

Station No. 2--Valley Creek 200m above the historical mill dam (VAFO)

Date	13 July 1987
Water	slightly turbid
Vegetation	<i>Elodea</i> , <i>Potamogeton</i>
Width	10-12m
Bottom	gravel-sediment
Current	pool
Shore	wooded
Depth of capture	0-2.0m
Depth of water	0.2.0m
Method of capture	10' x 5' x 1/8" seine
Time of effort	1310-1340
Dissolved Oxygen	11 mg/l
Temperature	22.7°C
pH	8.1
Gradient	6.25m/km

Appendix E: (continued, page 2 of 7)

Station No. 3--Valley Creek at the footbridge along Rt. 252 (VAFO)

Date	13 July 1987
Water	clear
Vegetation	<i>Elodea</i>
Width	10m
Bottom	gravel-rubble-cobble-some boulder
Current	riffle-run
Shore	wooded
Depth of capture	0-1.0m
Depth of water	0-1.0m
Method of capture	DC electroshocker
Time of effort	1400-1430
Dissolved Oxygen	11 mg/l
Temperature	22.9°C
pH	8.06
Gradient	1.72m/km

Station No. 4--Valley Creek at Wilson Rd. bridge (VAFO)

Date	13 July 1987
Water	clear
Vegetation	<i>Elodea</i>
Width	8-10m
Bottom	boulder-cobble-gravel
Current	riffle-run-pool
Shore	wooded-some open
Depth of capture	0-1.0m
Depth of water	0-1.0m
Method of capture	DC electroshocker
Time of effort	1550-1625
Dissolved Oxygen	10.4 mg/l
Temperature	23.3°C
pH	8.0
Gradient	5.88m/km

Appendix E: (continued, page 3 of 7)

Station No. 5--Little Valley Creek at Mill Rd. bridge

Date	14 July 1987
Water	clear
Vegetation	none
Width	3-5m
Bottom	cobble-gravel-rubble
Current	riffle-run-pool
Shore	wooded
Depth of capture	0-0.75m
Depth of water	0-0.75m
Method of capture	DC electroshocker
Time of effort	1010-1035
Dissolved Oxygen	9.7 mg/l
Temperature	18.7°C
pH	7.0
Gradient	6.89m/km

Station No. 6--Valley Creek at Mill Rd. bridge

Date	14 July 1987
Water	cloudy
Vegetation	none
Width	8-10m
Bottom	boulder-rubble-gravel
Current	riffle-run-pool
Shore	wooded
Depth of capture	0-1.0m
Depth of water	0-1.0m
Method of capture	DC electroshocker
Time of effort	1110-1135
Dissolved Oxygen	8.5 mg/l
Temperature	20.7°C
pH	8.17
Gradient	5m/km

Appendix E: (continued, page 4 of 7)

Station No. 7--Valley Creek at Church Rd.

Date	14 July 1987
Water	clear
Vegetation	none
Width	5m
Bottom	gravel-cobble
Current	riffle-run-pool
Shore	wooded
Depth of capture	0-1.5m
Depth of water	0- < 1.5m
Method of capture	DC electroshocker
Time of effort	1210-1235
Dissolved Oxygen	8.8 mg/l
Temperature	18.6°C
pH	7.92
Gradient	4.17m/km

Station No. 8--Valley Creek at Mill Lane

Date	14 July 1987
Water	muddy (rain)
Vegetation	duckweed, watercress
Width	5m
Bottom	boulder-gravel-mud
Current	run-riffle-pool
Shore	wooded
Depth of capture	0-1.0m
Depth of water	0-1.0m
Method of capture	10' x 5' x 1/8" seine
Time of effort	20 min
Dissolved Oxygen	8.1 mg/l
Temperature	20.0°C
pH	7.81
Gradient	3.28m/km

Appendix E: (continued, page 5 of 7)

Station No. 9--Trout Creek at Rt. 23 bridge

Date	16 June 1988 (fish collected)
Water	clear
Vegetation	none
Width	1-3m
Bottom	gravel-sand
Current	riffle-run-pool
Shore	wooded
Depth of capture	0-0.5m
Depth of water	0-0.5m
Method of capture	10'x5'x 1/8" seine
Time of effort	0800-0825
Dissolved Oxygen	8.1 mg/l
Temperature	18.4°C
pH	7.77
Gradient	3.57m/km

Station No. 10--Pickering Ck. at Charlestown Rd

Date	8 July 1987
Water	clear
Vegetation	<i>Elodea</i>
Width	5-10m
Bottom	silt-gravel-some rubble
Current	riffle-run-pool
Shore	wooded
Depth of capture	0-0.75m
Depth of water	0-0.75m
Method of capture	10'x 5'x 1/8" seine
Time of effort	1515-1545
Dissolved Oxygen	9.6 mg/l
Temperature	20.7°C
pH	7.59
Gradient	6.13m/km

Appendix E: (continued, page 6 of 7)

Station No. 11--French Ck. along Daisy Point Road just upstream of the intersection with Sheeder Rd., Chester Co.

Date	8 July 1987
Water	clear
Vegetation	<i>Potamogeton, Elodea</i>
Width	10-15m
Bottom	cobble-rubble, some bedrock
Current	riffle-run-pool
Shore	wooded
Depth of capture	0-1.25m
Depth of water	0-1.25m
Method of capture	5' x 10' x 1/8" seine
Time of effort	1325-1410

Station No. 12--East Branch of Perkiomen Creek at bridge on Salfordville Rd., Montgomery Co.

Date	8 July 1987
Water	muddy-turbid
Vegetation	filamentous algae
Width	10-12m
Bottom	cobble-rubble-mud
Current	riffle-run-pool
Shore	open/wooded
Depth of capture	0-1.25m
Depth of water	0-1.25m
Method of capture	5' x 10' x 1/8" seine
Time of effort	1010-1100

Station No. 13--Swamp Creek along Rt. 29 just above confluence with Perkiomen Creek, Montgomery Co.

Water	clear
Vegetation	algae
Width	20-25m
Bottom	rubble-boulder-bedrock
Current	riffle-run-pool
Shore	wooded
Depth of capture	0-1.0m
Depth of water	0-1.0m
Method of capture	5' x 10' 1/8" seine
Time of effort	1715-1750

Appendix E: (continued, page 7 of 7)

Station No. 14--Ridge Valley Creek at bridge on Perkiomenville Rd., Montgomery Co.

Date	9 July 1987
Water	clear
Vegetation	<i>Elodea, Potamogeton</i>
Width	8-15m
Bottom	rubble-boulder-bedrock
Current	riffle-run-pool
Shore	wooded-some open
Depth of capture	0-1.25m
Depth of water	0-1.25m
Method of capture	DC electroshocker
Time of effort	0900-0940

*Depth of capture is the range of depths at which fishes and macroinvertebrates were collected

Appendix F: Water quality data from selected stations collected 14 July 1987 by
The Pennsylvania State University personnel.

Parameter (mg/l)	Station No.					
	1	3	4	5	6	8
NO ₃ -N	1.65	1.85	2.00	2.15	2.15	2.10
NH ₃ -N	0.100	0.100	0.120	0.010	0.220	0.045
Total phosphates	0.046	0.042	0.044	0.020	0.220	0.045
Cu	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Ni	0.001	0.002	0.005	0.004	0.005	0.004
Mn	0.01	0.02	0.01	0.01	0.02	0.02
Pb	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Appendix G: Results of coliform testing completed by the Chester County Health Department on 21 August 1987 from samples collected by The Pennsylvania State University personnel.

Station	Fecal coliform (MPN/100ml)	Fecal streptococci (MPN/100ml)	coliform/strep***
1	36,000	260	138
2	29,000	360	81
3	29,000	3,000	9.7
4	29,000	570	51
5	14,700	780	19
6	40,000	710	56
7	25,000	890	28
8a*	10,200	650	16
8b*	9,000	590	16
9**	30,000	6,000	5
10	21,000	1,030	20

* Stations 8a and 8b are upstream and downstream, respectively of a potential sewage source at Mill Lane.

** Water samples were collected at Jennifer Lane while fish and macroinvertebrates were collected 5.5 km downstream at the Rt. 23 bridge.

*** When dividing fecal coliform by fecal *Streptococcus*, a value greater than 2 indicates human contamination.

MPN is most probable number, a statistical estimate of the bacterial particles in a sample.

Appendix H: Water quality data collected by the
Chester County Health Department, legend.

ID	ID number for the Chester County Health Department
DO	dissolved oxygen (mg/l)
coli.	coliforms (parts/100ml)
strept.	<i>Streptococcus</i> (parts/100ml)
spec. cond.	specific conductivity (umhos)
NH ₃ N	(mg/l) nitrogen as ammonia
(NO ₃ -NO ₂ -N)/(NO ₂ -N)	(unitless) nitrogen as nitrates and nitrites divided nitrogen as nitrites
Ortho PO ₄ -P	(mg/l) phosphorus as orthophosphates
Total PO ₄ -P	(mg/l) phosphorus as total phosphates
Cl-	(mg/l) choride ions
TKN	total Kjeldahl nitrogen (mg/l)
TDS	total dissolved solids
TSS	total suspended solids
COD	chemical oxygen demand (mg/l)
hard.	hardness CaCO ₃ (mg/l)
Alk.	alkalinity CaCO ₃ (mg/l)
Fe	Iron (mg/l)
Mn	Manganese (mg/l)
Na	Sodium (mg/l)
Zn	Zinc (mg/l)
Ca	Calcium (mg/l)
K	Potassium (mg/l)
Cd	Cadmium (mg/l)
Mg	Magnesium (mg/l)
F	Fluoride (mg/l)

Appendix Ha. (Page 1 of 11) Valley Creek at Morehall Rd. Chester County Health Department

Date	ID	pH	DO	air	Temp ^{°C} water	Fecal Strept Coli.	Fecal Coli.	Total Cond.	Spec. NH ₃ N	TKN	$\frac{NO_3-NO_2-N}{NO_2-N}$	Orth PO ₄ -P	Total PO ₄ -P	Cl-
6/18/81	26825	7.8	19.8	25	18	1110	4800	2800	469	0.06	0.63	1.9	0.05	43.4
10/1/81	27872	7.6	5.1	13	13	*	590	530	749	0.98	1.28	1.61	0.02	88
1/26/82	28561	7.5	10.7	<0	0	110	70	190	749 L	0.58	0.74	2.4	<0.01	87.2
5/20/82	29422	7.8	7.7	24	15	940	470	4300	440 F	0.75	0.95	2.26	0.06	84.8
8/23/82	30540	7.6	7.2	23	15	900	400	10700	689	0.88	0.88	3.44	0.03	89.3
1/20/83	31651	7.11	9.6	-8	0	20	150	170	753 L	0.88	0.97	2.5	0.03	43.3
6/9/83	32683	7.5	8.4	17	13	670	160	2300	630 F	0.93	0.93	<0.01	0.03	60.5
8/25/83	33793	7.6	6.2	21	15	900	660		510 F	0.93	0.93	2.33	0.03	60.5
3/26/84	35110	8.5	12	47°F	10	70	**		638 L	1.23	1.23	0.05	0.01	92
6/6/84	35615	7.7	10.2	28	15	390	300		420 F	1.23	1.23	1.9	0.01	92
8/30/84	36460	7.6	7.3	23.5	16.5	1990	980		810 L	1.23	1.23	0.04	0.01	92
4/8/85	37493	7.9	120	8	6.5	60	20		680 F	0.63	.77	0.04	0.03	60.2
8/5/85	38381	7.75	7.4	23	11	300	390		575 L	0.63	.77	0.04	0.03	60.2
10/31/85	39155	7.98	12.2	14	6.2	20	50		470 F	0.63	.77	0.04	0.03	60.2
									385 L	<0.01	0.20	2.77	<0.01	36
									519 F	<0.01	0.20	2.77	<0.01	36
									693 L	1.19	1.24	2.28	<0.01	68.5
									700 F	1.19	1.24	2.28	<0.01	68.5
									781.2 L	1.2	0.04	2.15	0.04	89.28
									500 F	1.2	0.04	2.15	0.04	89.28
									777.6 L	1.06	0.41	1.82	0.03	101.9
									720 L	1.06	0.41	1.82	0.03	101.9
									545 F	0.55	0.33	3.73	0.02	83.2
										0.55	0.33	3.73	0.02	83.2

Dilution not high enough.
 ** Low dilution (below detectable levels)
 L = Lab
 F = Field

*

Appendix Ha. (Page 2 of 11) Valley Creek at Morehall Rd. Chester County Health Department (cont.)

ID	SO-4	TDS	TSS	COD	Hard.	Alk.	Fe	Mn	Na	Zn	K	Cd	F
28625	51.3	312.5	76.5	13.9	242	175	0.97	0.14	25	<0.02	3.5	<0.0	
27872	42	460	0.5	30	270	246	<0.12	0.06	68	<0.02	4.9	<0.0	
28561	47*	431	7.5	<5.0	268	206	<0.12	<0.05	43.4	<0.02	4.0	<0.0	
29472	43	509	6.5	<5.0	287	214	<0.12	<0.05	62.5	<0.02	5.2	<0.0	
30540	43	381	1.5	<5.0	313	217	0.10	0.10	59.4	<0.02	5.0	<0.0	
31651	40	433	3.0	120	280	221	<0.12	<0.05	62.5	<0.02	18.0	<0.0	
32683	17	265	7.0	<5.0	236	188	0.30	<0.05	48	<0.02	4.48	<0.0	
33793	33	438	<0.5	<5.0	285	352	0.23	<0.05	77.5	<0.02	12.0	<0.0	
35112	33	375	<0.5	<5.0	219	33	0.8	0.05	76.8	<0.02	3.9	<0.01	0.069
35615	24.0	222	3.0	<5.0	166.6	19.0	0.185	<0.05	30.25	<0.02	9.5	<0.01	0.430
36460	34	361	11.0	<5.0	239.3	194.0	0.14	0.05	58.8	<0.02	4.9	<0.01	0.098
37493	40.0	394	2.0	<5.0	256.66	233.0	0.13	0.05	96.5	<0.02	3.12	<0.025	0.054
38381	43.0	377	2.0	<5.0	276.07	226.0	<0.12	0.13	75.0	<0.02	3.7	<0.025	0.089
39155	44	406	5.5	<5.0	230	210	<0.12	<0.05	55.5	<0.02	15.0	<0.025	.057

Appendix Hb. (Page 3 of 11) Valley Creek at Mill Rd. Chester County Health Department

Date	ID	pH	DO	air	Temp ^{°C} water	Fecal Coli.	Fecal Strept	Total Coli.	Spec. Cond.	NH ₃ N	TKN	NO ₃ -NO ₂ -N NO ₂ -N	Ortho PO ₄ -P	Total PO ₄ -P	Cl-
6/18/81	26824	7.8	19.6	23	18	2800	5000	4300	519	0.08	0.59	1.7	0.05	0.05	42.3
10/1/81	27874	8.25	5.3	12	13	20	1630	250	546	<0.01	0.28	1.77	0.02	0.02	43.5
1/26/82	28562	7.85	14.2	<0	0	1320	1190	2200	583 L	0.13	0.34	2.1	<0.01	0.03	46.7
									280 F						
5/26/82	29427	8.05	10	23	15	960	760	4000	530 L	0.12	0.37	2.01	0.03	0.03	41.4
									480 F			0.05			
8/23/82	30541	7.6	9.4	22	15	690	890	14000	615 L	<0.01	0.22	2.50	<0.01	0.03	53.6
									525 F						
1/20/83	31652	7.2	13.2	-9	0	300	1410	710	563 L	0.22	0.22	2.23	<0.01	0.02	
									275 F			0.01			
6/9/83	32684	7.7	9.3	14	14	800	290	2800	538 L	0.13	0.37	2.2	0.01	0.02	41.3
									450 F			0.05			
8/25/83	33794	8.3	9.6	20	19	2300	800		500 L	0.02	0.07	2.03	<0.01	<0.01	38
									310 F			<0.01			
3/26/84	35113	8.4	11.6	45°F	9	100	**		529 L	0.13	0.13	1.99	<0.01	0.01	39.5
									445 F			<0.01			
6/6/84	35616	7.9	11.2	27	15.5	1800	219		429 L	0.19	0.19	2.68	<0.01	<0.01	40
									500 F			<0.01			
8/30/84	36458	8.0	9.7	24.5	17.5	11500	1130		539 L	0.03	<0.05	2.07	<0.01	0.02	38.3
									550 F			<0.01			
4/8/85	37491	8.6	13	6.5	6.5	10	<0.4		567 L	0.01	<0.01	1.77	0.02	0.04	61.5
									435 F			<0.01			
8/5/85	38382	8.20	10.3	22.5	13.25	550	660		540.6 L	0.04	0.40	1.61	0.03	0.03	41.6
												<0.01			

** Low dilution (below detectable levels)

L = Lab

F = Field

Table Hb. (Page 4 of 11) Valley Creek at Mill Rd. Chester County Health Department (cont.)

ID	SO-4	TDS	TSS	COD	Hard.	Alk.	Fe	Mn	Na	Zn	K	Cd	F
26824	54.8	311	58.0	19.8	256	195	0.79	0.12	30	<0.02	4.8	<0.025	<0.10
27874	46.5	326	16.3	25.5	248	194	0.25	<0.05	25	<0.02	7.1	<0.025	<0.10
28562	49*	337	17.5	<5.0	264	180	<0.12	<0.05	17.4	<0.02	4.2	<0.025	<0.10
29427	41.5	381	29	<5.0	275	185	0.18	<0.05	75	<0.02	6.4	<0.025	0.098
30541	40	299	24.5	<5.0	309	197	0.40	<0.05	19	<0.02	4.6	<0.025	0.080
31652	34	312	5.5	11.5	259	185	0.25	<0.05	31.6	<0.02	3.4	<0.01	0.080
32684	33	313	38.0	<5.0	228	183	0.50	0.14	31.0	<0.02	13.0	<0.01	0.095
33794	34	297	6.5	<5.0	240	266	<0.12	<0.05	40.0	<0.02	15.5	<0.01	0.079
35113	31	361	3.5	<5.0	229	35	0.15	0.05	30	<0.02	9.5	<0.01	0.074
35616	31	236	14.5	<5.0	156.7	24	0.55	0.10	26	<0.02	7.0	<0.01	0.180
36458	34	301	23.5	<5.0	225.8	168	0.14	<0.05	29.25	<0.02	5.1	<0.01	0.092
37491	31	301	<0.5	<5.0	220	199	0.13	<0.05	41.72	<0.02	5.64	<0.025	0.058
38382	34	282	98	<5.0	239.03	180.0	0.45	<0.05	28.5	<0.02	2.2	<0.025	0.078

Table Hc. (Page 5 of 11) Little Valley Creek at Mill Rd. Chester County Health Department

Date	ID	pH	DO	Temp ^o C air	Temp ^o C water	Fecal Coli.	Fecal Strept	Total Coli.	Spec. Cond.	NH ₃ N	TKN	$\frac{NO_3-NO_2-N}{NO_2-N}$	Ortho PO ₄ -P	Total PO ₄ -P	Cl-
6/9/83	32688	7.9	10.0	15	14	330	210	4600	465 L 410 F	0.01	0.13	$\frac{2.86}{<0.01}$	<0.01	0.01	44.5
8/25/83	33797	8.7	9.6	20	19	850	780		490 L 450 F	<0.01	0.06	$\frac{2.59}{<0.01}$	<0.01	<0.01	42
3/26/84	35114	8.45	12.2	46 ^o F	9.5	40	**		477 L 400 F	0.03	0.20	$\frac{2.15}{<0.01}$	<0.01	0.01	35.7
6/6/84	35619	8.0	10.8	27	15	420	210		462 L 425 F	<0.01	0.24	$\frac{2.21}{0.01}$	<0.01	<0.01	37.6
8/30/84	36459	8.0	9.9	23	17	3100	580		484 L 480 F	<0.01	0.05	$\frac{2.66}{<0.01}$	<0.01	0.02	38.3
4/8/85	37482	8.3	13.1	6.5	6.5	30	50		111.8 L 410 F	0.41	0.38	$\frac{1.77}{<0.01}$	0.04	0.04	51.58
8/5/85	38385	8.2	11.6	25.5	13.7	270	630		540 L	0.04	0.27	$\frac{1.97}{<0.01}$	<0.01	<0.01	48.4

** Low dilution (below detectable levels)

L = Lab

F = Field

ID	SO-4	TDS	TISS	COD	hard.	name	no

ID	SO-4	TDS	TSS	COD	Hard.	Alk.	Fe	Mn	Na	Zn	K	Cd	F
32688	30	262.5	3.5	<5.0	201	132	0.30	<0.05	28	<0.02	8.0	<0.01	0.19
33797	36	270	<0.5	<5.0	216	218.5	<0.12	<0.05	30.0	<0.02	5.0	<0.01	0.110
35114	28	327	3.5	<5.0	209	30.5	0.105	0.05	27.4	<0.02	5.1	<0.01	0.093
35619	28	253	15.0	<5.0	210	29	0.185	0.05	26.75	<0.02	7.0	<0.01	0.125
36459	34	277	9.0	<5.0	208.9	135	0.08	<0.05	27.9	<0.02	5.1	<0.01	0.190
37492	33	275	1.5	12.5	183.33	173	0.13	<0.05	41.32	<0.02	3.12	<0.025	0.110
38385	37.5	287	4.0	<5.0	225.57	162.5	<0.12	<0.05	32.5	<0.02	2.3	<0.025	0.24

Table Hd. (Page 7 of 11) Valley Creek at Rt. 23 Chester County Health Department

Date	ID	pH	DO	Temp ^o C air	Temp ^o C water	Fecal Coli.	Fecal Strept	Total Coli.	Spec. Cond.	NH ₃ N	TKN	NO ₃ -NO ₂ -N NO ₂ -N	Ortho PO ₄ -P	Total PO ₄ -P	Cl-
6/18/81	26823	7.55	16.0	22	19	520	1360	1300	742	0.78	1.2	1.7	0.06	0.07	80.9
10/1/81	27873	8.2	5.2	11	13 20	640	1300	524	<0.01	0.04	1.72	<0.01	0.02	45.6	
1/26/82	28566	7.85	15.5	<0	0	180	280	510	605 L	0.05	0.14	2.3	<0.01	0.03	48.8
									290 F						
5/20/82	29423	8.2	10.2	21	15 230	520	5000	479 L	0.08	0.32	2.11	0.03	0.03	42.4	
									450 F			0.03			
8/23/82	30542	8.0	9.5	21	16 320	470	9000	530 L	<0.01	0.18	2.19	<0.01	0.01	45.6	
									500 F						
1/20/83	31650	7.12	13.5	-8	0 110	400	400	551 L	0.13	0.15	2.46	<0.01	0.02	43.3	
									270 F			<0.01			
6/9/83	32685	7.9	9.4	13	14 340	220	1700	482 L	0.03	0.23	2.2	<0.01	0.02	36.5	
									410 F			0.02			
8/25/83	33795	8.3	9.7	21	19	2000	540		500 L	<0.01	0.14	1.81	<0.01	<0.01	42
									350 F			<0.01			
3/26/84	35115	8.3	13.1	43 F	8 20	**		426 L	<.01	<.05	2.90	<.01	0.01	36.7	
									370 F			<.01			
6/6/84	35617	7.7	11.9	26	15 250	200		539 L	0.68	1.01	2.08	<0.01	<0.01	54.8	
									370 F			0.01			
8/30/84	36457	8.0	10	22.5	17	7100	730		506 L	0.03	0.12	2.01	<0.01	0.02	32.3
									525 F			<0.01			
4/8/85	37490	8.5	13.0	7	6.5	<0.4	<0.4		541.8 L	0.01	1.37	2.0	0.03	0.04	37.69
									430 F			<0.01			
8/5/85	38383	8.22		21.5	13.7	350	440		529.2 L	0.01	<0.01	1.75	0.02	0.03	43.7
									385 F			<0.01			
10/31/85	39156	8.16	13.0	12	5.5	100	90		552.0 L	<0.01	0.25	3.02	<0.01	<0.01	43.7
									400 F			<0.01			

** Low dilution (below detectable levels)

L = Lab

F = Field

Table Hd. (Page 8 of 11) Valley Creek at Rt. 23 Chester County Health Department (cont.)

ID	SO-4	TDS	TSS	COD	Hard.	Alk.	Fe	Mn	Na	Zn	K	Cd	F
26823	47	397	0.25	7.5	270	230	0.29	0.05	65	<0.02	6.0	<0.025	<0.10
27873	40	301	8.3	18.5	232	179	0.18	<0.05	21	<0.02	4.2	<0.025	0.10
28566	44*	349.5	8.8	<5.0	247	161	0.2	<0.05	19.9	<0.02	1.7	<0.025	<0.10
29423	39	425	40.5	<5.0	253	166	0.5	<0.05	57.5	<0.02	8.0	<0.025	0.118
30542	34	271	4.5	<5.0	273	167	0.30	<0.05	32	<0.02	4.6	<0.025	0.093
31650	37	317	2.0	11.5	242	176	0.13	<0.05	31.6	<0.02	6.4	<0.01	0.105
32685	34	218	16.0	<5.0	224	159	0.44	<0.05	29	<0.02	13.0	<0.01	0.115
33795	25	291	5.0	<5.0	226	246	0.20	<0.05	28.75	<0.02	5.0	<0.01	0.074
35115	29	278	<.5	<5.0	160	20.5	0.75	<.05	29.6	<0.02	4.7	<.01	0.56
35617	27	323	3.5	<5.0	220	33	0.23	0.035	48.25	<0.02	13.25	<0.01	0.090
36457	32	283	28.5	<5.0	212.3	157	0.14	<0.05	27.4	<0.02	9.2	<0.01	0.100
37490	31	328	<0.5	<5.0	193	178	0.13	<0.05	38.6	<0.02	5.0	<0.025	0.066
38383	35	276	14.5	<5.0	232.3	180	0.45	<0.05	28.0	<0.02	3.0	<0.025	0.110
39156	34	307	7.5	<5.0	240	180	<0.12	<0.05	25.8	<0.02	7.4	<0.025	0.121

Table He. (Page 9 of 11) Little Valley Creek at Morehall Rd. Chester County Health Department

Date	ID	pH	DO	Temp ^{°C} air	Temp ^{°C} water	Fecal Coll.	Fecal Strept	Total Coll.	Spec. Cond.	NH ₃ N	TKN	$\frac{NO_3-NO_2-N}{NO_2-N}$	Ortho PO ₄ -P	Total PO ₄ -P	Cl-
6/18/81	26826	7.75	18	27	20	1160	4100	4400	360	0.02	0.26	3.6	0.05	0.03	46.8
10/1/81	27875	7.8	5.2	14	13	20	970	1200	465	<0.01	0.11	2.76	0.01	0.01	44.6
1/26/82	28563	7.85	15.1	<0 ^{°C}	0 ^{°C}	380	460	580	518 L	0.03	0.16	3.4	<0.01	0.03	67.5
5/26/82	29421	8.07	8.7	24	15	21000	51000	23000	285 F	0.13	0.11	<u>3.06</u>	0.03	0.01	44.5
8/23/82	30539	7.6	9.1	25	16	240	790	4200	390 F	0.66	0.04	0.01	0.01	0.01	55.6
1/20/83	31653	7.19	13.1	-6	0	90	120	140	456 L	0.1	0.11	<u>3.61</u>	<0.01	0.02	52.2
6/9/83	32686	7.80	9.0	17	13	290	360	2800	440 F	<0.01	0.10	<u>3.17</u>	<0.01	0.01	42.2
8/25/83	33796	8.15	8.6	21	18	1040	820		238 F	<0.01	0.07	<u>3.84</u>	0.02	0.02	44
3/26/84	35116	8.4	12.0	48 F	11.5	10	20		400 F	<0.01	0.11	<u>2.8</u>	<0.01	<0.01	43.7
6/6/84	35618	7.9	10.4	29	16	490	140		472 L	0.08	0.43	<u>2.12</u>	<0.01	<0.01	34.5
8/30/84	36461	7.8	9.0	24.5	17.5	7100	1220		350 F	<0.01	0.05	<u>0.03</u>	<0.01	0.01	34.3
4/8/85	37494	8.4	12.2	7	6.5	40	120		401 F	0.02	0.19	<u>3.15</u>	0.03	0.04	50.59
8/5/85	38384	7.84	9.1	23.5	13.6	710	1600		424 L	0.01	0.10	<u>1.85</u>	0.02	<0.01	46.8
10/31/85	39157	7.82	12	18	7.0	20	210		478.8 L	<0.01	0.10	<u>2.77</u>	<0.01	<0.01	43.7
									410 F			<u>4.76</u>			
									453.6 L						
									678 L						
									360 F						

L = Lab
F = Field

Table He. (Page 10 of 11) Little Valley Creek at Morehall Rd. Chester County Health Department (cont.)

ID	SO-4	TDS	TSS	COD	Hard.	Alk.	Fe	Mn	Na	Zn	K	Cd	F	
26826	20	218	7.0	10.0	144	91	0.12	<0.05	28	<0.02	2.7		<0.025	<0.10
27875	31	262.5	4.5	30	188	132	<0.12	<0.05	25	<0.02	2.7		<0.025	0.58
28563	35*	299	14.5	<5.0	186	111	0.35	<0.05	7.5	<0.02	<0.04		<0.025	0.792
29421	32	350	9.5	<5.0	189	110	<0.12	<0.05	75	<0.02	10.2		<0.025	0.87
30539	19	221	5.0	<5.0	206	105	0.10	<0.05	31.2	<0.02	5.0		<0.025	0.50
31653	30.5	285.5	15.25	11.5	184	115	0.13	<0.05	33.8	<0.02	5.6		<0.01	0.64
32686	28	232	7.0	<5.0	163	104	<0.12	<0.05	25	<0.02	1.93		<0.01	0.50
33796	19	206	4.0	<5.0	130	115	<0.12	<0.05	31.25	<0.02	7.5		<0.01	0.068
35116	33.5	296	1.0	<5.0	189	24.5	0.13	<0.05	17.6	<0.02	5.9		<0.01	0.165
36461	28	270	19.0	<5.0	220	33.0	0.27	0.035	28.25	<0.02	5.75		<0.01	0.094
37494	29	237	15.5	<5.0	158.4	108	0.08	<0.05	35.5	<0.02	16.5		<0.01	0.670
38384	25	228	<0.5	26.5	135	117	0.13	<0.05	38.6	<0.02	3.76		<0.025	0.620
39157	31	246	8.0	<5.0	178.43	120	0.18	<0.05	33.1	<0.02	0.9		<0.025	0.62
	34.3	282	5.0	<5.0	198.3	131.5	<0.12	<0.05	24.8	<0.02	7.0		<0.025	1.78

**Appendix I: Macroinvertebrates collected on 17 November 1987 by
Penn State personnel**

Station Number	1	2	3	4	5	6	7	8	9	10
----------------	---	---	---	---	---	---	---	---	---	----

[illegible]

[illegible]

Appendix I. (continued, Page 3 of 4)

Station No.	1	2	3	4	5	6	7	8	9	10
<i>Leucotrichia</i>										4
Limnephilidae										3
<i>Apatania</i>										
Philopotamidae						5				
<i>Chimarra</i>										
Polycentropodidae										1
<i>Cynellus</i>			1							
<i>Polycentropus</i>										
Phrygaenidae										1
<i>Ptilostomis</i>										
Psychomyiidae				2						15
<i>Psychomyia</i>										
Lepidoptera										
Noctuidae									1	
<i>Simyra</i>	1		1							
Pyrilidae										1
<i>Petrophila</i>										
Coleoptera			1							1
Dytiscidae										5
Elmidae	125	1	73	65	19	8	79	7	2	28
<i>Dubiraphia</i>		2	1	1			1	2		4
<i>Optioservus</i>	235	2	98	187	308	64	351	75	2	
<i>Stenelmis</i>	37	1	27	10	4	19	2	7	1	
Hydrophilidae										5
<i>Berosus</i>									1	
Psephenidae										
<i>Psephenus</i>	5	1	1			1				
Diptera						1				
Athericidae										
<i>Atherix</i>								1		
Chironomidae	257	347	136	383	293	93	145	423	28	74
Culicidae										
<i>Anopholes</i>		1								

Appendix I. (continued, Page 4 of 4)

Station No.	1	2	3	4	5	6	7	8	9	10
Psychodidae										
<i>Pericoma</i>			1						1	
Simuliidae										
<i>Prosimulium</i>				2						7
<i>Simulium</i>								1		
Tabanidae										
<i>Chrysops</i>		2					1			
Tipulidae	124	4	40	173	52	109	52		11	9
<i>Antocha</i>					3		2		1	1
<i>Tipula</i>						2			5	48
Gastropoda	1	1	27					1		66
Ancylidae				3						9
<i>Pelecypoda</i>							1			
No. of Specimens	2227	1355	1299	2332	1808	1150	1523	1391	116	781
No. of Species	24	17	22	22	17	19	20	23	21	47
Diversity Index	2.26	0.98	2.25	2.02	2.03	1.73	2.20	1.56	1.96	2.83

Appendix J: Fishes collected July 1987 by Penn State personnel.

Station No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
<i>Anguilla rostrata</i>													1	9
<i>Oncorhynchus mykiss</i> 1											5			
<i>Salmo trutta</i>		2	7	37+	6	79+	7			3				
<i>Esox americanus</i>										2				
<i>Cyprinella analostana</i>			2								21	1		
<i>Cyprinella spiloptera</i>												5	16	9
<i>Cyprinus carpio</i>													1	
<i>Exoglossum maxillingua</i>							2				7	3		86
<i>Luxilus cornutus</i>									12	19	149		1	
<i>Margariscus margarita</i>									34					
<i>Notemigonus crysoleucus</i>											2			
<i>Notropis amoenus</i>										1				4
<i>Notropis hudsonius</i> 4										40	3	16	12	45
<i>Notropis procne</i>									2			1		
<i>Pimephales promelas</i>			2											
<i>Rhinichthys atratulus</i>				13	33	36	7	2	3	3	21	6	1	1
<i>Rhinichthys cataractae</i> 2				1	2	1	5				9		2	4
<i>Semotilus atromaculatus</i>									2		21			14
<i>Semotilus corporalis</i>										1	15		5	6
<i>Catostomus commersoni</i> 1		52	18	12	3	12	11	5	4	10	1			1057
<i>Erimyzon oblongus</i>									5					
<i>Ameiurus natalis</i>											1		1	
<i>Fundulus diaphanus</i>										7				
<i>Ambloplites rupestris</i>			1	3			1				14	10	16	1623
<i>Lepomis auritus</i>											2	11	53	19
<i>Lepomis cyanellus</i>				1		1			1	1	1	11	10	19
<i>Lepomis gibbosus</i>					2	2	12		7	3	14	1	12	
<i>Lepomis macrochirus</i>								3			65	15		
<i>Micropterus dolomieu</i>											12	2	6	730
<i>Micropterus salmoides</i>											12	1		26
<i>Pomoxis nigromaculatus</i>											1			
<i>Etheostoma olmstedii</i>			34	13	2		1				10	3		18
<i>Percina peltata</i> 1										3	2			
No. of Specimens	9	91	50	57	77	37	97	63	8	262	97	244	149	241
No. of Species	5	5	6	6	4	9	5	6	3	20	19	13	17	19
Diversity Indices	0.99	0.83	1.29	1.08	0.83	1.57	0.62	1.21	0.70	2.37	2.23	1.45	2.02	2.21

Appendix K: Field measurements of gamefishes collected July 1987 by
Penn State personnel.

Station	Fish Species	Length(cm)	Weight(g)
1	<i>Oncorhynchus mykiss</i>	33	370
2	<i>Ambloplites rupestris</i>	15	85
3	<i>Salmo trutta</i>	8	-
		30	-
	<i>Abloplites rupestris</i>	15	90
		16	90
		8	60
4	<i>S. trutta</i>	23	100
		25	170
		30	300
		24	160
		20	100
		25	-
		10	18
5	<i>S. trutta</i>	29	280
		27	240
		25	230
		20	70
		22	90
		19	90
		22	90
		5-8 (over 30 this size)*	
6	<i>S. trutta</i>	20	70
		5-10 (five this size)*	
	<i>A. rupestris</i>	18	160
	<i>Lepomis gibbosus</i>	14	60
		13	6
	<i>Lepomis cyanellus</i>	11	30
7	<i>S. trutta</i>	25	210
		13	20
		10	10
		37	400
		27	210
		24	160
		11	15
		10	10
		38	400
		5-13 (over 70 this size)*	
	<i>L. macrochirus</i>	11	22
		12	40
	<i>L. gibbosus</i>	11	30
		9	18
	<i>S. trutta</i>	5-12 (7 this size)	
	<i>L. gibbosus</i>	4-8 (12 this size)	

* These individuals could not be weighed

Macrominvertebrates for ~~fishes~~ collected by ~~1~~ November 1987

[illegible]

July 1967

13

Appendix N: Historical fish collections currently catalogued in
The Pennsylvania State University Fish Museum, collected by Dr. E. L. Cooper,
Professor Emeritus of Zoology at Penn State.

Collection #828 Valley Creek 2 mi. SE of Devault, Chester Co., 19 August 1969

<i>Rhinichthys atratulus</i>	7 at 1-3"
<i>Semotilus atromaculatus</i>	4 at 2"
<i>Catostomus commersoni</i>	7 at 2-10"

Collection #736 Pickering Creek 3 mi. SW of Phoenixville, PA, 19 August 1969

<i>Exoglossum maxilllingua</i>	2
<i>Cyprinella analostana</i>	1
<i>Cyprinella spiloptera</i>	3
<i>Rhinichthys cataractae</i>	1
<i>Semotilus corporalis</i>	6
<i>Catostomus commersoni</i>	1
<i>Noturus insignis</i>	7
<i>Ambloplites rupestris</i>	3
<i>Lepomis gibbosus</i>	8
<i>Lepomis macrochirus</i>	8
<i>Micropterus dolomieu</i>	4
<i>Etheostoma olmsted</i>	2
<i>Percina peltata</i>	3

Collection #1383 Unami Creek, Montgomery Co., tributary to Perkiomen Creek,
31 March 1971

<i>Exoglossum maxilllingua</i>	3
<i>Luxilus cornutus</i>	2
<i>Notropis hudsonius</i>	1
<i>Rhinichthys atratulus</i>	4
<i>R. cataractae</i>	3
<i>Pimephales notatus</i>	1
<i>Semotilus corporalis</i>	16
<i>Catostomus commersoni</i>	1
<i>Noturus insignis</i>	1
<i>Lepomis auritus</i>	3
<i>Micropterus dolomieu</i>	1
<i>Etheostoma olmsted</i>	10

Appendix N: (continued, page 2 of 5)

Collection #1379 Northeast Branch Perkiomen Creek, Montgomery Co., PA, 31 March 1971

<i>Cyprinella spiloptera</i>	2
<i>Cyprinus carpio</i>	1
<i>Exoglossum maxilllingua</i>	33
<i>Luxilus cornutus</i>	4
<i>Notropis hudsonius</i>	1
<i>Notropis procne</i>	3
<i>Pimephales notatus</i>	22
<i>Catostomus commersoni</i>	4
<i>Ameiurus natalis</i>	1
<i>Fundulus diaphanus</i>	6
<i>Lepomis auritus</i>	6
<i>Lepomis cyanellus</i>	4
<i>Etheostoma olmsted</i>	12

Collection #1265 Skipjack Creek at Rt. 422, Montgomery Co., (tributary to Perkiomen Creek), 31 March 1971

<i>Exoglossum maxilllingua</i>	14
<i>Cyprinella spiloptera</i>	5
<i>Luxilus cornutus</i>	6
<i>Notemigonus crysoleucas</i>	1
<i>Notropis amoenus</i>	4
<i>Notropis hudsonius</i>	1
<i>Notropis procne</i>	11
<i>Pimephales notatus</i>	10
<i>Rhinichthys atratulus</i>	21
<i>R. cataractae</i>	2
<i>Catostomus commersoni</i>	6
<i>Ameiurus natalis</i>	1
<i>Fundulus diaphanus</i>	17
<i>Lepomis cyanellus</i>	1
<i>Etheostoma olmsted</i>	17

Appendix N: (continued, page 3 of 5)

Collection #880 Swamp Creek, 1 mile above mouth, Montgomery Co., tributary to Perkiomen Creek, 8 July 1969

<i>Cyprinella spiloptera</i>	1
<i>Cyprinus carpio</i>	1
<i>Exoglossum maxillingua</i>	1
<i>Notemigonus crysoleucas</i>	1
<i>Catostomus commersoni</i>	2
<i>Anguilla rostrata</i>	1
<i>Lepomis auritus</i>	8
<i>Lepomis cyanellus</i>	3
<i>Lepomis gibbosus</i>	5
<i>Micropterus dolomieu</i>	3
<i>Micropterus salmoides</i>	1

Collection #658 French Creek at Kimberton Farm School, Chester Co., 18 April 1969

<i>Anguilla rostrata</i>	5
<i>Salmo trutta</i>	2
<i>Cyprinella analostana</i>	5
<i>Exoglossum maxillingua</i>	63
<i>Luxilus cornutus</i>	19
<i>Notropis hudsonius</i>	1
<i>Pimephales notatus</i>	1
<i>Rhinichthys atratulus</i>	2
<i>Rhinichthys cataractae</i>	1
<i>Semotilus atromaculatus</i>	1
<i>Semotilus corporalis</i>	17
<i>Catostomus commersoni</i>	X
<i>Noturus insignis</i>	24
<i>Ambloplites rupestris</i>	18
<i>Lepomis auritus</i>	8
<i>Micropterus dolomieu</i>	5
<i>Etheostoma olmsted</i>	29
<i>Percina peltata</i>	4

Appendix N: (continued, page 4 of 5)

Collection #735 South Branch French Creek, Chester Co., 19 August 1969

<i>Exoglossum maxillingua</i>	55
<i>Cyprinella analostana</i>	96
<i>Luxilus cornutus</i>	91
<i>Notropis hudsonius</i>	3
<i>Notropis procne</i>	20
<i>Rhinichthys atratulus</i>	48
<i>Notropis cataractae</i>	3
<i>Semotilus atromaculatus</i>	11
<i>Notropis corporalis</i>	7
<i>Catostomus commersoni</i>	62
<i>Noturus insignis</i>	37
<i>Anguilla rostrata</i>	4
<i>Ambloplites rupestris</i>	14
<i>Lepomis auritus</i>	26
<i>Lepomis gibbosus</i>	2
<i>Lepomis macrochirus</i>	2
<i>Micropterus dolomieu</i>	2
<i>Etheostoma olmsted</i>	141

Collection #734 French Creek at Knauertown, Chester Co., 19 August 1969

<i>Salmo trutta</i>	2
<i>Clinostomus funduloides</i>	9
<i>Cyprinella analostana</i>	27
<i>Exoglossum maxillingua</i>	70
<i>Luxilus cornutus</i>	81
<i>Notropis hudsonius</i>	16
<i>Notropis procne</i>	14
<i>Rhinichthys atratulus</i>	263
<i>Rhinichthys cataractae</i>	57
<i>Semotilus atromaculatus</i>	1
<i>Semotilus corporalis</i>	13
<i>Catostomus commersoni</i>	62
<i>Noturus insignis</i>	37
<i>Anguilla rostrata</i>	9
<i>Ambloplites rupestris</i>	2
<i>Lepomis cyanellus</i>	4
<i>Lepomis macrochirus</i>	1
<i>Micropterus salmoides</i>	2
<i>Etheostoma olmsted</i>	81
<i>Percina peltata</i>	29

Appendix N: (continued, page 5 of 5)

Collection #733 Pine Creek, Chester Co., tributary to French Creek, 18 August 1969

<i>Salmo trutta</i>	2
<i>Salvelinus fontinalis</i>	1
<i>Esox americanus</i>	2
<i>Clinostomus funduloides</i>	203
<i>Exoglossum maxillingua</i>	39
<i>Notropis cornutus</i>	79
<i>Rhinichthys atratulus</i>	101
<i>Rhinichthys cataractae</i>	1
<i>Semotilus atromaculatus</i>	1
<i>Rhinichthys corporalis</i>	82
<i>Catostomus commersoni</i>	38
<i>Noturus insignis</i>	1
<i>Anguilla rostrata</i>	11
<i>Lepomis cyanellus</i>	3
<i>Lepomis gibbosus</i>	2
<i>Etheostoma olmstedii</i>	64

Appendix O: Common names of the fishes collected and listed in historical collections.

<i>Anguilla rostrata</i>	American eel
<i>Oncorhynchus mykiss</i> ^I	rainbow trout
<i>Salmo trutta</i> ^E	brown trout
<i>Esox americanus americanus</i>	redfin pickeral
<i>Cyprinella analostana</i>	satinfin shiner
<i>Cyprinella spiloptera</i>	spotfin shiner
<i>Cyprinus carpio</i> ^E	common carp
<i>Exoglossum maxillingua</i>	cutlips minnow
<i>Luxilus cornutus</i>	common shiner
<i>Margariscus margarita</i>	pearl dace
<i>Notemigonus crysoleucus</i>	golden shiner
<i>Notropis amoenus</i>	comely shiner
<i>Notropis hudsonius</i>	spottail shiner
<i>Notropis procne</i>	swallowtail shiner
<i>Pimephales notatus</i>	bluntnose minnow
<i>Pimephales promelas</i>	fathead minnow
<i>Rhinichthys atratulus</i>	blacknose dace
<i>Rhinichthys cataractae</i>	longnose dace
<i>Semotilus atromaculatus</i>	creek chub
<i>Semotilus corporalis</i>	fallfish
<i>Catostomus commersoni</i>	white sucker
<i>Erimyzon oblongus</i>	creek chubsucker
<i>Ameiurus natalis</i>	yellow bullhead
<i>Noturus insignis</i>	marginated madtom
<i>Fundulus diaphanus</i>	banded killifish
<i>Ambloplites rupestris</i> ^I	rock bass
<i>Lepomis auritus</i>	redbreast sunfish
<i>Lepomis cyanellus</i> ^I	green sunfish
<i>Lepomis gibbosus</i>	pumpkinseed
<i>Lepomis macrochirus</i> ^I	bluegill
<i>Micropterus dolomieu</i> ^I	smallmouth bass
<i>Micropterus salmoides</i> ^I	largemouth bass
<i>Pomoxis nigromaculatus</i> ^I	black crappie
<i>Etheostoma olmsted</i>	tessalated darter
<i>Percina peltata</i>	shield darter

^I=introduced; ^E=exotic

Note: For the purposes of this table, an introduced fish species is one that does not naturally occur in its recorded drainage, rather, it was transplanted there from within North America. Exotic fish species are also transplanted but come from other continents, i.e. the brown trout is originally from Europe. Original ranges of fishes were taken Lee et al., 1980. All those unmarked are within their native ranges.

Appendix P: Results of small mammal trapping done by Penn State personnel on
16-17 July 1987.

<u>Site</u>	<u>Date</u>	<u>Trap 1</u>	<u>Trap 2</u>	<u>Trap 3</u>	<u>Trap 4</u>	<u>Trap 5</u>
1	7/16/87 7/17/87	P.m.		P.m. P.m.		
2*	7/16/87 7/17/87	X	X	X	X	X
		X	X	X	X	X
3	7/16/87 7/17/87		P.m.	X		
4	7/16/87 7/17/87		M.p.			
5	7/16/87 7/17/87	P.l.		P.m. P.m.	P.m. M.p.	
6	7/16/87 7/17/87	P.l.			P.m. P.m.	P.m. P.m.
7	7/16/87 7/17/87		X M.p.	M.p.		
8	7/16/87 7/17/87		M.p.	P.m.		P.m.

P.l. - *Peromyscus leucopus*, white-footed mouse; P.m. - *Peromyscus maniculatus*, deer mouse; M.p. - *Microtus pennsylvanicus*, meadow vole; X - sprung trap (not a trap night)

* - At this site, on both nights, all the traps were sprung and not in their original locations. Total trap nights = 68

Appendix Q: Woody vegetation identified by Penn State personnel during summer 1987.

1. Valley Creek at Washington's Headquarters

Acer saccharinum, silver maple
Acer negundo, ashleaf maple (boxelder)
Juglans nigra, black walnut
Morus alba, white mulberry
Platanus occidentalis, sycamore
Robinia hispida, bristly locust
Salix spp., willow
Tilia americana, basswood
Ulmus americana, American elm
Vitis spp., wild grape

2. Valley Creek 200m above mill dam

Acer negundo, ashleaf maple (boxelder)
Acer saccharinum, silver maple
Cercis canadensis, eastern redbud
Juglans nigra, black walnut
Liriodendron tulipifera, tulip-tree
Morus rubra, red mulberry
Paulownia tomentosa, princess-tree
Prunus serotina, black cherry
Rhus glabra, smooth sumac
Robinia hispida, bristly locust
Ulmus americana, American elm

Appendix Q: (continued, page 2 of 4)

3. Valley Creek at footbridge along Rt. 252

Acer negundo, ashleaf maple (boxelder)
Acer saccharum, sugar maple
Betula nigra, river birch
Forsythia viridissima, forsythia
Hamamelis virginia, witch hazel
Liriodendron tulipifera, tulip-tree
Parthenocissus quinquefolia, Virginia creeper
Platanus occidentalis, sycamore
Quercus velutina, black oak
Tilia americana, American basswood
Ulmus americana, American elm
Ulmus rubra, slippery elm
Viburnum acerifolium, mapleleaf viburnum

4. Valley Creek at Wilson Rd bridge

Acer negundo, ashleaf maple (boxelder)
Acer platanoides, Norway maple
Fraxinus pennsylvanica var. *subintegerrima*, green ash
Lonicera morrowi, morrow honeysuckle
Morus rubra, red mulberry
Platanus occidentalis, sycamore
Prunus serotina, black cherry
Robinea pseudo-acacia, black locust
Rosa multiflora, multiflora rose
Salix spp., willow
Juglans nigra, black walnut
Ulmus americana, American elm
Vitis spp., wild grape

Appendix Q: (continued, page 3 of 4)

5. Little Valley Creek at Mill Road Park

Acer negundo, ashleaf maple (boxelder)
Lonicera tatarica, tartarian honeysuckle
Morus rubra, red mulberry
Platanus occidentalis, sycamore
Prunus virginiana, choke cherry
Robinia hispida, bristly locust
Rhus glabra, smooth sumac
Rubus occidentalis, black raspberry
Salix spp., willow
Juglans nigra, black walnut
Ulmus americana, American elm
4 spp., wild grape
1 exotic (unknown)

6. Valley Creek at Mill Rd.

Acer negundo, ashleaf maple (boxelder)
Acer saccharinum, silver maple
Betula nigra, river birch
Crataegus spp., hawthorn
Fraxinus pennsylvanica var. *subintegerrima*, green ash
Lindera benzoin, spicebush
Liriodendron tulipifera, tulip-tree
Lonicera morrowi, morrow honeysuckle
Juglans nigra, black walnut
Parthenocissus quinquefolia, Virginia creeper
Platanus occidentalis, sycamore
Robinia pseudo-acacia, black locust
Rosa multiflora, multiflora rose
Salix spp., willow
Vitis spp., wild grape

Appendix Q: (continued, page 4 of 4)

7. Valley Creek at Church Rd

Acer negundo, ashleaf maple (boxelder)
Acer Platanoides, Norway maple
Cercis canadensis, eastern redbud
Fraxinus pennsylvanica var. *subintegerrima*, green ash
Ligustrum obtusifolium, regal privet
Lindera benzoin, spicebush
Juglans nigra, black walnut
Platanus occidentalis, sycamore
Prunus serotina, black cherry
Robinia pseudo-acacia, black locust
Rosa multiflora, multiflora rose
Rubus allegheniensis, blackberry
Salix spp., willow
Rhus radicans, poison ivy
Tsuga canadensis, eastern hemlock
Ulmus americana, American elm
Vitis spp., wild grape

8. Valley Creek at Mill Lane

Ailanthus altissima, tree-of-heaven
Acer negundo, ashleaf maple (boxelder)
Acer rubrum, red maple
Cornus amomum, silky dogwood
Juglans nigra, black walnut
Platanus occidentalis, sycamore
Populus grandidentata, bigtooth aspen
Prunus virginiana, choke cherry
Robinia hispida, bristly locust
Rhus glabra, smooth sumac
Rosa multiflora, multiflora rose
Salix spp., willow
Ulmus americana, American elm
Ulmus rubra, slippery elm

**Appendix R: Data taken from National Park Service files in
Valley Forge National Historical Park.**

**Appendix S: Reprint of Buikema, A. L., Jr., K. E. Schwaab, and J. Cairns, Jr. 1980.
Pollution assessment: a training manual. UNESCO's Man and the Biosphere,
U.S. MAB Handbook No. 1.**

Appendix T: A copy of Reed, 1990. Qualitative evaluation of the effects of changing watershed land uses on the hydrology, channel morphology and historical uses of Valley Creek, Valley Forge National Historical Park, Pennsylvania.