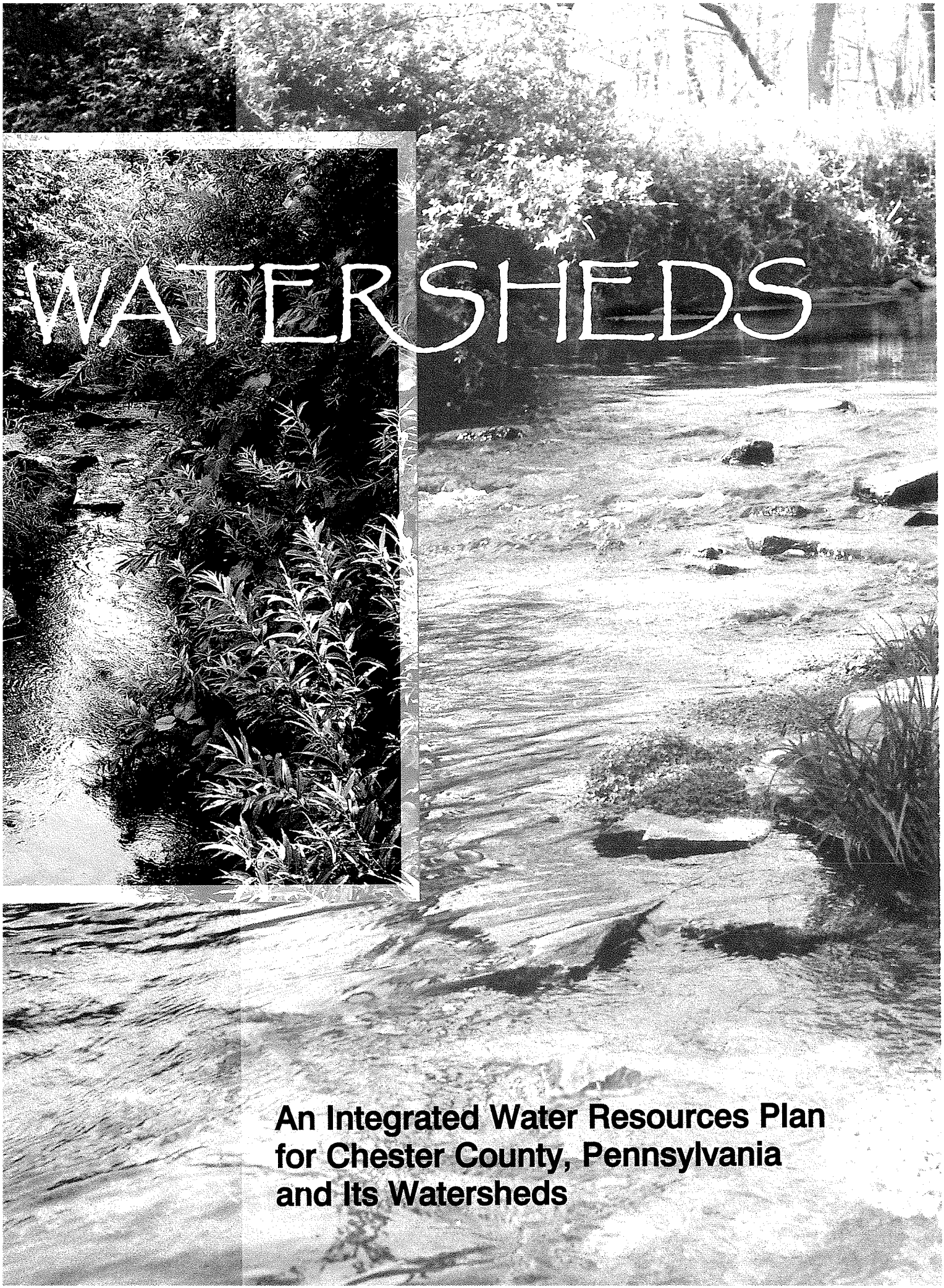


An Integrated Water Resources Plan for Chester County, Pennsylvania and Its Watersheds

Watersheds Mission Statement

To protect, sustain, and enhance the quality and quantity of all water resources to insure the health, safety, and welfare of the citizens, and preserve the diverse natural resources and aesthetic and recreational assets of Chester County and its watersheds.

Disclaimer

The maps, data and information presented herein were compiled by the Chester County Water Resources Authority for the County of Chester, PA and are hereby referenced to the *Chester County, Pennsylvania Water Resources Compendium* (2001). These information and data are provided for reference and planning purposes only. This document is based on and presents the best information available at the time of the preparation.

Funding Partners

Chester County and the Chester County Water Resources Authority express their appreciation to those entities who provided financial support for this effort. This project was funded by:

- Chester County Board of Commissioners.
- Pennsylvania Department of Conservation and Natural Resources, Bureau of Recreation and Conservation, Keystone Recreation, Park and Conservation Fund Program.
- Pennsylvania Department of Environmental Protection, and U. S. Environmental Protection Agency Nonpoint Source Pollution Management Program.
- Brandywine Valley Association and William Penn Foundation.
- U. S. Geological Survey.

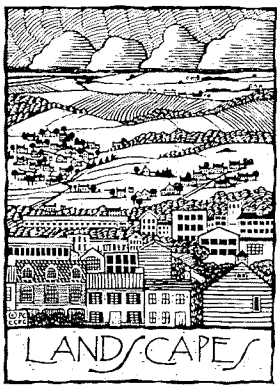
Chester County Board of Commissioners

Karen L. Martynick, Chairman
Colin A. Hanna
Andrew E. Dinniman

WATERSHEDS

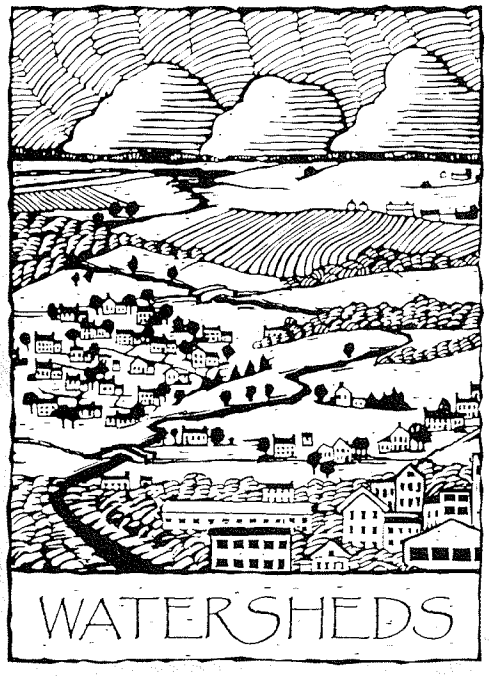
An Integrated Water Resources Plan for Chester County, Pennsylvania and Its Watersheds

A Functional Element of



Chester County
Comprehensive Plan

Adopted
September 17, 2002


WATERSHEDS

Resolution #52–02

WHEREAS, the Chester County Board of Commissioners adopted **LANDSCAPES**, *Managing Change in Chester County 1996 2020*, the Policy Element of the Chester County Comprehensive Plan on July 12, 1996; and

WHEREAS, **LANDSCAPES** includes 31 policies that promote water resources protection, planning and management in a manner that supports planned growth while sustaining our natural resources; and

WHEREAS, the Pennsylvania Municipalities Planning Code, as amended (in particular by Acts 67 and 68 of 2000), requires county comprehensive planning to address water resources and water supply planning; and

WHEREAS, the Chester County Board of Commissioners recognize that with continuing growth pressures, conservation and restoration of the quality and quantity of the water resources of Chester County's 21 watersheds, 1,310 miles of streams, and 780 square miles of ground water aquifers are of critical importance to the quality of life in Chester County; and

WHEREAS, the County of Chester prepared ***Watersheds*** — *An Integrated Water Resources Management Plan for Chester County, Pennsylvania and its Watersheds* to address these needs, with assistance from the Chester County Water Resources Task Force, the public, and other stakeholders of the County's watersheds, and thereby represents the interests of the constituents of Chester County; and

WHEREAS, the Commonwealth of Pennsylvania, Department of Conservation and Natural Resources, Bureau of Recreation and Conservation has established a Pennsylvania Rivers Conservation Registry on which several of Chester County's watersheds are listed or are in the process of being listed, and ***Watersheds*** was prepared to serve as a County-wide Rivers Conservation Plan and includes recommendations for implementation throughout Chester County;

NOW, THEREFORE, be it resolved that on the 17th day of September 2002, the Board of Commissioners of the County of Chester do hereby adopt ***Watersheds*** — *An Integrated Water Resources Management Plan for Chester County, Pennsylvania and its Watersheds* here attached as the Water Resources Element of the Chester County Comprehensive Plan, **LANDSCAPES**, and

FURTHER, be it resolved that the Board of Commissioners of the County of Chester do hereby request that all remaining rivers, river segments and tributaries of the watersheds of Chester County be listed on the Pennsylvania Rivers Conservation Registry.

ATTEST:

Nancy N. Seltzer
Chief Clerk

September 17, 2002
Date

Chester County Board of Commissioners

Karen L. Martynick
Karen L. Martynick, Chairman

Colin A. Hanna
Colin A. Hanna, Vice Chairman

Andrew E. Dinniman
Andrew E. Dinniman, Commissioner

Dear Reader,

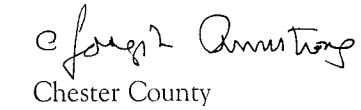
Watersheds was adopted as a component of LANDSCAPES to assist governments and other entities to more effectively integrate water resources and land use decisions. It provides scientifically-sound goals, objectives and strategies for accommodating existing land uses and planned growth while maintaining the integrity of Chester County's watershed resources.

Watersheds will serve different readers in different ways. It addresses many complex and inter-related issues and much of its content is necessarily technical in nature. Collectively, ***Watersheds*** presents:

- *A Call to Action (Part 1)* which explains why the Plan is needed and what it intends to accomplish.
- *A Primer (Part 2)* to assist the Reader in understanding how watersheds work and their importance to society.
- *A Snapshot (Part 3)* of the existing conditions of Chester County's watersheds.
- *Goals and Objectives (Part 4)* that provide an overall context for achieving measurable improvements within the watersheds over time.
- *Priorities for Watershed Management (Part 5)* to identify the areas and problems with greatest needs.
- *Planning for Future Water and Wastewater Needs (Part 6)* to assist municipalities, utilities and others to consider and develop Integrated Water Resources Planning to more effectively integrate infrastructure and land use planning.
- *Stakeholder Roles (Part 7)* to encourage all stakeholders (residents; municipalities; other government agencies; land developers; agricultural, commercial and industrial land owners and operators; water and wastewater utilities; and watershed conservation organizations) to become involved in protecting and preserving the County's natural watershed resources.
- *Strategies for Implementation (Part 8)* with specific scientifically-sound guidance for achieving the purpose and goals of ***Watersheds***.
- *Measures of Progress (Part 9)* that will be used to measure the effectiveness of ***Watersheds*** over time.
- An Inventory of Watershed *Management Needs (Part 10)* for each of the 21 watersheds.
- A *Glossary of Terms and Acronyms* to assist the Reader in understanding the terms and abbreviations commonly used in discussing water resources topics.

Watersheds is based on and developed from the supporting technical documentation published in the *Chester County, Pennsylvania Water Resources Compendium* (2001). All data, maps and information presented in ***Watersheds*** are taken from and hereby referenced to the *Compendium* (unless otherwise noted).

The natural water resources have significantly influenced the history, heritage, and economic prosperity of Chester County. It is hoped that ***Watersheds*** will contribute to the long-term preservation of these resources and the unique character of Chester County, Pennsylvania for the future.



Chester County
Water Resources Authority

Table of Contents

List of Tables & Figures 8

Acknowledgements 11

Glossary of Terms and Acronyms 229

Part 1 **A Call to Action** 15

The Setting 15

The Problems and Opportunities 19

The Vision—Balancing Nature and Society 24

The Planning Framework 26

Part 2 **A Primer — What is a Watershed?** 27

Where does Water Come From? (The Natural Water Cycle) 29

How do Streams Work? 30

What is Ground Water? 30

What are Riparian Buffers? 33

What are the Impacts of Land Use on Water Resources? 34

What are Best Management Practices (BMPs)? 37

The Future—With and Without BMPs 40

Part 3 **A Snapshot — What We Learned** 41

Community Values 42

Resources Management Practices and Philosophies 44

Population and Growth 47

Land Use 48

Impervious Cover 50

Ground Water Quality 50

Stream Water Quality 52

Cultural and Historic Resources 56

Biological Diversity 56

Stormwater and Flooding 58

Stormwater and Pollutant Runoff 59

Stormwater Management Requirements 62
First Order Streams 63
Stream Corridor Land Use 66
Watershed Water Budgets 67
Ground Water Balances 68
Water Withdrawals and Discharges 71
Sustainability of Present and Future Water Needs 72
Water Supply 73
Wastewater Disposal 74

Part Goals and Objectives—Achieving the Vision 75
Goal 1: Engage and Educate Individuals, Communities and Governments in Watershed Stewardship 76
Goal 2: Enhance Water-Based Recreational and Cultural Resources 77
Goal 3: Preserve Natural Resources 78
Goal 4: Improve Water Quality 82
Goal 5: Reduce Stormwater Runoff and Flooding 83
Goal 6: Protect Watershed Water Balances 88
Goal 7: Integrate Utility and Municipal Planning to Meet Future Water Supply and Wastewater Needs 96

Part Priorities for Watershed Management—Where to Begin 99
The Need for Priorities 99
The Prioritization Process 101
Regional Watershed Priorities 102
Regional Subbasin Priorities 104
Priority Management Objectives and Action Plans 106

Part Planning for Future Water and Wastewater Needs—Integrated Water Resources Planning 109
The Need for "Integrated" Planning 109
What Is "Integrated Water Resources Planning"? 110
Integrated Water Resources Planning Areas 112
Basic Components of Integrated Water Resources Planning 112
Projecting Future Growth in Population and Employment 114
Identifying Planned Public Water/Wastewater Service Areas 114
Estimating Current and Future Water Demand 119

Identifying Potential Alternatives for Meeting Future Water Demand 122
Identifying Constraints 129
Evaluating Alternatives 129
Techniques for Protecting Rural Pipeline Corridors 131
Protecting Sources of Public Drinking Water Supplies 132
Recommendations for Small Water Systems 133
Considerations for Wastewater Planning 135

Part Stakeholder Roles—Opportunities for Stewardship 151
Municipal Role 152
Chester County Role 155
Roles for Water and Wastewater Utilities 161
Roles for Watershed, Conservation, and Land Conservancy Organizations 163
Roles for Land Owners and Operators 164
Roles for State Agencies 166
Roles for Inter-State and Federal Agencies 168

Part Strategies for Implementation 171
Goal 1: Engage and Educate Individuals, Communities and Governments in Watershed Stewardship 172
Goal 2: Enhance Water-Based Recreational and Cultural Resources 174
Goal 3: Preserve Natural Resources 176
Goal 4: Improve Water Quality 183
Goal 5: Reduce Stormwater Runoff and Flooding 187
Goal 6: Protect Watershed Water Balances 193
Goal 7: Integrate Utility and Municipal Planning to Meet Future Water Supply and Wastewater Needs 198

Part *Watersheds* Indicators—Measures of Progress 201
LANDSCAPES Indicators 202
Watersheds Indicators 202

Part Management Needs 205

List of Tables

1-1 Characteristics of the 21 Study Watersheds 18

2-1 Impacts of Traditional Development on Watershed Resources 35

2-2 Relationship of Stream Health and Directly-Connected Impervious Cover . . . 36

3-1 Top "Perceived" Problems Identified by Stakeholders 43

3-2 Land Use in Chester County (1995) 48

3-3 Stream Miles and Impaired Stream Miles in Chester County 55

3-4 Stream Miles and First Order Stream Miles in Chester County 66

5-1 Results of Prioritization of Chester County Watersheds 103

5-2 Highest Priority Subbasins Located Within Chester County 104

5-3 Priority Management Objectives for 21 Individual Watersheds 107

6-1 1998 and 2020 Population and Employment Estimates and Projections 138

6-2 Small Community Water Systems within Chester County (as shown in Figure 6-3) 140

6-3 Estimated 1998 and 2020 Average Daily Water Demand by Municipality (GPD) 141

6-4 Estimated 1998 Net Ground Water Balances by Subbasin (in million gallons per year, MGY) 143

6-5 Estimated Average Annual Water Withdrawals and Future Needs by Subbasin—1998 and 2020 (MGY) 147

9-1 Relevant Components of the *Landscapes Index* 203

9-2 New ***Watersheds*** Indicators for *Landscapes Index* 203

9-3 Potential ***Watersheds*** Indicators under Consideration 204

List of Figures

1-1 Watersheds of Chester County, PA 17

1-2 Inventory of Problems and Potential Concerns 20

1-3 Stream Resources and Competing Water Uses 21

1-4 Municipalities and Watersheds of Chester County 23

1-5 Chester County 2020 Livable Landscapes 25

2-1 What is a Watershed? 27

2-2 The Natural Water Cycle 28

2-3 Watersheds Have Many Shapes and Sizes 29

2-4 Stream Order Concept 30

2-5 Generalized Geology 32

2-6 Forested Riparian Stream Buffer 33

2-7 Desired Buffer Function and Minimum Buffer Width 34

3-1 Population Growth in Chester County 47

3-2 Land Use (1995) 49

3-3 Estimated Percent Impervious Cover in Subbasins (1998) 51

3-4 Elevated Nitrate Levels 52

3-5 State Protected Water Use Designations 53

3-6 TMDLs under Development 54

3-7 Cultural, Recreational, and Historic Resources 57

3-8 Estimated Percent Change in Total Suspended Solids Loadings without BMPs (1998–2020) 60

3-9 Estimated Percent Change in Total Suspended Solids Loadings with BMPs (1998–2020) 61

3-10 Chester County Municipalities Required to Comply with NPDES Phase II Regulations 64

3-11 Drainage Areas that Contribute to First Order Streams 65

3-12 Watershed Water Budget 67

3-13 Net Ground Water Withdrawals as a Percent of 1 in 25 Year Average Annual Baseflow (1998) 69

3-14 Net Ground Water Withdrawals as a Percent of 1 in 25 Year Average Annual Baseflow (2020) 70

3-15 Water Withdrawals 71

3-16 Public Water Systems and Wells 73

3-17 Estimated Water Demands 73

3-18 Estimated Wastewater Disposal 74

4-1 Chester County Municipalities Located within the DRBC Southeastern PA Ground Water Protected Area 91

4-2 Recommended Net Ground Water Withdrawal Management Targets 93

5-1 Overall Highest Priorities 102

5-2 Water Quality Restoration 102

5-3 Subbasins in the Study Watersheds 105

5-4 West Valley Creek Subbasin Ranked Highest 106

6-1 Potential Integrated Water Resources Planning Partners 113

6-2 Areas of Future Need and Growth—Water and Wastewater 116

6-3 Community Water Supply Systems in and Near Chester County, PA 117

6-4 Current and Future Delivery of Water Supply 120

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The County of Chester and the Chester County Water Resources Authority gratefully acknowledge the participation and support of the many individuals, County staff, agencies, organizations, and other entities in the development of the ***Watersheds*** Plan and the *Chester County, Pennsylvania Water Resources Compendium.*

Funding Partners

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- Pennsylvania Department of Environmental Protection, and U. S. Environmental Protection Agency Nonpoint Source Pollution Management Program.
- Brandywine Valley Association and William Penn Foundation.
- U. S. Geological Survey.

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- Christina Basin Water Quality Management Committee
- Delaware County, PA
- Delaware River Basin Commission
- Green Valleys Association
- Lancaster County, PA
- Maryland State Office of Planning
- Pennsylvania Department of Environmental Protection
- U.S. Geological Survey
- University of Delaware–Water Resources Agency

Chester County Water Resources Task Force Members

Chester County and the Chester County Water Resources Authority express their great appreciation for the extensive time, effort and contribution of the Chester County Water Resources Task Force and agency participants. *Watersheds* presents the collective inputs and recommendations of the Task Force members and agency participants. All inputs and views contributed significantly to the content and value of this Plan. Participation of the individual Task Force members and agency representatives does not necessarily imply endorsement by the organizations or agencies they represent.

Wayne G. "Ted" Reed, Chairman
- Pennsylvania American Water Company
- PA Municipal Authorities Association

Ralph Heister, Vice-Chairman
- Green Valleys Association
- Valley Creek Coalition

A. Joseph Armstrong
- Chairman, Chester County Water Resources Authority
- Trout Unlimited
- Valley Creek Coalition

George Asimos
- Pennsbury Township Planning Commission
- Chester County Planning Commission
- Brandywine Conservancy (Environmental Committee)

John Bachich
Brian Rupp (alternate)
Paul White (alternate)
- Woodridge Construction Co., Inc.
- Home Builders Assoc. of Chester/Delaware Counties

William Beam
- Farm Owner/Operator
- 4–H
- West Nantmeal Township Planning Commission

Dennis Capella
- Chester County Water Resources Authority

Sarah L. Caspar
Dorothy Cook (alternate)
- League of Women Voters–Chester County
- U.S. Environmental Protection Agency

Sally Cheyne
- London Britain Township Planning Commission
- London Britain Township Secretary
- League of Women Voters

George Cominsky
- Chester County Water Resources Authority

Barbara D'Angelo
- Wallace Township Planning Commission
- Chester County Water Resources Authority
- U.S. Environmental Protection Agency

Robert Day
- Real Time Computer Systems
- Warwick Township Citizen

Vincent DiEuliis
John Lichman (alternate)
- Downingtown Municipal Water Authority

G. Winfield Fairchild
- West Chester University, Biology Department

Trudi Green
- Octoraro Watershed Association
- West Fallowfield Township Planning Commission
- Governor's Task Force on Riparian Buffers

Betsy Huber
- Supervisor, Upper Oxford Township
- PA Grange–State Vice President
- Legislative Aide, Office of Representative Art Hershey

Charles Jacob
- Chairman, Warwick Township Board of Supervisors
- Chairman, Federation of Northern Chester County Communities
- Chester County Association of Township Officials

John Johnson
- West Chester Fish Game & Wildlife
- Valley Creek Coalition

Margaret Kramaric
- Chester County Water Resources Authority
- Glaxo–Smith Kline

Preston Luitweiler
- Philadelphia Suburban Water Company
- Water Resources Association of Delaware River Basin
- AWWA Source Water Protection TAC

Peter Marriner
- Conestoga High School Biology Teacher
- Chester Ridley Crum Watershed Association, Director

Donald Needham, Sr.
- Supervisor, London Grove Township
- Needham Mushroom Farms, Inc.
- HyTech Mushroom Compost, Inc.
- C.A.C. Mushroom

Denis Newbold
- Stroud Water Research Center
- Chester County Water Resources Authority

James O'Brien
- Bethlehem Lukens, Inc.
- Brandywine Valley Association

Neil Phillips
Philadelphia Suburban Water Company

Leon Slauch
- PA Groundwater Association
- Chester County Board of Health
- Water Well Contractor (retired)

Louis "Rick" Smith
- East Goshen Township Manager
- Chester County Water Resources Authority

Robert Struble, Jr.
- Brandywine Valley Association
- Red Clay Valley Association
- Chester County Water Resources Authority
- Chester County Conservation District

Robin Vannote
- Red Clay Valley Association

Joseph Viscuso
Judith A. Shuler (alternate)
- Chester County Development Council, Board of Directors
- Brandywine Valley Engineers/ Vollmer Associates LLP

Agency Representatives

Cecil County, MD Office of Planning and Zoning
- Eric Sennstrom

Chester County Conservation District
- Dan Greig
- Charlotte Sprenkle

Chester County Parks and Recreation Department
- Isadore (Bill) Mineo
- Karen Hesser

Chester County Health Department
- David Jackson
- Ralph DeFazio

Chester County Planning Commission
- William H. Fulton, AICP
- W. Wayne Clapp
- Jake Michael

DE Department of Natural Resources and Environmental Control
- Steven Williams

Delaware River Basin Commission
- Greg Covallo
- Jonathon Zangwill

Delaware County Planning Department
- Karen Holm

PA Department of Conservation and Natural Resources
- Terry Hough
- Fran Rupert
- Todd Stell

PA Department of Environmental Protection
- Nancy Crickman
- John Fabian
- David Jostenski
- Donna Suevo

Philadelphia Water Department
- Howard Neukrug

Susquehanna River Basin Commission
- Steven Runkle
- Richard Cairo

U.S. Geological Survey
- Ronald A. Sloto

Chester County Water Resources Authority Board of Directors

Chester County Water Resources Authority Board of Directors is acknowledged for their leadership and oversight of this project:

- A. Joseph Armstrong, Chairman
- Louis "Rick" Smith, Vice Chairman
- Robert G. Struble, Jr., Treasurer
- Margaret Kramaric, Secretary
- A. Sidney Brookes, Jr.
- Dennis P. Capella
- George B. Cominsky
- Barbara D'Angelo
- Denis Newbold

Planning Team

Chester County Planning Commission

- William H. Fulton, AICP
- W. Wayne Clapp

Chester County Water Resources Authority

- Janet L. Bowers, PG
- Craig A. Thomas
- Kimberly T. Gordon

Gaadt Perspectives, llc

- John M. Gaadt, AICP

Camp Dresser & McKee

- Mark Maimone, PE
- Hilary Lauer
- N. Rao Sankarmanchi, PE

Technical Assistance, Design & Production

Chester County Planning Commission

- Diana M. Gent
- David D. Ward, AICP
- Thomas P. West, AICP
- Christopher B. Bittle
- Polly Chalfant
- Carolyn Fry
- Elizabeth M. Kolb
- Jake Michael
- Stephen A. McCulloch, AICP
- Robert E. Walker

A Call to Action

1

The Setting

Water and society—two linked and inter-dependent elements—together have shaped the countryside now known as Chester County. For centuries, the natural waters of Chester County have supported life and economic development and have influenced the patterns of society. Simultaneously, the growth and expansion of society have influenced and impacted the natural waters in many ways. Virtually everything that society does, and has done, on the surface of the land has impacted our water resources. Today it is achievable—and necessary— to encourage the growth and vitality of society, while sustaining the integrity of the natural water resources that support our existence.

Chester County is blessed with approximately 1,300 miles of streams (including all rivers, creeks, streams, and their tributaries) and 780 square miles of underlying ground water aquifers. These aquifers and streams exist as 21 watersheds. Each watershed drains a unique area of Chester County land and the ground water that lies beneath that land through a connected network of streams. These 21 watersheds originate within Chester County. Waters from the watersheds in the north, east and center of Chester County ultimately drain to the Delaware Bay. Waters from the County's western watersheds ultimately drain to the Chesapeake Bay.

Figure 1-1 presents a map of the watersheds within which Chester County is located. Table 1-1 summarizes the characteristics of these watersheds (including areas outside of Chester County).

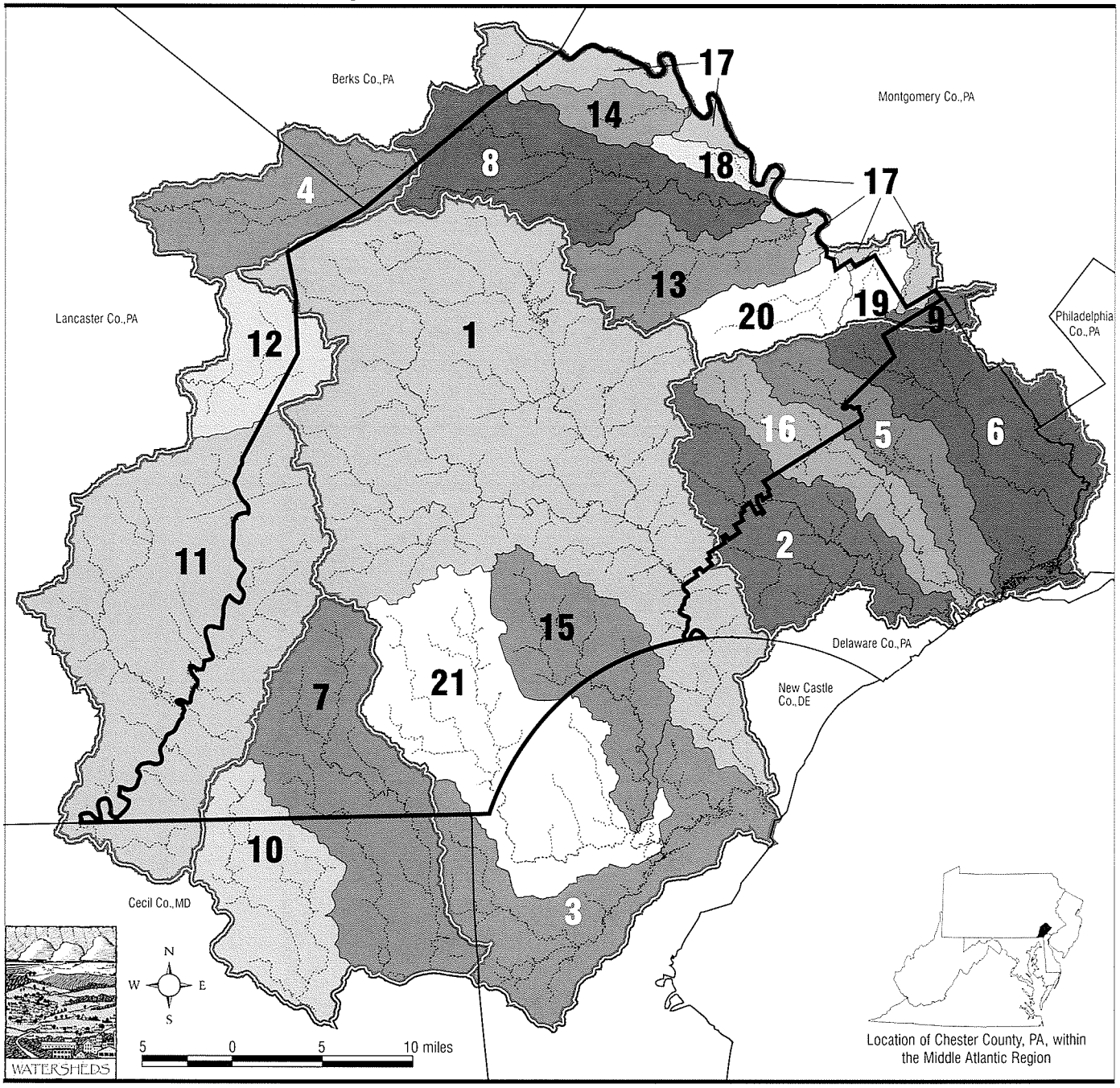
These complex and important water resources require careful management not seen in years past. Today, water resources management needs to focus on:

- The desire to support the growth of our agricultural, industrial, commercial, ecotourism, and residential economies in a manner that sustains our natural land and water resources,
- The desire to accommodate and manage that growth in a way that is less land consumptive and polluting, and
- The need to correct the surface and ground water problems of the past to improve the integrity of the County's water resources for the future.

Watersheds was prepared to address these needs for Chester County and its municipalities. Because the County's watersheds extend across political boundaries, it was necessary to expand the study area for this Plan beyond the bounds of Chester County. The study area used for the Plan includes the drainage areas of the 21 watersheds as they extend across Chester County and into Lancaster, Berks, Delaware, Montgomery, and Philadelphia Counties in Pennsylvania. It also includes parts of New Castle County, Delaware, and Cecil County, Maryland. In total, the study area used as the basis for ***Watersheds*** includes all or portions of 160 municipalities that are located within 8 counties, 3 states, 21 watersheds, and 78 subbasins. Several of the maps included in the Plan present information for the entire study area of each watershed. This will help to provide the watershed-wide perspective of the resources and their problems.

Watersheds was also prepared to serve as a County-wide Rivers Conservation Plan, under the Keystone Rivers Conservation Program that is administered by the Pennsylvania Department of Conservation and Natural Resources (PADCNR). The Keystone Rivers Conservation Program is designed to encourage local planning and prioritization of individual watershed needs and to support the listing of rivers and streams on the Pennsylvania Rivers Conservation Registry. Several streams and watersheds within Chester County are already listed, or are in the process of being listed, on the Registry by local entities. As a County-wide Rivers Conservation Plan, ***Watersheds*** will be submitted to PADCNR in conjunction with a request to list all remaining rivers and streams and their tributaries, within the boundaries of Chester County, on the Pennsylvania Rivers Conservation Registry. This will allow all of the municipalities and other entities of Chester County to be eligible for additional state funding programs.

Figure 1-1:
Watersheds of Chester County, PA



Chester County
Adjacent county

Major Basin Boundary
Stream

Watersheds

1 Brandywine Creek
2 Chester Creek
3 Christina River
4 Conestoga Creek
5 Crum Creek
6 Darby Creek
7 Elk Creek
8 French Creek
9 Gulph Creek
10 Northeast Creek
11 Octoraro Creek
12 Pequea Creek
13 Pickering Creek
14 Pigeon Creek
15 Red Clay Creek
16 Ridley Creek
17 Schuylkill River Drainages
18 Stony Run
19 Trout Creek
20 Valley Creek
21 White Clay Creek

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Table 1-1: Characteristics of the 21 Study Watersheds

Watershed	Land Area (sq. mi.)	% Land Area 1995 Land Use			Total Stream Miles	First Order Stream Miles	% First Order Streams	Impaired Stream Miles	1998 Estimated Withdrawals (BGY)	1998 Estimated Population	% Population Increase by 2020	% 1998 Population on Public Water	Predominant Geology
		Ag.	Dev.	Other									
Susquehanna River Basin													
Conestoga Creek	49	54	19	27	63	32	51	0	0.3	9,400	40	5	Carbonate
Octoraro Creek	187	66	9	25	311	175	56	37	10.7	31,000	32	9	Crystalline
Pequea Creek	34	64	12	24	44	27	60	24	0.2	8,000	29	1	Carbonate
Chesapeake Bay Tributaries													
Elk Creek	96	54	16	30	164	92	56	0	0.6	27,000	26	14	Crystalline
Northeast Creek	56	51	15	34	86	43	50	24	0.4	15,300	25	0	Crystalline
Delaware River Basin													
Brandywine Creek	325	37	26	37	567	315	55	140	19.5	220,700	27	62	Crystalline
Chester Creek	66	13	50	37	128	67	53	17	1.5	100,100	18	93	Crystalline
Christina River	78	13	54	33	123	49	40	101	0.5	168,300	11	95	Sedimentary
Crum Creek	38	11	54	35	72	41	57	24	7.1	66,700	5	93	Crystalline
Darby Creek	77	2	78	20	119	53	45	59	0.3	460,600	1	98	Crystaline
French Creek	70	35	16	49	104	60	58	0	0.5	25,200	24	43	Mixed
Gulph Creek	6	0	83	17	11	5	46	3	0.0	11,500	8	98	Crystalline
Pickering Creek	39	39	22	39	62	35	56	2	1.5	18,300	33	48	Crystalline
Pigeon Creek	14	41	26	33	22	15	67	0	0.1	5,500	18	0	Triassics
Red Clay Creek	54	34	36	30	102	61	60	93	1.0	43,200	16	69	Crystalline
Ridley Creek	38	16	45	39	80	36	45	0	1.4	55,600	9	87	Crystalline
Schuylkill River	34	31	35	34	78	26	33	31	2.7	33,200	17	76	Triassics
Stony Run	6	60	23	17	10	5	53	0	0.1	2,800	26	1	Triassics
Trout Creek	9	1	79	20	15	9	63	0	0.8	11,700	13	98	Mixed
Valley Creek	24	7	51	42	34	19	55	11	3.2	22,300	11	100	Carbonate
White Clay Creek	108	35	35	30	176	97	55	136	8.2	110,300	16	84	Crystalline
Total	**1,408**	**37**	**30**	**33**	**2,373**	**1,262**	**53**	**702**	**61.0**	**1,446,700**	**25**	**81**	

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

The Problems and Opportunities

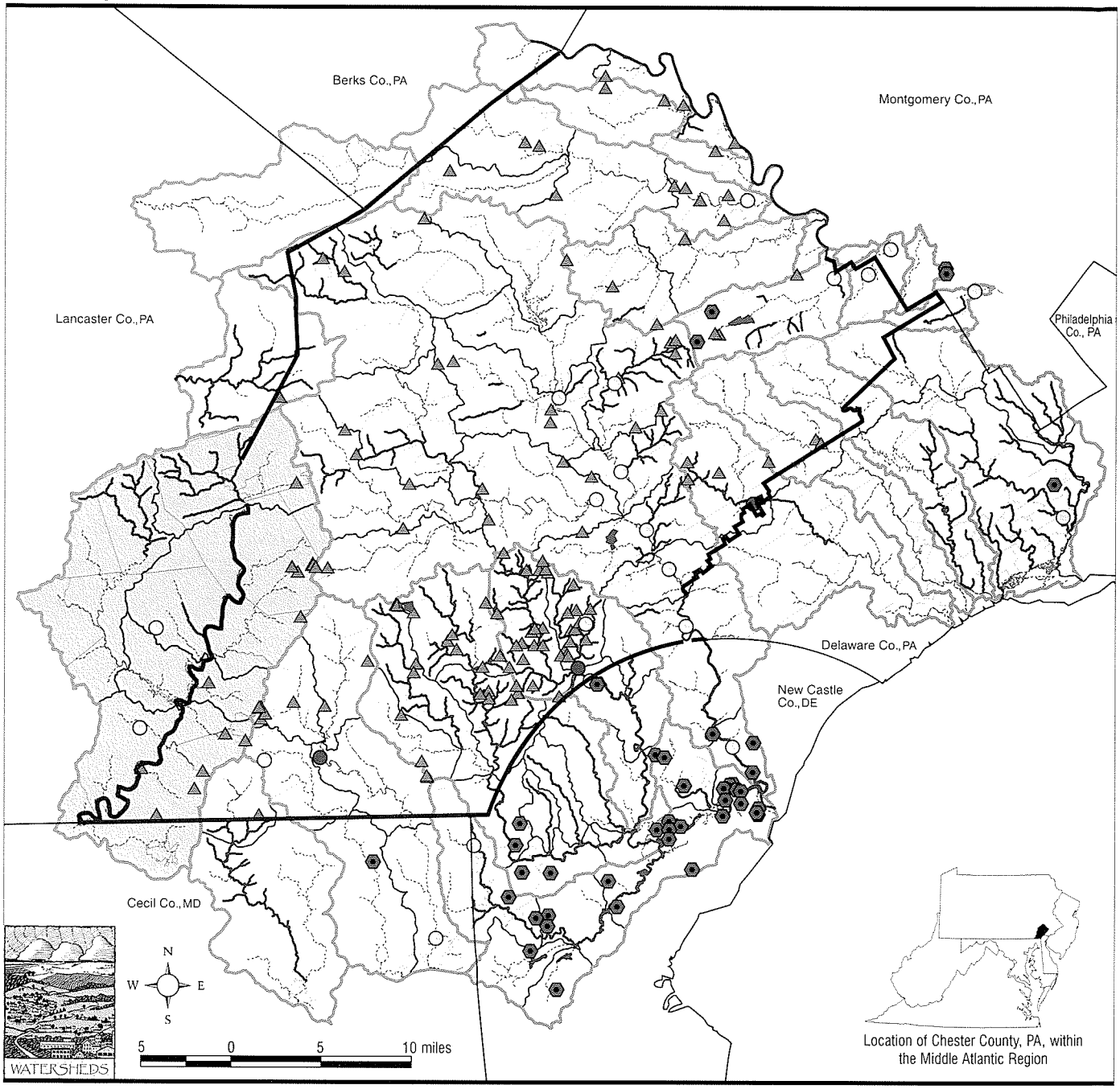
Over the past 50 years, dramatic improvements in the condition of our water resources have been achieved. Technologies and techniques have been implemented by all sectors of society. These changes have returned the once odorous, multicolored flows of discharges of untreated wastewaters into clear flowing streams. Uncontrolled dumping practices have been nearly eliminated. Widespread erosion of natural soil resources has been significantly reduced by improved soil management practices. The elimination of severely toxic agricultural chemicals has allowed the recovery of aquatic and avian species. While flooding remains a problem in some areas, improved management of floodplains and better understanding of natural stream functions have reduced property damage and loss of life. Safe and reliable drinking water supplies are available virtually everywhere. Wastewater treatment systems and technologies provide sanitary disposal of wastewater, protecting public health and the environment.

Many of the impacts and problems that resulted from detrimental activities of the past centuries have been solved. But some of the toughest, most persistent problems remain. Figure 1-2 presents the locations of known problems. In Chester County, 276 miles of streams (21%) are currently "impaired" by pollutants and runoff from agriculture, existing development and wastewater discharges. Numerous scattered locations of impaired ground water quality exist. Frequent flooding is affecting more people. Concerns have been raised regarding the potential over-withdrawal of water from streams and ground water.

Since the late 1980s, growing communities and neighborhoods have consumed more land at a faster rate than at any time in the region's history. The increase in impervious cover has reduced the amount of rainfall that can be recharged to ground water and has increased stormwater runoff. The growth of businesses and residents continues to increase the demand for additional water supplies and the need for viable alternatives for disposal of increased volumes of wastewater. Rapid economic growth has raised questions of the ability of the streams and ground water to be sustained under the pressures of such rapid growth conditions.

Equally important to addressing these problems is the preservation of the unique resources associated with the streams and watersheds of Chester County. Figure 1-3 illustrates many of the unique resources and sensitive water uses located within the County's watersheds. Forty-seven percent of the County's land area drains to Exceptional Value (EV) or High Quality (HQ) waters. Over one hundred sites have been listed on the Pennsylvania Natural Diversity Index (PNDI) as unique or threatened natural resources. Three streams are designated by the Commonwealth for their natural ability to support trout fisheries, while several lakes and hundreds of miles of other streams also support fisheries. Approximately 266 miles of stream corridors have been designated as either Pennsylvania Scenic Rivers or Federal Wild and Scenic Rivers corridors. Virtually thousands of historic features, many water-related, have been inventoried, and many are listed on the National Register of Historic Places. Approximately 70 percent of Chester County's watershed areas serve as sources of water for public drinking water supplies for southeastern Pennsylvania and northern Delaware. Instream recreation supports a growing ecotourism economy. Virtually all of these resources depend upon reliable stream baseflows (which in turn rely on ground water recharge) and good water quality.

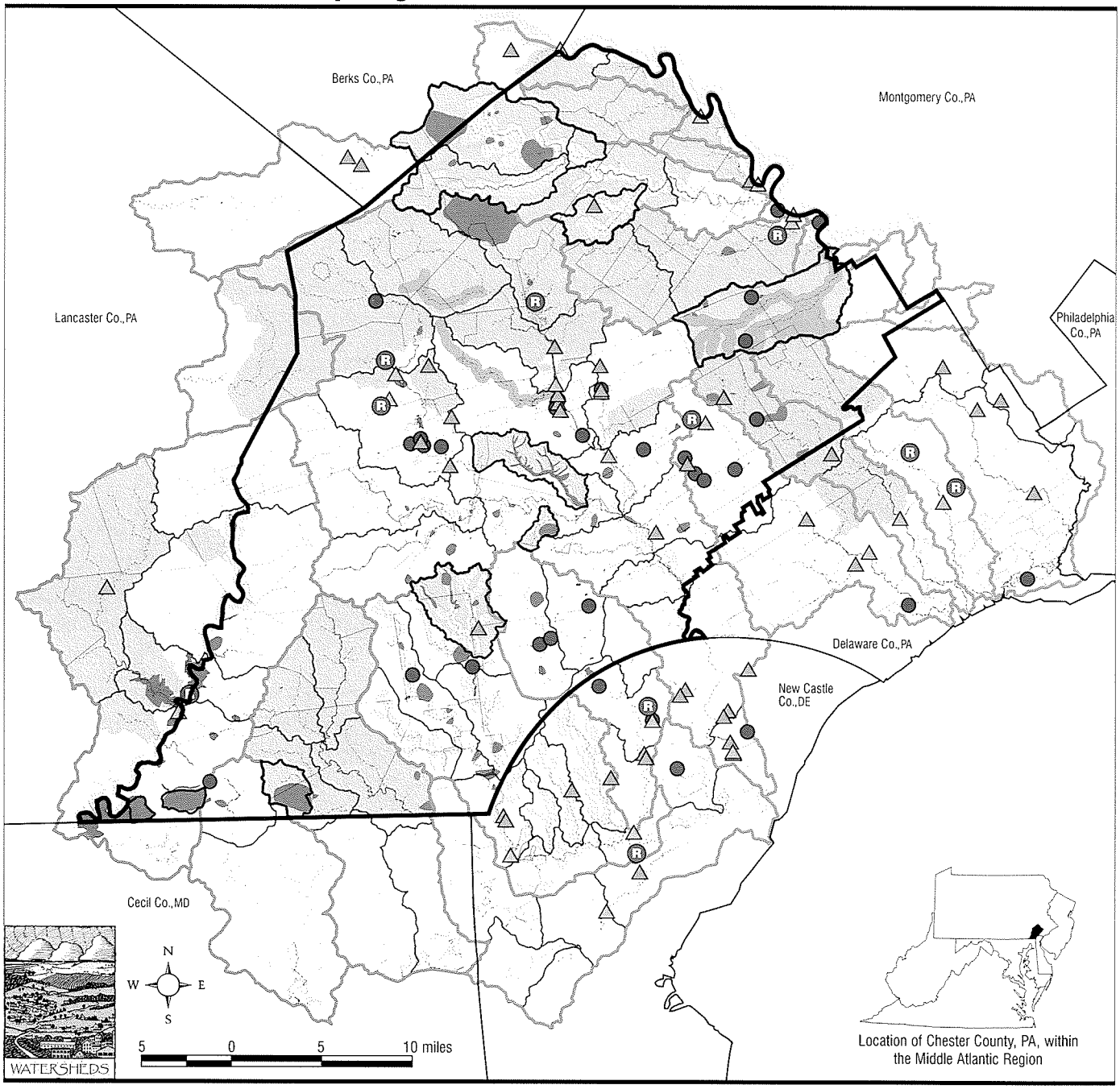
Figure 1-2
Inventory of Problems and Potential Concerns



- Chester County
- Adjacent county
- Municipality
- Watershed
- Subbasin
- Stream
- Section 303(d) impaired streams
- Regional Impact Flooding
- Biodiversity Concerns
- Ground Water Problems
- CERCLIS/Superfund Sites
- Landfills
- Subbasins with Widespread Elevated Nitrates

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Figure 1-3:
Stream Resources and Competing Water Uses



Notes: The National Heritage Area includes the Schuylkill River watershed within the counties of Chester, Berks, Montgomery, and Philadelphia.

* EV drainage areas are designated by a black outline where multiple mapped resources are present.

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

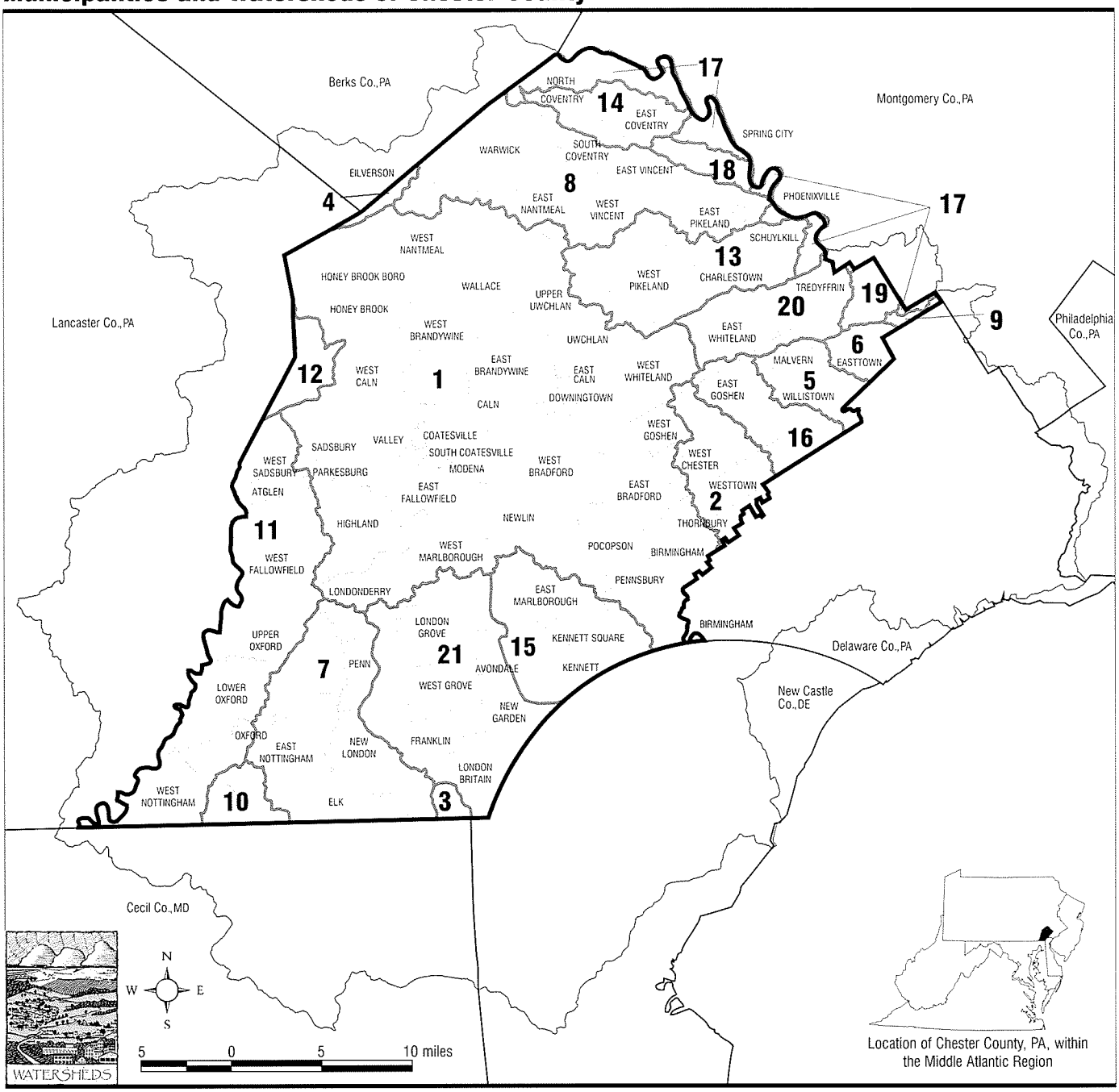
Compounding the challenges of sustaining the County's natural water resources are the numerous municipal governments located within each watershed. Figure 1-4 presents the boundaries of the municipalities and watersheds within Chester County. Some municipalities include portions of several watersheds. For example, Tredyffrin Township includes portions of seven different watersheds. In addition, each watershed consists of portions of numerous municipalities. For example, Brandywine Creek watershed includes portions of 43 municipalities.

Based on the integrated approach of ***Watersheds,*** and a thorough inventory of problems and conditions in the County's watersheds, the following list of key planning issues was identified:

- The need to protect ground water recharge and stream baseflows.
- The need to restore streams to achieve their designated uses.
- The need to reduce pollutants from all sources, including nonpoint sources and point sources.
- The need to reduce the impacts of stormwater runoff (ground water recharge, runoff rates and volume, velocity, water quality, and erosion).
- The need to reduce the frequency and magnitude of flooding.
- The need to keep people linked to streams to maintain their understanding and appreciation of the importance of natural water resources.
- The need to sustain the quantity of ground and surface waters to support current and future water use (water supply, irrigation, instream aquatic resources, recreation, etc.).
- The need to protect first order streams and sensitive stream resources (including Exceptional Value and High Quality streams, reservoirs and intakes for public drinking water supplies, state-designated fisheries, and sites included in the Pennsylvania Natural Diversity Index).
- The need to improve the integrated planning of land use and infrastructure to guide growth into the most desirable areas and to protect rural and natural lands.
- The need to protect sources of public drinking water supplies from pollutants and over-withdrawal.
- The need to involve **ALL** stakeholders including citizens, residential property owners, municipalities, county, state and federal governments, industrial and commercial lands managers, agricultural operators, land developers, water and wastewater utilities, land conservancies and community-based conservation organizations, among others.

Without addressing these needs, the cumulative impacts of current and future land use activities will continue to degrade the streams and ground waters, erode riparian properties, reduce property values and tourism revenues, increase the costs of water supply and wastewater treatment, increase flooding and stormwater damages, and eliminate the rich and diverse aquatic ecosystem of the watersheds. These impacts will affect not only Chester County, but also our downstream neighbors in Lancaster, Montgomery, Philadelphia, and Delaware Counties (Pennsylvania), New Castle County (Delaware), and Cecil County (Maryland).

Figure 1-4:
Municipalities and Watersheds of Chester County



Chester County
Adjacent county
Municipality

Watershed

Watersheds

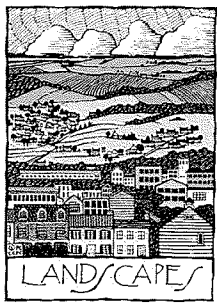
1 Brandywine Creek
2 Chester Creek
3 Christina River
4 Conestoga Creek
5 Crum Creek
6 Darby Creek
7 Elk Creek
8 French Creek
9 Gulph Creek
10 Northeast Creek
11 Octoraro Creek
12 Pequea Creek
13 Pickering Creek
14 Pigeon Creek
15 Red Clay Creek
16 Ridley Creek
17 Schuylkill River Drainages
18 Stony Run
19 Trout Creek
20 Valley Creek
21 White Clay Creek

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Chester County Commissioners adopt *Watersheds*

The Vision—Balancing Nature and Society

Watersheds was adopted in 2002 by the Chester County Board of Commissioners as the water resources element of LANDSCAPES. In 1996, the Chester County Board of Commissioners adopted LANDSCAPES as the County's comprehensive policy plan document. The vision of LANDSCAPES is to "preserve and enhance the unique character of Chester County's landscapes by concentrating growth in the most appropriate areas." LANDSCAPES sets forth a vision of the growth patterns of Chester County (Figure 1-5) based on public input. It also includes goals and related policies that lay the foundation for the protection and use of the County's natural resources and includes among its goals:



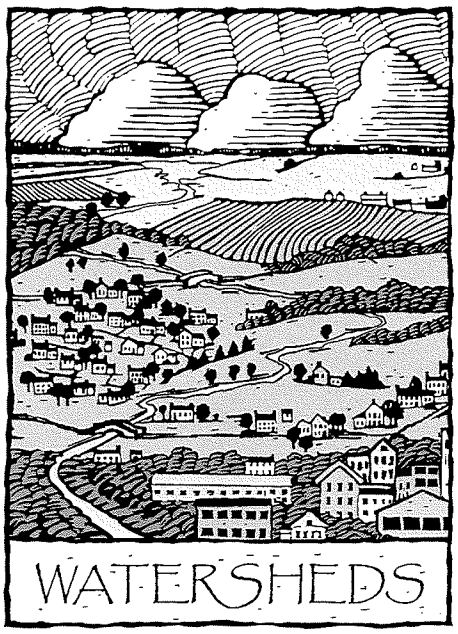
Resources Goal

To sustain and enhance the natural, scenic, and historic resources for the benefit of current and future generations while accommodating planned growth.

Utilities Goal

To provide utility facilities and services to meet all needs in the County, protect the environment and public health, and support development consistent with the future landscapes pattern.

When LANDSCAPES talks about changing the future it is referring to changing the patterns of growth in Chester County and the way we think about our various resources—natural and cultural. In the context of the County's natural water resources, this means better management of water for domestic, commercial, industrial, agricultural, recreational, and natural uses. On a broader scale, the intent is to accommodate existing land uses and planned growth in a manner that maintains or re-establishes the natural hydrologic characteristics of the watersheds. Furthermore, LANDSCAPES strives to preserve and protect the historic and cultural resources, scenic rivers, and areas of natural habitats and diversity that comprise the County's natural landscape and character.

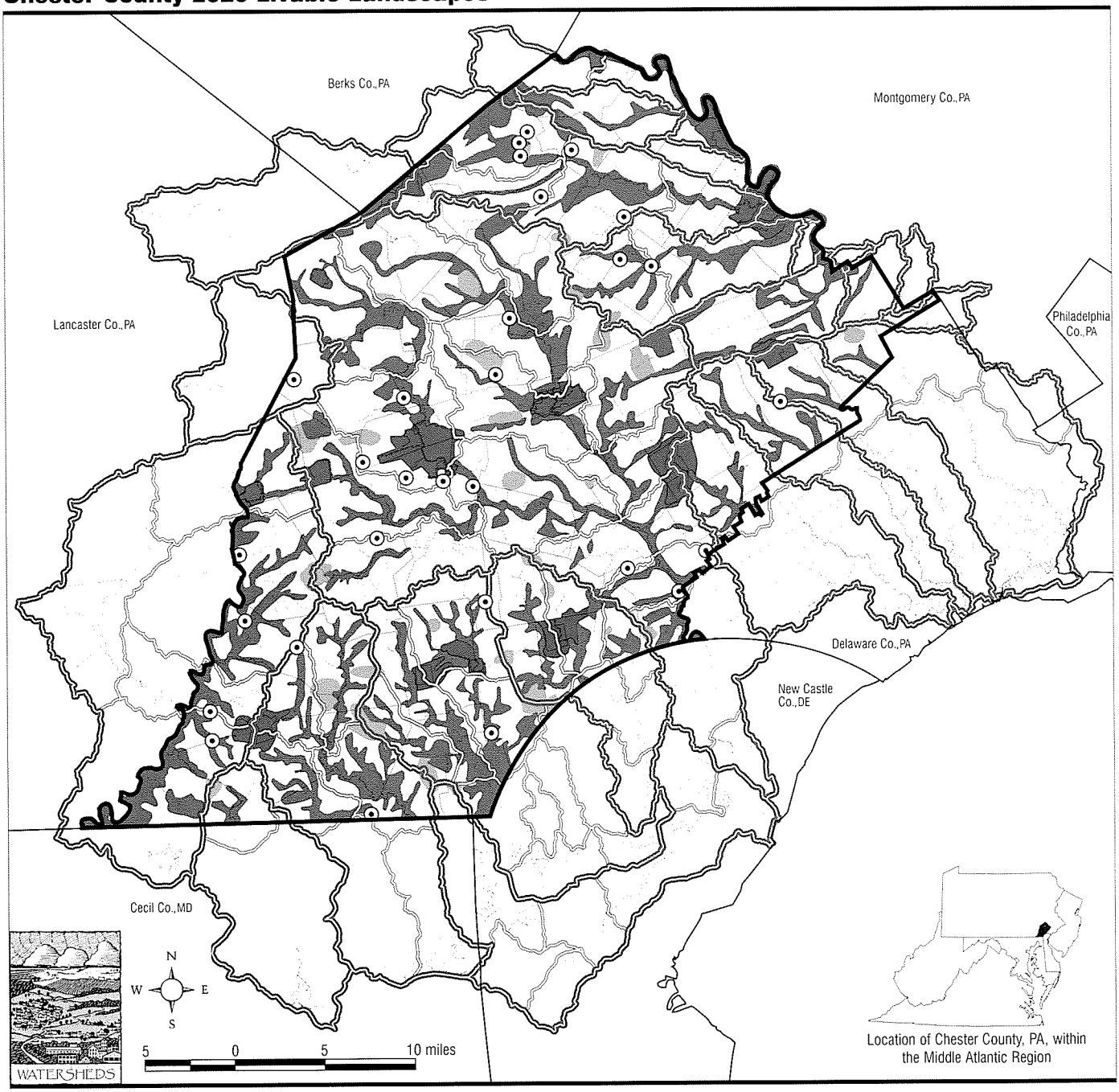


The inter-related nature of water and society, and the need to involve all stakeholders, present overlapping and complex challenges. Sound planning can provide effective, achievable strategies that are based on sound science, and that are consistent with LANDSCAPES, local land use planning, and Pennsylvania's existing regulatory framework. *Watersheds* was developed to accomplish this planning and to:

- Provide a water resources management plan to protect Chester County's natural resources and balance the needs of all users (in nature and society) in support of existing land uses and planned growth.
- Provide municipalities and other entities with an integrated framework of strategies and guidance to support sound land use and water resources management.
- Help citizens and stakeholders understand water resources issues and their role in protecting and preserving ground and surface water.

To this end, the mission statement for *Watersheds* defines what the Plan ultimately seeks to accomplish.

Figure 1-5:
Chester County 2020 Livable Landscapes



Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Watersheds
Mission Statement

To protect, sustain, and enhance
the quality and quantity
of all water resources
to insure the health, safety, and welfare
of the citizens, and preserve the
diverse natural resources and aesthetic and
recreational assets of Chester County
and its watersheds.

Through sound planning, we can accommodate existing land use and planned growth in a manner that is consistent with the natural characteristics of our streams and aquifers and that sustains:

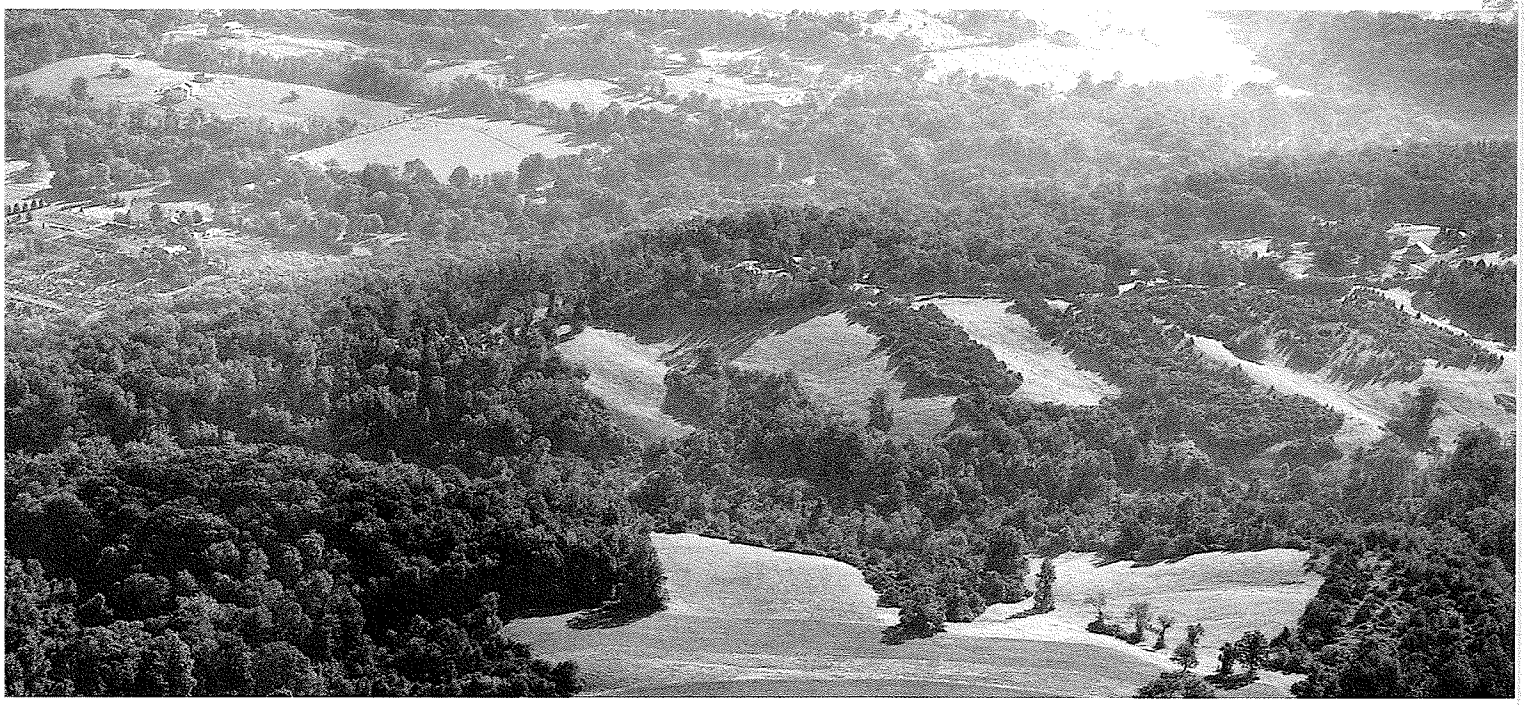
- Ground water recharge,
- Stream baseflows,
- Stable stream channel processes,
- Flood-carrying capacity of streams and their floodplains,
- Water quality of streams and ground water, and
- Riparian and aquatic living resources.

Through sound planning, we can bring together stakeholders and today's knowledge, techniques and technologies to manage and sustain both economic growth and our natural waters. ***Watersheds*** challenges all of the stakeholders of Chester County's watersheds to take part in sustaining our natural water resources and enjoying their many benefits.

The Planning Framework

Watersheds is an Integrated Water Resources Plan for Chester County and its watersheds. Like **LANDSCAPES,** the planning horizon for ***Watersheds*** is 2020. ***Watersheds*** is based on supporting documentation, published in the *Chester County, Pennsylvania Water Resources Compendium.* The *Compendium* presents the technical background for ***Watersheds,*** as well as the results of extensive stakeholder input, data collection and analysis, modeling, and planning exercises. The *Compendium* is the reference document for all information presented in ***Watersheds,*** and can be used to obtain additional information or assist municipalities and others in better planning for the future.

Watersheds presents the results of the many components of the overall planning process. *2: A Primer* introduces the reader to the basic concepts of how watersheds work. *3: A Snapshot* summarizes the conditions of the 21 watersheds studied in the *Compendium. 4: Goals and Objectives* presents the Plan's goals and objectives and the supporting rationale for achieving them. *5: Priorities for Watershed Management* identifies and prioritizes the most pressing needs of the watersheds and subbasins of Chester County. *6: Planning for Future Water and Wastewater Needs* explores water and wastewater planning needs of Chester County. *7: Stakeholder Roles* identifies the roles and opportunities for stakeholders living and working in the County to affect positive change in how we manage our water resources. *8: Strategies for Implementation* discusses the key implementation strategies to achieve the Plan's goals and objectives. *9: Watersheds Indicators* outlines how the County intends to monitor progress towards achieving the Plan's goals and objectives over time. *10: Management Needs* presents an inventory of the problems to be corrected and resources to be preserved for each watershed. For the reader's reference, a *Glossary of Terms and Acronyms* is also provided.



A Primer

What is a Watershed?

No matter where you are, you're in a watershed! A watershed is the area of land that captures rain and snow and stores, filters, drains or seeps this water into a common marsh, stream, river, or lake. A watershed is surrounded by ridgelines that form its boundary and separate it from adjacent watersheds. Figure 2-1 shows the components of a watershed.

Figure 2-1:
What is a Watershed?

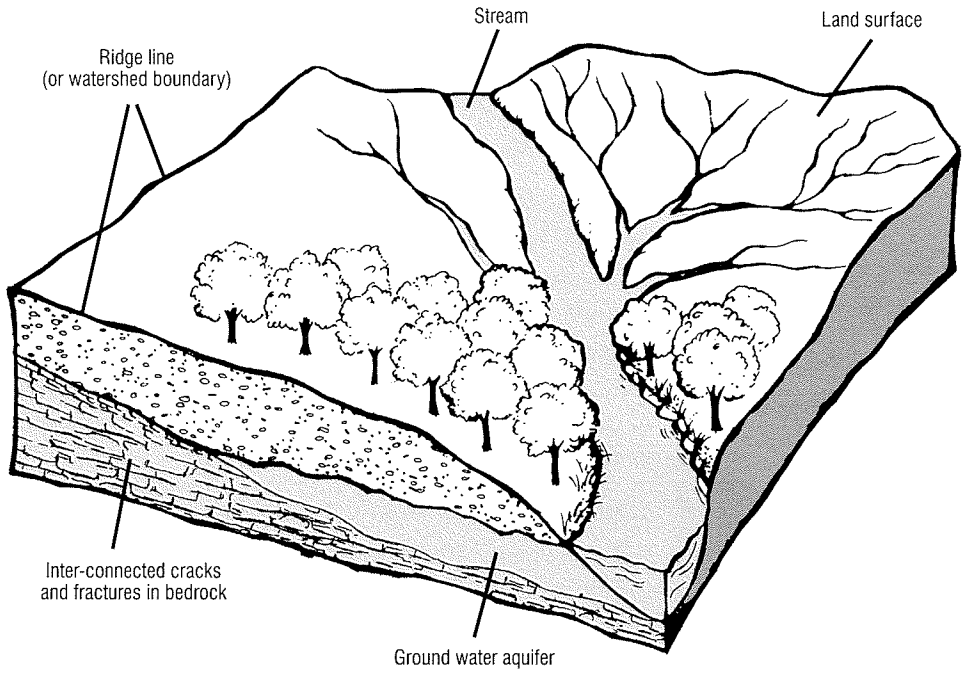
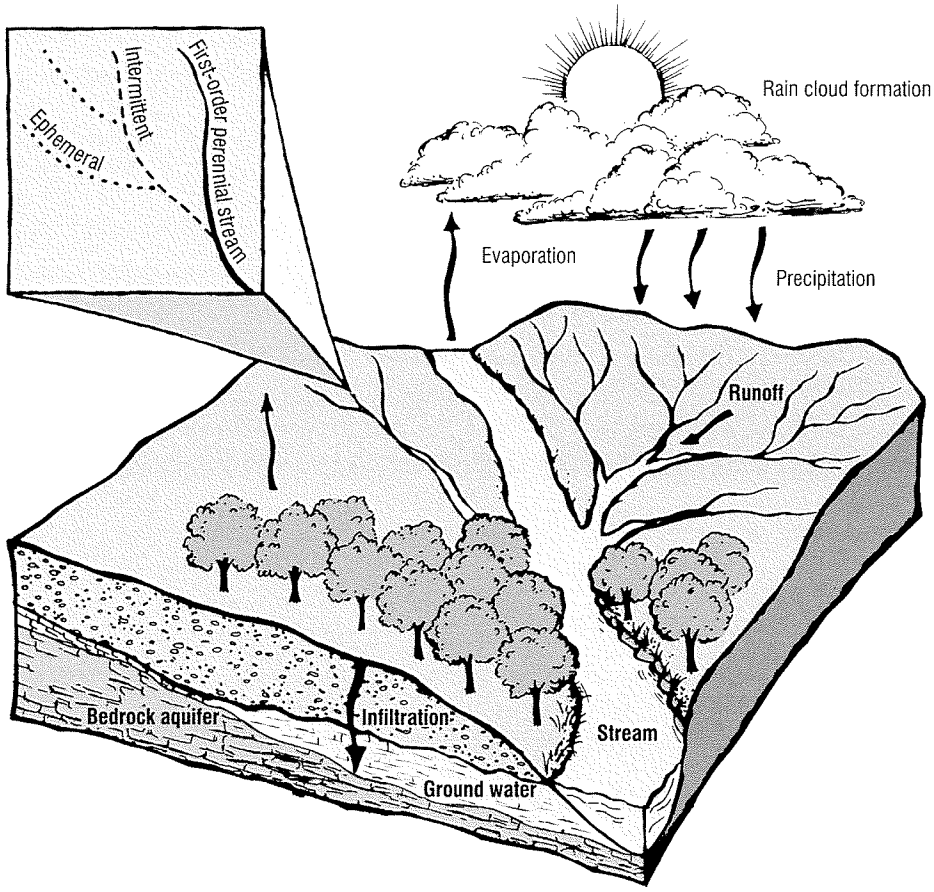
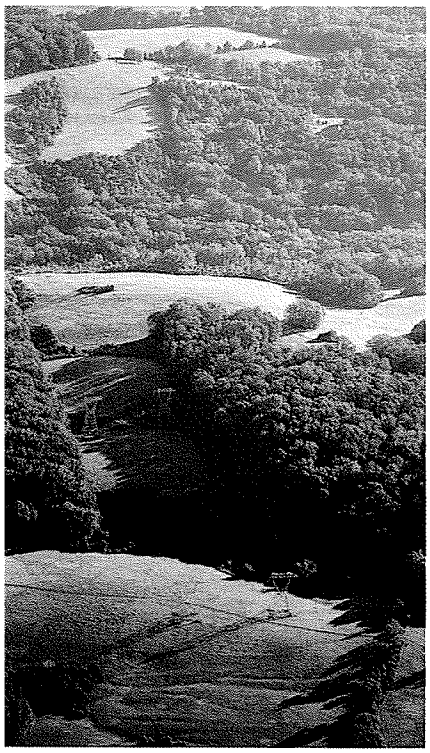


Figure 2-2: The Natural Water Cycle

Figure 2-2 illustrates how water moves through a watershed as part of the natural hydrologic cycle. John Wesley Powell, scientist-geographer, described a watershed as: "that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community."



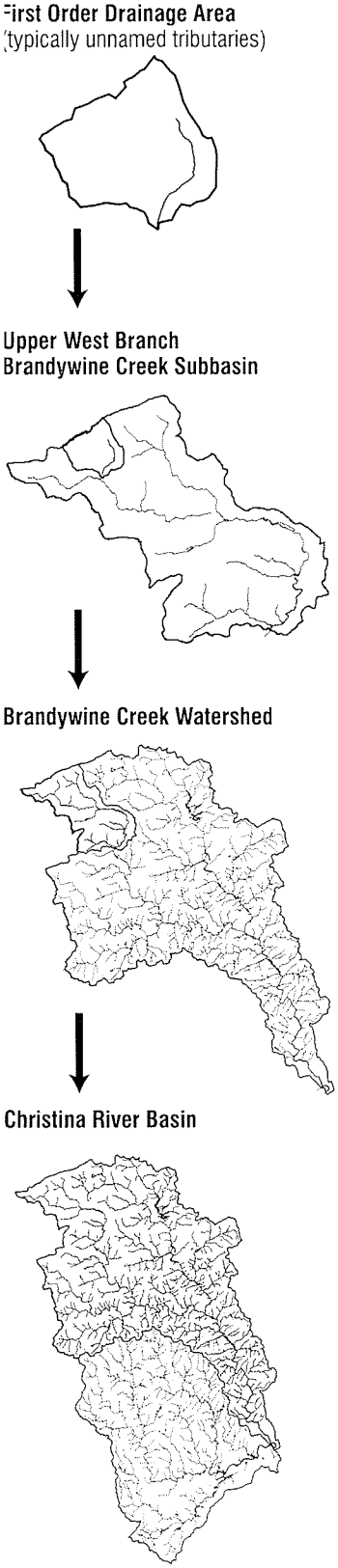


Watersheds include the land area, bounded by ridges, that drain to a common stream or stream network. They, of course, also include the streams that drain that land area. But watersheds also include the ground water and aquifers located underground and below the entire land area that contributes to those streams. Ground water is perhaps the most important component of a watershed, as it provides the water that flows from springs and provides about 60% of the water that flows in streams.

Watersheds come in all shapes and sizes. Some cross county, state, and even international borders. Some are millions of square miles in size; others are just a few acres. Just as creeks drain into rivers, watersheds are nearly always part of a larger watershed. As shown in Figure 2-3, watersheds can be subdivided into smaller watersheds or "subbasins", which collectively flow together to form larger watersheds and "basins." From smallest to largest, the terms used to describe watersheds of different sizes in this Plan are: (first order stream) drainage areas, subbasins, watersheds, and basins.

Watershed management involves the collective strategies, approaches, implementation, tools, and coordination to protect the quality and quantity of the water resources while achieving the desired land and water uses. The following discussions introduce how the various elements of a watershed function and the impacts that land and water uses can have on those watershed systems.

Figure 2-3: Watersheds Have Many Shapes and Sizes



Where does Water Come From? (The Natural Water Cycle)

You may be familiar with how water moves or cycles on the Earth, continually changing from liquid water to water vapor to ice. Figure 2-2 illustrates the components of the natural water cycle: precipitation, infiltration (and percolation), surface runoff (via streams), evaporation, and transpiration.

Chester County experiences the typical humid climate characteristic of the northeastern U.S. mainland, and receives approximately 46 to 47 inches of precipitation (including rainfall and the rainfall equivalent of snowfall) each year. Rainfall is fairly constant throughout the year. What is interesting to note is that close to 90 percent of the total rainfall that occurs each year, falls in small storms of one inch or less. Larger storm events are much less frequent. In fact, almost two thirds of all storms provide less than 0.25 inches of rainfall.

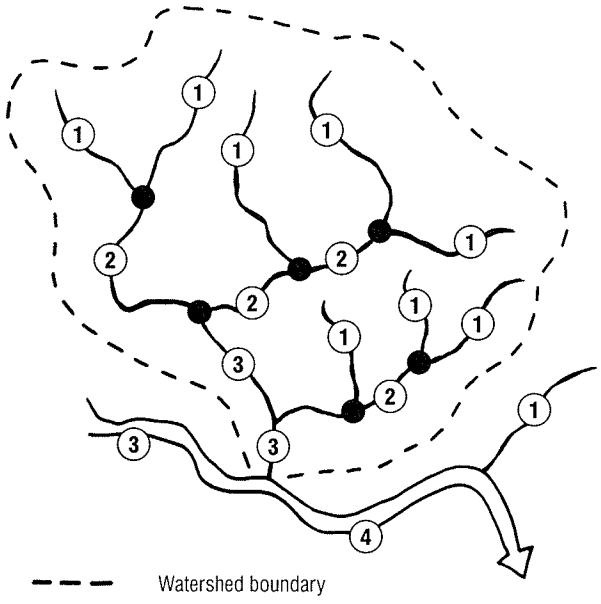
It is important to understand that although precipitation (rain and snow) is an important component of the natural water cycle, it is not the "beginning" of the water cycle. One way to envision the natural water cycle is to follow a drop of water as it moves on its way. The heat from the sun evaporates the drop from the ocean or other water body into water vapor. It rises into the air and continues rising until winds carry it over land. There, warm updrafts coming from the heated land surface take the drop (now water vapor) even higher, where the air is quite cold. When the vapor gets cold, it changes back into a liquid. The vapor condenses on tiny particles of dust, smoke, and salt crystals to become part of a cloud, a combination of many drops which together fall to the Earth as precipitation.

Once it starts falling there are many places for a water drop to go. It can land on a leaf in a tree, in which case it would probably evaporate and rise to the clouds again. It could land on a patch of dry dirt and perhaps sink into the ground to begin its journey down to an underground aquifer (as ground water). Or, it could land on the roof of a house, run through the downspouts, into a storm sewer, and then into a stream and remain on the Earth's surface as a component of surface water.

If the drop had gone into the ground it could take hundreds (or thousands) of years before it came to the surface again. Then again, the drop could be pumped out of the ground through a well and be used as drinking water or as irrigation water for crops, before continuing on its journey. If the drop remained on the surface, it could either evaporate or flow over the ground until it reaches a stream.

Regardless of the trip taken, there is a good chance that the drop will be picked up and used before it continues its journey back to the clouds. Along with other drops it could be used to cool electrical equipment at power plants, or be used to wash dishes, fight a fire, water tomatoes, or flush a toilet. After it is used, the drop may be sent to a wastewater treatment plant (or septic system). Once the drop has been cleaned (or "treated") to remove harmful pollutants, it may be either infiltrated into the ground, discharged to a stream, or evaporated back to the atmosphere. Then the drop begins the cycle again.

Figure 2-4:
Stream Order Concept



How do Streams Work?

Streams and rivers are an integral part of our landscape. They carry water and sediment from high elevations to downstream rivers, estuaries, and oceans. Part of the rain that falls in a watershed runs off of the land surface into streams or lakes. As surface runoff moves downslope, it concentrates in low areas and forms small stream channels. These are referred to as "ephemeral" channels (see Figure 2-2) that only carry water during rainfall runoff. Downstream from ephemeral channels are "intermittent" streams, which carry water during wet periods of the year. These streams are partially supplied by ground water seeping into the stream bottom providing stream "baseflow." Intermittent streams dry up periodically as ground water levels decline in drier seasons. Further downstream where baseflow is large enough to sustain stream flow throughout the year, "perennial" streams are formed.

The size and flow of a stream are directly related to its watershed area. Other factors which affect channel size and stream flow are land use, soil types, geology, topography, and climate.

One way of categorizing stream size is by "stream order." "first order" streams are the uppermost perennial tributaries in the watershed that have not yet intersected another perennial stream. When two "first order streams" intersect, they form a "second order" stream; when two "second order" streams intersect, they form a "third order" stream, and so on. Figure 2-4 illustrates how streams in a watershed are categorized by stream order.

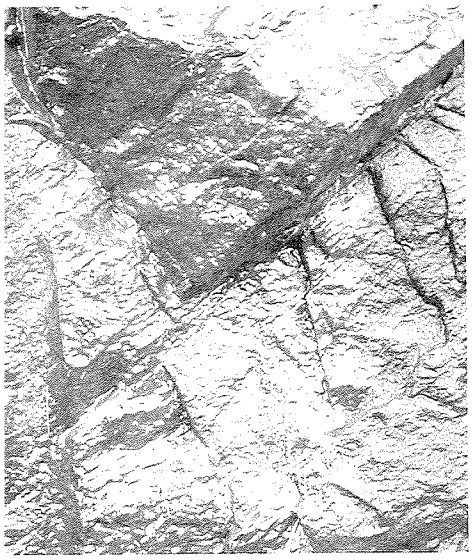
Healthy streams evolve and meander over time to maintain a "balance" with their contributing watershed. This occurs as the flowing water gently erodes the banks and bottom of the stream. The amount of in-stream erosion is determined by the amount of water draining from the land area, as well as the slope of the stream and the nature of its sediments. But this balance can be upset by changes in development patterns. Changes in land use and land cover occur much more quickly than the streams can adjust. This causes the streams to experience rapid—and destructive—erosion and sedimentation that sets off a sequence of undesired consequences. These consequences include flooding, property damage (from erosion and flooding), destruction of aquatic habitats, and water quality impacts. Thus, it is important to understand how streams work so that watershed management and land use decisions can maintain this "balance" between the land and streams, and maintain stable, healthy stream channel processes.

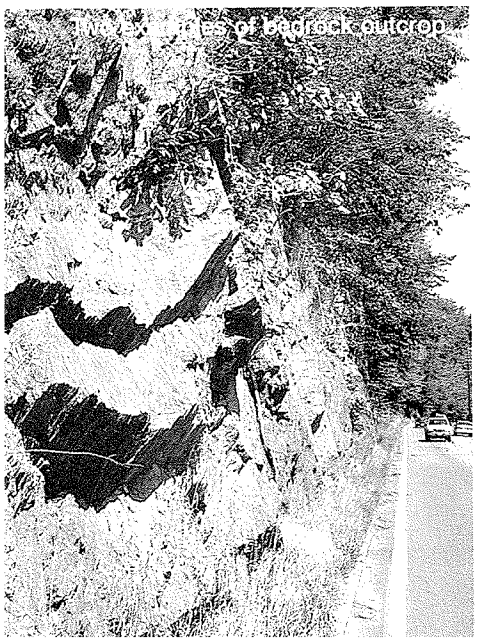
What is Ground Water?

Ground water is the water located underground that saturates the spaces between particles of sand, gravel, silt, and clay, or fills the crevices or fractures in rocks. Ground water may exist near to the land surface (less than 10 feet down) or it may occur at depths of up to several hundred feet. The underground rock units in which the ground water occurs are called "aquifers." Aquifers are major sources of drinking and irrigation water and can provide water for residential, agricultural, commercial, industrial, public water supply and other purposes.

Ground water and surface water are interconnected. In fact, it is often difficult to separate the two because they "feed" each other. Aquifers interact closely with streams, often releasing water into a stream, wetland or lake and sometimes receiving water from the stream, wetland or lake. This is why one can contaminate the other—if the ground water is contaminated, it will carry the contamination into the stream. An aquifer that feeds streams is said to provide the stream's baseflow (this is called a gaining stream). In fact, ground water is responsible for maintaining the hydrologic balance of surface streams, springs, lakes, wetlands and marshes. Successful watershed programs, therefore, protect not only a particular stream, lake or other surface water body, but also protect the aquifer that interacts with it.

The source of ground water is recharge from precipitation or surface water that percolates downward through the land surface. In Chester County, approximately 28% of annual precipitation is recharged to ground water. In some areas, streams literally recharge the aquifer through streambed infiltration (this is called a losing stream). Left untouched, ground water naturally arrives at a balance, discharging to streams about the same volume of water as it receives from recharge, depending on hydrologic conditions.



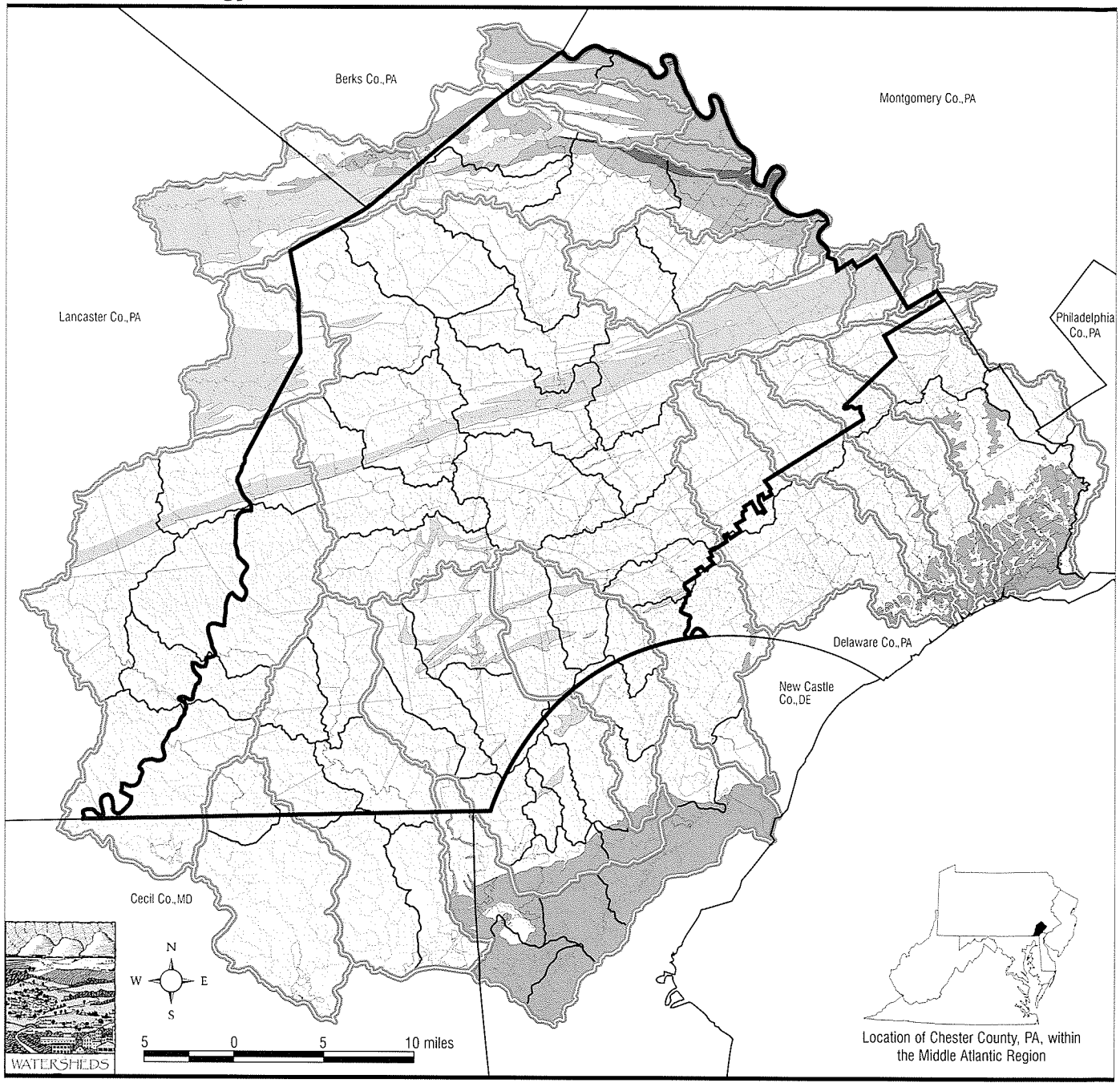


The aquifers that lie below Chester County's watersheds consist of three primary types of rock (see Figure 2-5): crystalline (including diabase, among other types of rock), carbonate (including limestone and marble), and Triassic sedimentary rocks (including Brunswick, Hammer Creek, Lockatong, and Stockton Formations). The most abundant is crystalline rock that occurs in both the northern and southern parts of Chester County. Crystalline rock underlies approximately 90% of the County's watersheds. Well yields in the crystalline rock are generally much lower than in the sedimentary or carbonate rocks, but can provide sufficient yields for domestic wells and occasionally for public water supply wells.

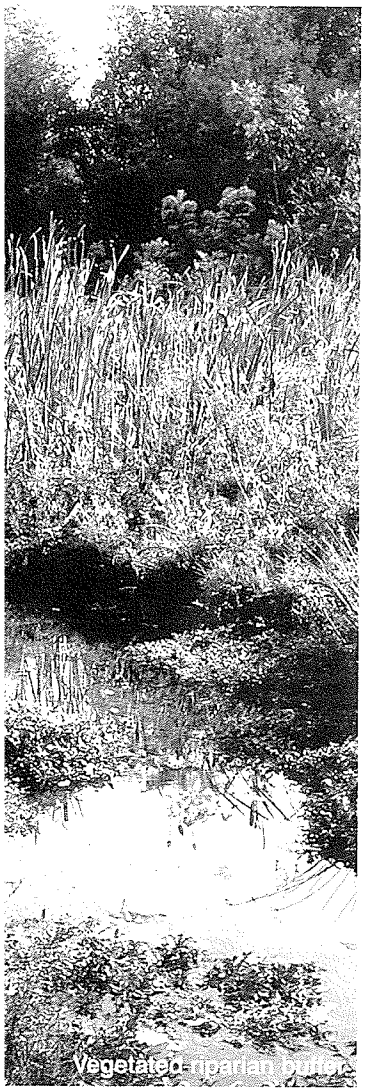
In the northeast, Triassic sedimentary rocks are found. Triassic sedimentary rocks occur along the Schuylkill River in the northern part of the County and comprise less than 10% of the study watersheds. Some of these aquifers are more productive than others. In general, well yields for these rock units are significantly higher than well yields in crystalline rocks, but are generally less than those of carbonate rocks. The sedimentary formations can provide sufficient yields for public water supply wells.

Carbonate rocks occur in the Chester Valley, which cuts through the center of Chester County. Carbonate rocks comprise less than 5% of the study watersheds. Ground water in carbonate rocks flows through a network of secondary openings (fractures, fissures, caves, etc.) in the rock that are enlarged as the carbonate rock is dissolved by flowing water. Fractures can vary from a fraction of an inch wide to several feet wide, and are capable of transmitting large quantities of water. For this reason, carbonate rocks form some of the most productive aquifers in the study area. In general, well yields for the carbonate rocks are significantly higher than well yields in other geologic groups (with the exception of some wells in the sedimentary rocks), and can provide sufficient yields for public water supply wells.

Figure 2-5:
Generalized Geology



Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)



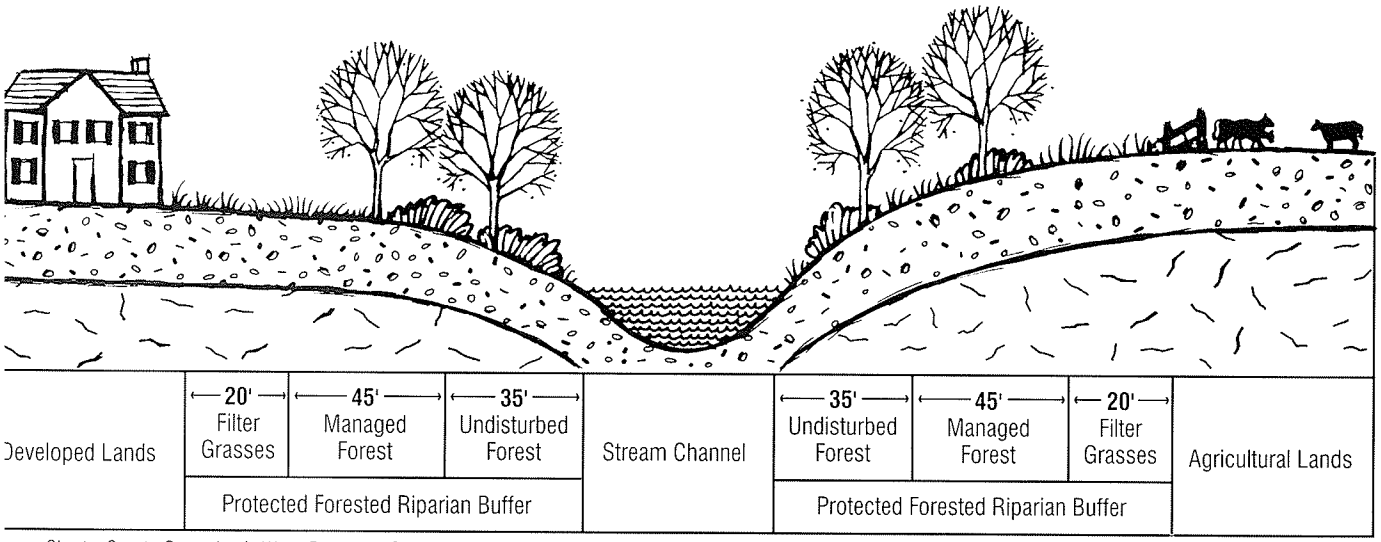
What are Riparian Buffers?

Forested riparian (meaning "along the water") buffers are as essential to a watershed as ground water and rainfall. An inter-connected network of forested riparian buffer is essential for a healthy and thriving stream ecosystem. The benefits of a vegetated buffer cannot be mimicked by any other management practice. Forested buffers along stream banks protect stream waters from direct sunlight and resulting high temperatures, provide detritus in the stream that serves as food and shelter for aquatic species, and stabilize stream banks, stream channels and floodplains from the erosion and scour of high velocity flood flows. These buffers also serve as the link between terrestrial wildlife and their source of water, food and cover. The roots of the riparian vegetation absorb and "take up" nutrients and other pollutants from ground water as it migrates through the root zone. Riparian vegetation also serves to filter sediment and pollutants from overland runoff and stormwater.

To be most effective, riparian buffers should include three zones. The streamside zone should include natural, undisturbed trees and bushes that provide shade and detritus to the stream, and root masses that stabilize stream banks and channels. The second zone is a managed forest zone with trees and shrubs that provide pollutant filtering and uptake through the roots of the plants, as well as infiltration. The third or upland zone includes grasses and features to slow and disperse the runoff as it enters the buffer and filters sediments and pollutants.

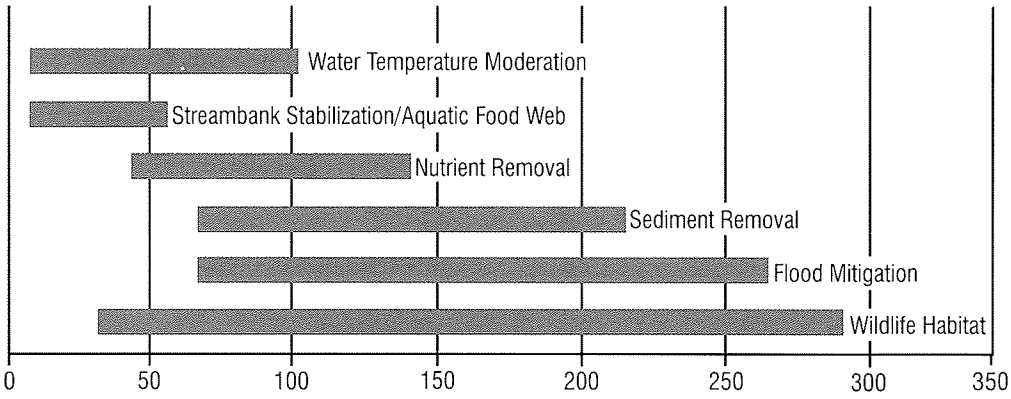
Figure 2-6 presents a cross-section view of a forested riparian buffer. Included in the plan view are recommended buffer widths and set backs for development adjacent to riparian areas. While buffer areas should remain clear of impervious cover, it is certainly possible to permit building lot area within the buffer (provided structures and potential sources of pollutants remain outside of the identified buffer).

igure 2-6:
orested Riparian Stream Buffer



urce: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Figure 2-7: Desired Buffer Function and Minimum Buffer Width



Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

No model is yet available to calculate the optimum width for riparian buffers based on site-specific conditions. However, Figure 2-7 summarizes the functions that are needed from forested riparian buffers in Chester County's watersheds and the range of minimum buffer widths needed to achieve them. This illustration supports the 100-foot buffer width for each side of a water body recommended by the strategies of this Plan. This width has been applied for many years in Chesapeake Bay watershed communities and elsewhere.

What are the Impacts of Land Use on Water Resources?

Everything we do on the land surface impacts the quality or quantity of streams and ground water to some degree. Grading a site for construction compacts the soils under the cleared area and reduces the amount of water that can infiltrate as ground water recharge. Farmed lands, depending on the farming practices used, can generate large amounts of runoff and sediment. Constructing swimming pools, buildings, roads, sidewalks, parking areas and other features that are "impervious" (that do not allow water to penetrate through them and into the underlying soils) eliminate ground water recharge and convert that volume of water to stormwater runoff. Increased runoff not only represents some loss of ground water recharge, but also increases the frequency and magnitude of flooding.

Chemicals intentionally applied to the land (fertilizers and pesticides for example), particularly if applied in quantities greater than what is taken up by the target plants, can run off into streams as pollutants. Where such chemicals build up in the soil, rainfall infiltrating into the ground can leach the chemicals from the soil and carry them as pollutants into the underlying

Severe streambank erosion

aquifers. Virtually all land surfaces (except forest and meadows) have some type and quantity of pollutants that are carried to streams and ground water by rainfall runoff or infiltration.

Table 2-1 summarizes several of the impacts of traditional development on streams and watersheds. Most of these impacts are created by the expansion of impervious cover across portions of the land surface, where the impervious cover is directly connected to a stream by a stormwater conveyance system.

Table 2-1: Impacts of Traditional Development on Watershed Resources

Changes in Stream Hydrology
Increased magnitude/frequency of severe floods
Increased frequency of erosive bankfull and sub-bankfull floods
Reduced ground water recharge
Higher flow velocities during storm events
Changes in Stream Geomorphology
Increased channel widening and downcutting
Increased streambank erosion
Increased channel scour
Shifting bars of coarse sediments
Imbedding of stream substrate by fine sediments
Loss of stream pool and riffle structure
Stream enclosed in a pipe, culvert or concrete channel
Changes in Stream Water Quality
Increased instream pulse of sediment during construction
Increased nutrient loads promoting stream and lake algae growth and eutrophication
Bacteria contamination during dry and wet weather
Higher loads of organic matter
Higher concentrations of metals, hydrocarbons, and other toxic pollutants
Warming of stream water temperature
Frequent trash and debris jams
Changes in Stream Ecology
Riparian buffer reduced or eliminated
Shift from external production to internal production
Reduced diversity of aquatic insects
Reduced diversity of fish and other aquatic organisms
Creation of barriers to fish migration
Degradation of wetlands, riparian zones and springs
Decline in amphibian populations

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Substantial research has documented the often unnecessary impacts of the expansion of traditional development on watershed "health." One of the primary indicators of stream health is the percent of impervious cover in the watershed that is directly connected to a stream. Table 2-2 summarizes the impacts on stream health from increasing amounts of directly-connected impervious cover.

In addition to the impacts associated with stormwater runoff, there are direct impacts associated with water use, i.e., the activities of water supply and wastewater disposal. These impacts include increased water withdrawals and consumption from streams and ground water; increased pollutants going into ground water and streams from increased volumes of treated wastewater discharged; and increased infrastructure expansion, and its associated costs and environmental and planning implications. Although these issues can cross jurisdictional boundaries, it is important to recognize that these issues can also be addressed in the planning process. In addition, techniques such as land application or spray irrigation of treated wastewater can reduce discharges to streams, potentially recharge ground water, and contribute to overall watershed health.

Land development and its associated impervious cover need not be discontinued to maintain watershed health. There are many design and protection practices that are being incorporated into the development process to reduce or eliminate these impacts. For example, many techniques and alternative designs are now widely used in nearby areas to reduce the amount of impervious cover required to safely meet the needs of vehicles and pedestrian movement. *Watersheds* is designed to encourage these management techniques, and to increase awareness of the importance of implementing them to protect our water and land resources.

Table 2-2: Relationship of Stream Health and Directly-Connected Impervious Cover

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

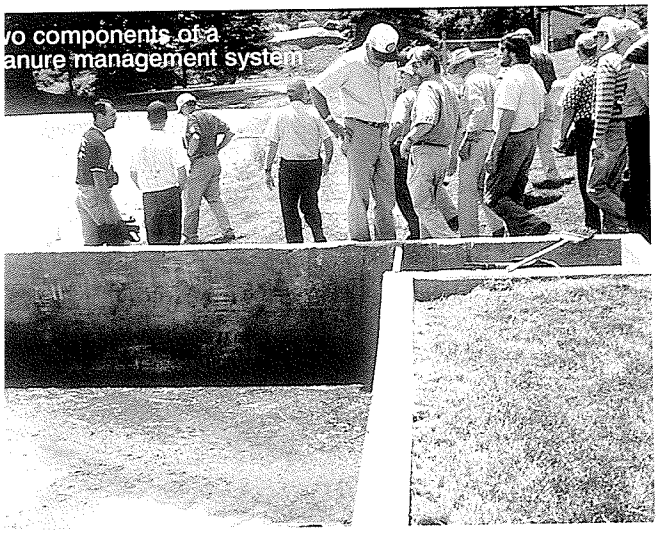
Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

What are Best Management Practices (BMPs)?

Best Management Practices (BMPs) are design techniques that have been shown to be most effective in providing for development, stormwater and agricultural activities in a manner that is more consistent with the natural characteristics of the receiving watershed resources. Taken together, BMPs are a broad series of land and water management strategies designed to minimize the adverse impacts of land disturbance and development. These BMPs provide varying levels of watershed protection and are becoming more widely used in Chester County's watersheds as applied practice demonstrates their value for all types of uses.

Watershed management is fundamentally about modifying human behavior and activities to better protect the natural resources so those resources can sustain the diverse needs and interests of society. BMPs offer the opportunity to reduce our impacts without unduly restricting sensible growth.

BMPs can be "structural" or "non-structural." "Structural" BMPs are measures that require the design and physical construction of a facility or feature to help reduce or eliminate a nonpoint source of pollution and control stormwater. "Structural" BMPs are most often applied to agricultural operations and stormwater management. "Non-structural" BMPs are approaches to planning, site design, or regulations that positively affect the water quality and reduce stormwater runoff. "Non-structural" BMPs are most often applied to planning, design and regulation of land development.



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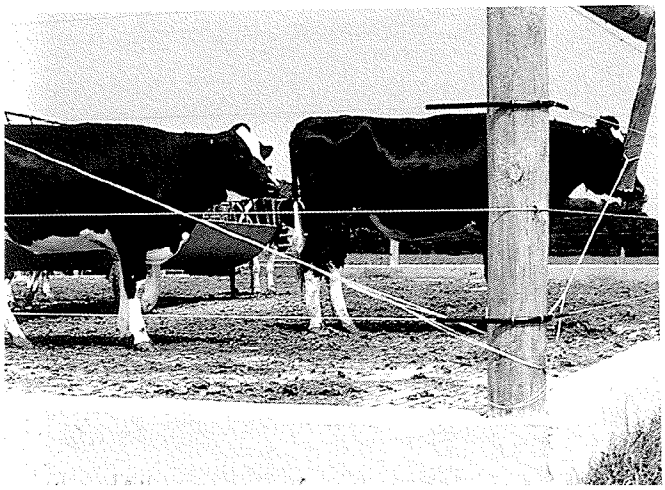
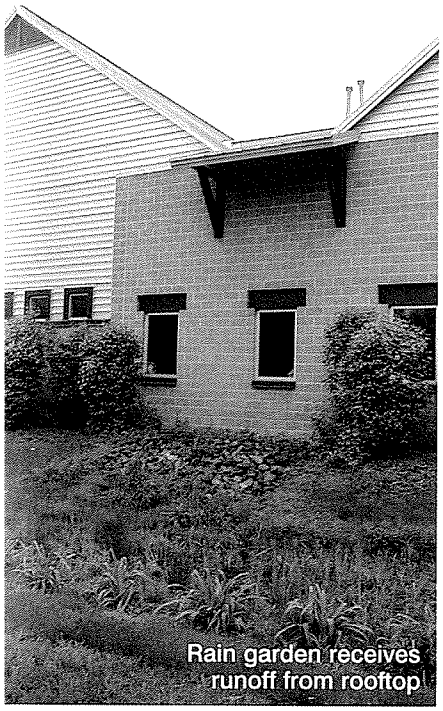


Agricultural BMPs

Principal among the various programs and practices for agriculture is the soil and water conservation plan. Plans generally consist of three components which include recommendations for management techniques and BMPs. The first component addresses soil erosion control measures. The second component addresses nutrient management, and the last component addresses pest management. Techniques and approaches are quite diverse, depending upon the particular agricultural activity taking place.

Among the common agricultural BMPs are:

- Conservation tillage and contour farming (intended to limit disturbance and erosion of soil, respectively).
- Grass or filter strips (intended to remove sediment or other pollutants from runoff).
- Stream fencing (intended to keep livestock out of stream channels).
- Pesticide management (intended to reduce the off-site impacts of spraying or applying pesticides).
- Manure management (to reduce runoff of nutrients and pathogens to streams).


Rain garden receives runoff from rooftop

Stormwater BMPs

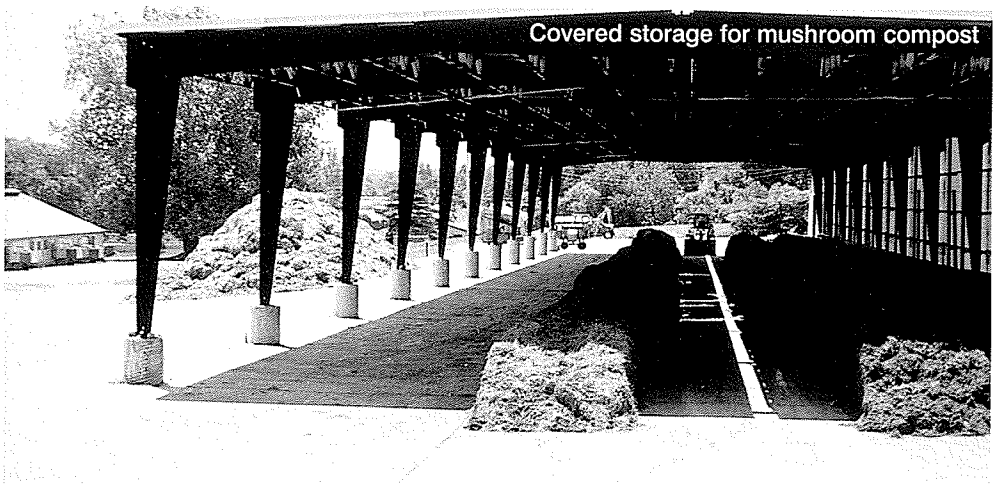
The most effective stormwater BMPs and management measures are designed to be consistent with the characteristics of the watershed's streams and ground water. This means that after construction is complete, the drainage from the developed site has maintained the volume of ground water recharge and the frequency, rate and volume of surface runoff that would exist if the site were covered in open meadow. Important to remember are the ten principles of stormwater management:

- Minimize the volume of stormwater runoff generated.
- Protect ground water recharge.
- Protect water quality (surface and ground water).
- Protect receiving stream channels.
- Reduce rate and volume of runoff to reduce flooding.
- Design sites consistent with "open meadow" conditions.
- Protect adjacent lands from direct stormwater discharge.
- Insure effective facility operation and maintenance (O&M) plans and programs.
- Establish networks of forested riparian buffers.
- Protect wetlands and floodplains to reduce runoff and flooding.

The strategies for treatment of stormwater runoff from developed lands encourage the use of BMPs to remove sediments and nutrients. By capturing and treating up to the 1-inch storm event through implementation of effective BMPs, the runoff of between 85% and 90% of annual average rainfall is handled for pollutant removal.

Many recommended BMPs and BMP design guidance manuals are described and recommended in the *Compendium*. Based on past experience through demonstration projects, the use of these techniques can help to achieve pollutant reduction goals. Types of stormwater BMPs include (among others):

- Uses of pervious areas for infiltration.
- Infiltration BMPs.
- Water quality BMPs.
- Urban area BMPs.
- Suburban development BMPs.
- Agricultural BMPs.


Covered storage for mushroom compost

Land Development BMPs

In addition to the use of stormwater management BMPs, many communities are applying "conservation development design" approaches to developing land. "Conservation Development Design" (also known as Low Impact Development) forms a holistic approach to development design that achieves the land development objectives and maximizes the preservation of key land resources, protects site hydrology, preserves natural resources, and satisfies community interest in complimentary and aesthetically pleasing development. Conservation Development Design is a term that encompasses a number of land development design practices that have some or all of the following goals in common:

- Reduction of roads and infrastructure necessary to support the development.
- Conservation of significant natural resources and habitat.
- Minimization of the environmental impact resulting from the change in land use (minimum disturbance, minimum maintenance).
- Maintenance of a balanced water budget by making use of available site characteristics and natural infiltration.
- Incorporation of unique site features (natural, scenic and historic) into the configuration of the development to increase property owners' enjoyment of and access to those features.
- Preservation of the integral characteristics of the site as viewed from adjoining roads.
- Reduction of property owner, homeowner association, and community maintenance responsibility for the number and size of structural or engineered stormwater management practices.

Cul-de-sac planted with grass and shrubs

Several effective approaches to Conservation Development Design are recommended in this Plan for implementation by municipalities. These include (among others):

- Eliminate unnecessary impervious cover requirements.
- Incorporate use of non-structural stormwater BMPs and alternative site drainage techniques into site landscaping to minimize stormwater runoff and maximize infiltration (including the use of grading elements that maximize flow over pervious, vegetated surfaces to reduce the concentration of runoff and therefore the need for structural stormwater management practices).
- Initiate negotiations between the municipality and developer early in the development review process (i.e., at the sketch plan level) to identify opportunities for incorporating conservation designs and BMPs (as opposed to discussions that often occur after developers have spent large sums of money on design and engineering).
- Permit downzoning (a reduction in density through enlargement of minimum lot area requirements) where requested by land owners and consistent with municipal planning and limited development objectives.

- Include incentives in municipal development regulations to achieve site design sensitive to existing site resources (environmental, scenic, or historic).
- Require protection of certain site resources (or constraints), such as by protecting all or part of critical natural features of a site from disturbance by netting out (or not including) these features from the acreage otherwise used for development.
- Reduce impediments to the use of cluster and other conservation subdivision options.
- Employ minimum disturbance/minimum maintenance standards (i.e., land disturbance ordinance provisions) to reduce or eliminate the affects of land disturbance, clearing and grading.

Several of these techniques lend themselves to implementation through regulations. However, Conservation Development Design is less a function of regimented codes and procedures than it is about communication among land planning and environmental professionals, knowledgeable developers, community representatives and regulatory authorities who combine their understanding and perspectives to create economically and environmentally viable plans.

The Future—With and Without BMPs

In developing ***Watersheds,*** an assessment was conducted of the potential for BMPs to provide positive improvements to the County's watersheds. The *Compendium* presents results of a watershed runoff computer model used to replicate land and water disturbances in Chester County's watersheds with and without BMPs. These estimates provide a screening level comparison of the relative pollutant potential of various areas within the study watersheds. The results provide insight into the potential to reduce pollutant loading if the entire study area were provided with the recommended BMPs.

Based on this modeling, if no BMPs are installed and the study area continues to develop, pollutant loading will change by the year 2020. Without BMPs, most contaminants would increase in the future as land is developed (including biological oxygen demand, metals, nitrate, and phosphorus). Some contaminants may stay relatively the same or even decrease slightly, where agricultural land without BMPs is converted to suburban land use.

However, BMPs do make a big difference. When the model was applied with BMPs, the estimates of future pollutant loads in 2020 were reduced to less than the estimates for existing (1998) land use conditions. Reduced pollutant loading estimates range from substantial potential reductions in metals and sediments (or Total Suspended Solids, TSS), to more modest but still significant reductions in nitrate and biological oxygen demand (BOD).

By designing our land uses using the techniques, practices, and approaches of structural and non-structural best management practices, the resulting land cover can maintain a "balance" with the natural characteristics of the receiving streams and ground water of the watershed.

A Snapshot
What We Learned

3

As part of the overall ***Watersheds*** planning process, the 21 watersheds that originate within Chester County were evaluated. Many types of data were collected and synthesized, many maps were prepared to present and interpret the data, and numerous analyses were performed of all 21 watersheds. The methodologies and results of these analyses are presented in detail in the *Compendium*. The following discussions provide brief summaries of what was learned about Chester County's watersheds in these studies. The conclusions from these analyses were used to prepare an inventory of specific problems and resources to be protected, and to establish priorities to help guide future management planning and decisions for each watershed.

Twenty-one watersheds were evaluated

1 Brandywine Creek
2 Chester Creek
3 Christina River
4 Conestoga Creek
5 Crum Creek
6 Darby Creek
7 Elk Creek
8 French Creek
9 Gulph Creek
10 Northeast Creek
11 Octoraro Creek
12 Pequea Creek
13 Pickering Creek
14 Pigeon Creek
15 Red Clay Creek
16 Ridley Creek
17 Schuylkill River Drainages
18 Stony Run
19 Trout Creek
20 Valley Creek
21 White Clay Creek

Chester County Water Resources Task Force

Community Values

Watersheds was built upon the ongoing participation of the Chester County Water Resources Task Force and significant public and "stakeholder" input. The Task Force itself represented a broad array of interest groups, agencies, and stakeholders who met numerous times throughout the planning process to guide and participate in the efforts. The Task Force included representatives from over 40 different entities involved in aspects of water resources and land use management. In addition, representatives from several state agencies and river basin commissions participated with the Task Force. The collective inputs of the Task Force members and agency participants were incorporated into the *Compendium* and ***Watersheds.***

In the summer of 1999, a series of four public meetings were held at various locations across Chester County to obtain input from municipalities and the public. A second series of public meetings was held in the summer of 2002 to solicit comments from the public on the draft Plan, followed by a Public Hearing in August 2002. In addition, numerous workshops were held to solicit direct input from watershed organizations, water suppliers, and land developers.

Of significant relevance were responses to detailed questionnaires distributed to water and wastewater purveyors, municipalities, watershed organizations, and private citizens. A public questionnaire was also posted on the CCWRA ***Watersheds*** web site and widely distributed through the mail and at meetings. Information on intermediate results and progress was widely disseminated on a quarterly basis via the web site and through quarterly newsletters mailed to a large distribution list.

Dozens of public presentations were provided to various groups, organizations and events during the development of the Plan, where additional inputs and suggestions were received.

The participants and respondents overwhelmingly concurred that in order to achieve the changes and goals envisioned in ***LANDSCAPES,*** significant changes in the way we manage our natural water systems were needed as well. In fact, most participants felt strongly that better land and water management and land development patterns are critical to achieving watershed health.

In addition to a call for change, stakeholders identified over 100 water resource-related problems they felt existed within the watersheds. These lists of problems, presented in the *Compendium*, were compared with data and information derived from data analyses and modeling to determine which problems were "perceived" and which problems currently exist. This understanding of "real" versus "perceived" problems provided the basis to develop a clear and effective set of planning goals and objectives.

Overall, problems of water quantity, quality, and supply topped the lists of "perceived" problems. As an indicator of the problems "perceived" as important by the public and stakeholders, Table 3-1 lists the top problems that each group identified.

After evaluating the "perceived" problems identified by the stakeholders in light of the results of the data collection and analyses, these priorities were revisited by the Water Resources Task Force. Because the complete listing of identified problems was long, it was divided into twelve categories to assist the Task Force in re-prioritizing the issues. The Task Force prioritized the categories and ranked the problems within each category. From this, the highest ranked problems within each category were then combined into one list and again prioritized by the Task Force.

As a result of this series of prioritization exercises completed by the Task Force, the following were identified as the highest priority concerns:

- Lack of integration of water resources in land use planning.
- Growth depleting ground water supplies and reducing ground water recharge.
- Lack of coordination between land use and water supply decisions.
- Need for education at all levels regarding water resources management issues.
- Cumulative ground water withdrawals not sustainable in the long term without environmental damage.

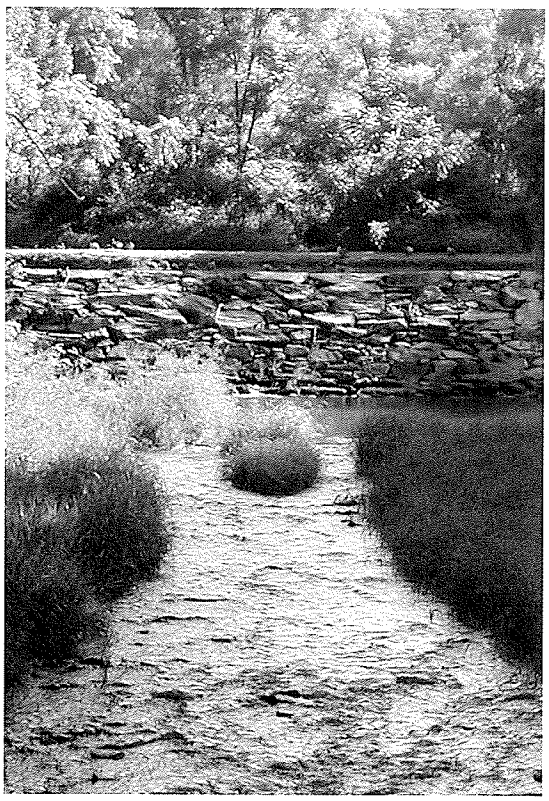
Table 3-1: Top "Perceived" Problems Identified by Stakeholders

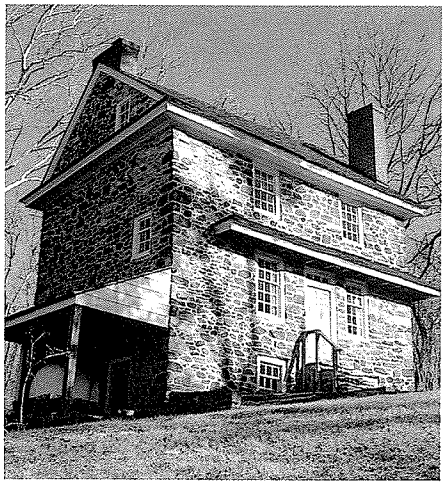
Stakeholder Group	Top "Perceived" Problems
Public	Depletion of ground water levels due to increased impervious cover
	Stormwater pollution entering streams from nonpoint sources
	Depletion of ground water levels due to the increased number and volume of new wells
Municipalities and Watershed/Conservation Organizations	Need for reliable quantities of water supplies to support future growth
	Depletion of ground water levels due to the increased volume and number of new wells
	Pollution entering streams from nonpoint sources
Water Supply Purveyors	Meeting new regulatory requirements
	Aging infrastructure repair and replacement
	Protection of sources of water supplies
Wastewater Purveyors	Infiltration and inflow of ground water into wastewater pipelines
	Aging pipelines
	Treatment process upgrade costs

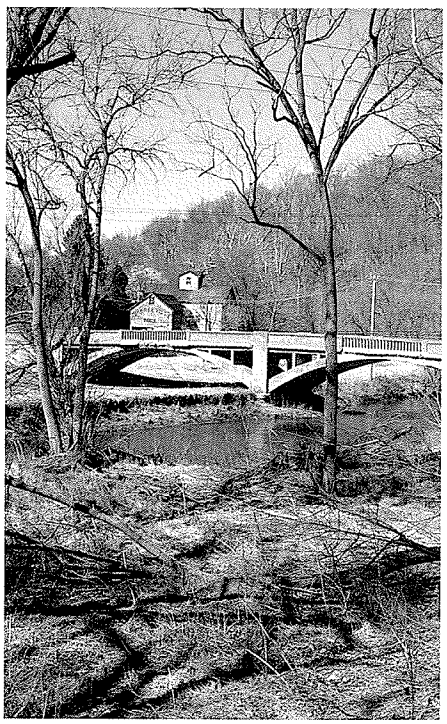
Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

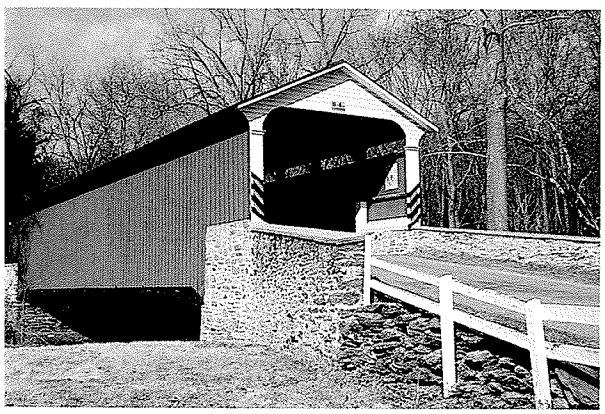
Resources Management Practices and Philosophies

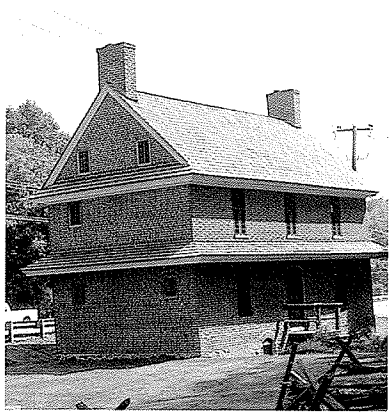
Mills and industries were historically attracted to Chester County because the many streams provided a plentiful source of power. The valleys of the region were rich in iron ore, lumber and fertile soils for grains. Towns and villages emerged around industrial centers and where ample water supplies were easily accessible. Floodplains with rich agricultural soils were cleared for farming of cash crops and for livestock. Hillsides were cleared for lumber for construction of homes and businesses. Terraces, formed by and along the streams, provided grades suitable for railroad corridors and roads, many of which evolved from trails of the Native Americans. Fords and covered bridges — now some of the area's most valuable historic features — were built to move people and commerce safely across the region's streams. These activities supported the growth and economy of not only Chester County, but that of Philadelphia, Wilmington, and Baltimore during the Industrial Revolution and beyond.

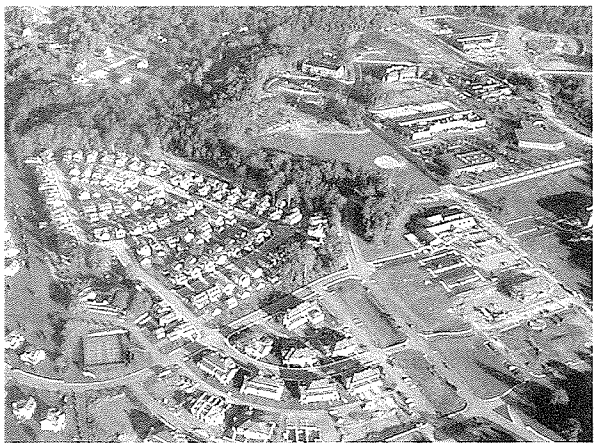


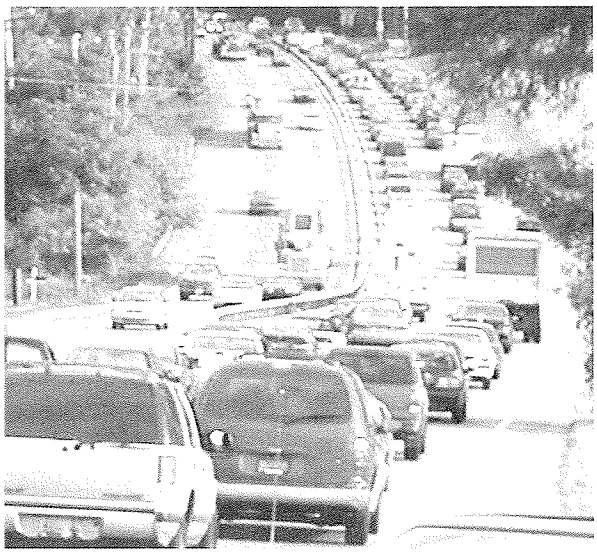












However, the early clearing of forests for farming, settlements and building materials increased flooding and allowed rapid and excessive erosion of fertile soils. Dams built for mills and industries to harness water power disrupted migration of fishes. Wastes from industry and sewage from towns were discharged directly into streams — largely untreated until the mid-twentieth century. Industrial chemicals and waste materials were used for fill or discarded in abandoned landfills to be later found as sources of ground water contamination. Toxic agricultural pesticides and over-applied fertilizers were washed by rainfall into the streams and ground water, dramatically sterilizing the streams of their aquatic communities.

The post-World War II economy brought the popularity of automobiles and the building boom of suburban subdivisions and commercial centers that afforded many people the "American Dream." This began the "sprawling" patterns of vehicle-dependent communities with ever-expanding networks of hard-surface roads, parking lots, and driveways. The cumulative impacts of centuries of agrarian, timbering, industrial, and residential growth became so severe near the mid-twentieth century that they threatened the ability of society to rely on the heavily polluted and flooding waters of the region's streams.

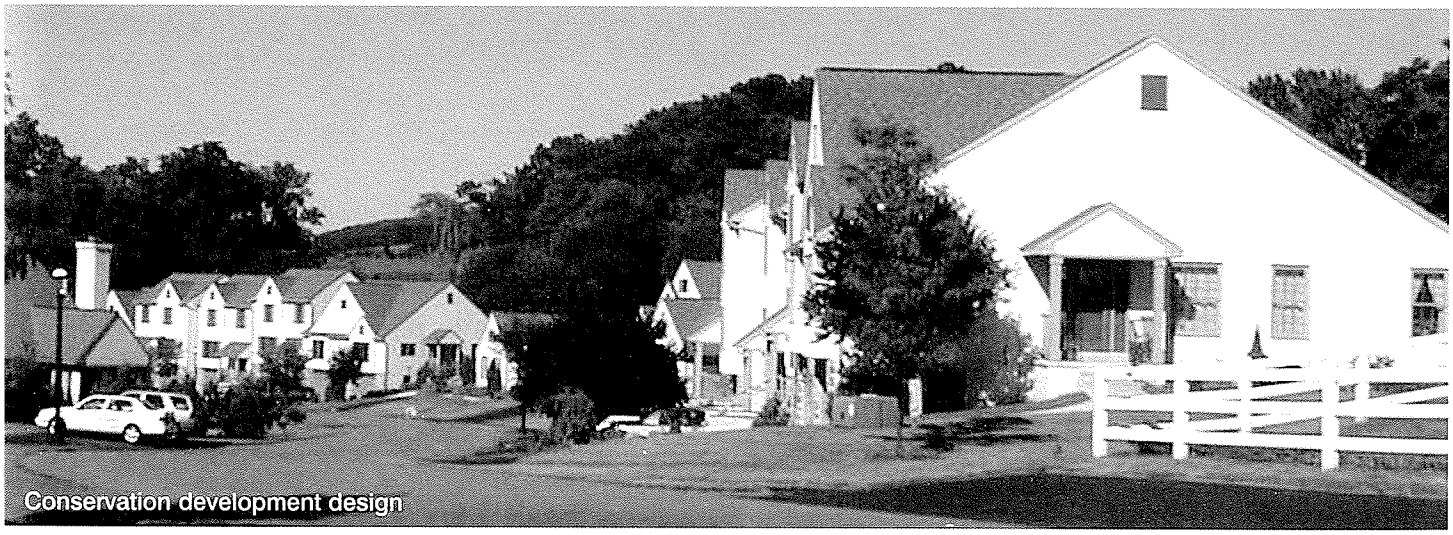
Over the past 50 years, increased public awareness, advances in technologies, and broadened regulations have resulted in substantial improvements. Today, many of these extreme pollution and runoff conditions have been reduced or eliminated. However, many complicated and persistent problems still exist.

The outreach and information collection conducted to develop ***Watersheds*** revealed emerging trends that are occurring within each of the sectors of Chester County's economy to improve their land and water management practices and to reduce the impacts to water resources. Some of these trends include:

- Agricultural operators — reducing runoff of agriculture chemicals and animal waste, and improving soil management.
- Wastewater dischargers — reducing pollutant loadings in wastewater discharges from industrial, commercial, and public wastewater facilities.
- Contaminated sites — progress in controlling and remediating contamination from abandoned landfill disposal of hazardous and toxic substances, and beneficial re-use of "brownfields" sites.
- Industrial and commercial facility operators — improving safe practices for commercial and industrial storage, handling, and transportation of hazardous materials and chemicals, and improving landscape management practices.
- Land development designers — understanding the need for resources protection and reducing stormwater runoff and pollutant loadings from new development.
- Transportation designers — reducing stormwater runoff volume, velocity, and pollutant loadings from existing and expanding highways and roads and improving bridge and culvert design to reduce instream erosion and improve fish passage.

- Water and wastewater utilities—maintaining the quality and quantity of waters to provide drinking water, balancing watershed water balances by returning treated wastewater to ground water or to the stream where it was withdrawn, and reducing the volume of water used to reduce the need for new water withdrawals.
- Land use and infrastructure planners—improving the coordinated and integrated planning for land use and water and wastewater infrastructure to meet future needs in a manner consistent with the communities' visions of the future and to best utilize the available resources to support planned growth.
- Municipalities—expanding their understanding and implementation of improved governance tools and management programs to reduce the impacts of growth and land use on environmental resources.
- Government agencies—expanding the availability of technical and financial assistance to encourage voluntary implementation of improved management practices to augment regulatory approaches.
- Resource managers—transitioning from structural to non-structural approaches to mitigate impacts and restore environmental systems.
- Residential land owners—increasing their awareness and understanding of their watershed resources and improving residential land stewardship practices.
- Conservation entities—targeting environmentally sensitive and riparian lands for conservation and enhancing opportunities for people to access and enjoy the streams and other water features.

These changes in management practices are demonstrating that growth and land use can occur in a manner more consistent with the natural characteristics of environmental resources. These trends represent positive changes, but their occurrence is limited. Much more needs to be done to correct the existing impairments and avoid future impacts. These changes in management philosophies and improvements in management practices need to be expanded on a widespread basis.



Conservation development design

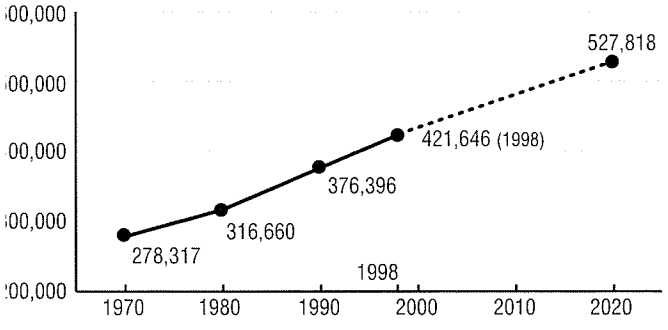
Population and Growth

Since 1970, the growth rate in Chester County has remained steady (Figure 3-1). It is important to understand the current distribution of Chester County's population, as well as the projected 2020 population distribution, in order to best plan for and manage the water resources in the County for the future. For Chester County, 1998 population estimates and projected 2020 population by municipality were based on data from the Chester County Planning Commission (CCPC) and the Delaware Valley Regional Planning Commission (DVRPC). Because *Watersheds* uses watersheds as the planning unit, the 1998 and 2020 populations were distributed geographically by 1990 census blocks to allow population to be summed by municipality, watersheds and subbasins. Table 1-1 presents estimates of 1998 population and rate of projected growth for each watershed. For all of Chester County, population figures used were:

- 1998 (estimated)—421,686.
- 2020 (projected)—527,818.

Thus, a 25% increase in population was projected for Chester County by 2020. These population distribution data were used to estimate the current (1998) and future (2020) population density distribution, future land use, current and future population on public and private water and wastewater supplies, and current and projected water and wastewater demands for various analyses conducted for *Watersheds*. The *Compendium* presents the full population distribution analyses conducted for the planning effort. Municipal population estimates and projections are presented in Part 6.

'igure 3-1:
'opulation Growth in Chester County



ource: *Chester County, Pennsylvania Water Resources Compendium* CCWRA 2002 and U.S. Census)

Land Use

In an effort to accommodate planned growth while protecting and wisely managing water resources, it is important to understand the existing land uses within the County's watersheds (Table 1-1 and 3-2 and Figure 3-2) as well as to understand the factors that are shaping the way the County is changing. To gain that perspective, an evaluation of land use was made. The evaluation was based on the DVRPC 1995 land use data for Chester County. Land use was also analyzed for the portions of adjacent counties in order to better understand the land use influences throughout the watersheds. Table 3-2 indicates that agriculture (42%), development (25%), and woodland (30%) dominated Chester County's landscape in 1995.

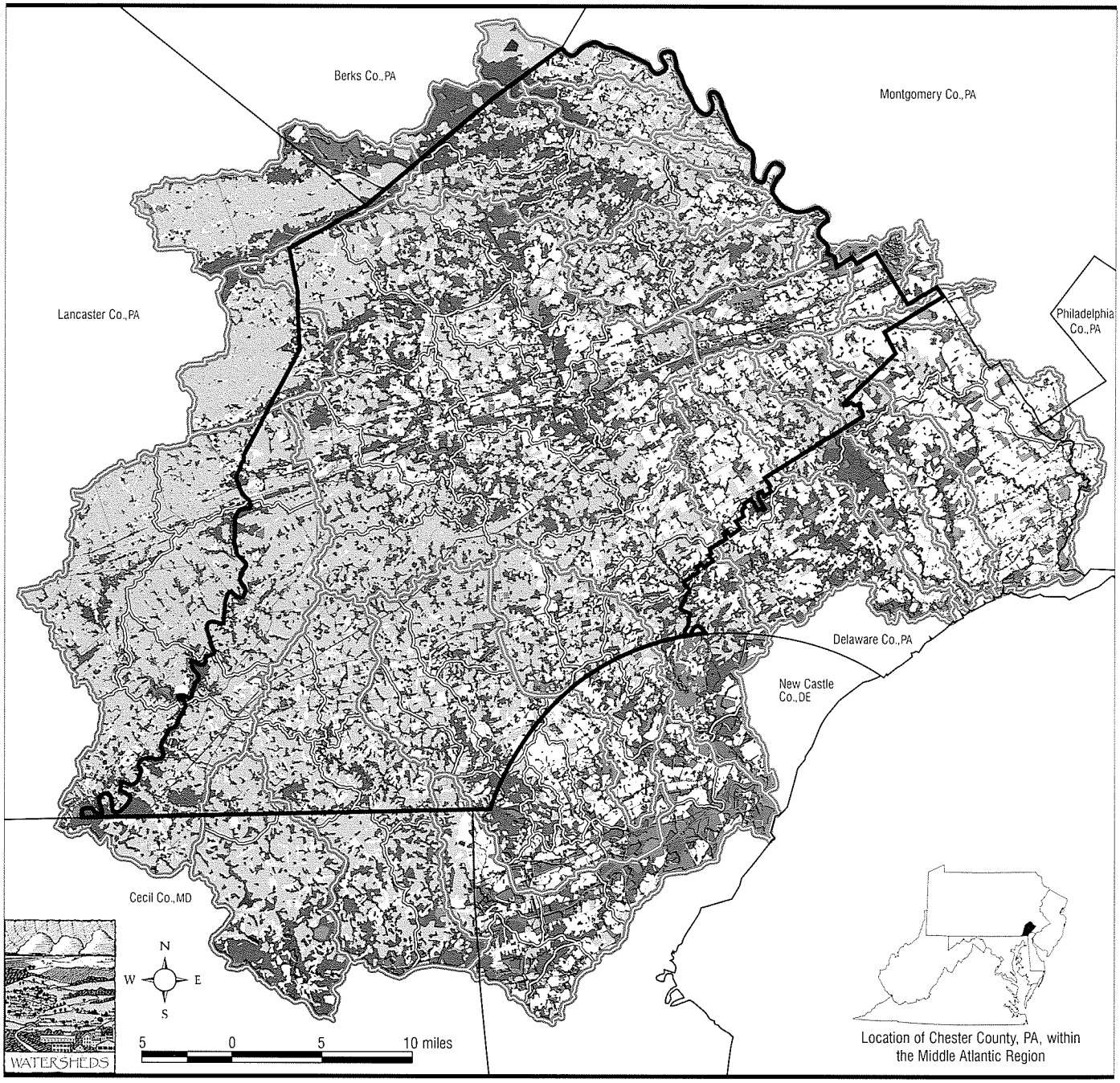
Historically, Chester County's agricultural industry, urban settings and suburban development all came about due in large part to a complex array of factors that include environmental resources (streams, agricultural soils, and ridgelines), transportation opportunities (rail, automobile, transit), and economic opportunities (agriculture, steel, pharmaceuticals, etc.). The growth pressures felt in recent years reflect not just local events but the regional impacts of the fast growing eastern seaboard of the United States. The distribution of land uses throughout the watersheds influences water quality and quantity. Thus, detailed land use data were used as the basis for several analyses presented in *Watersheds.*

Table 3-2: Land Use in Chester County (1995)

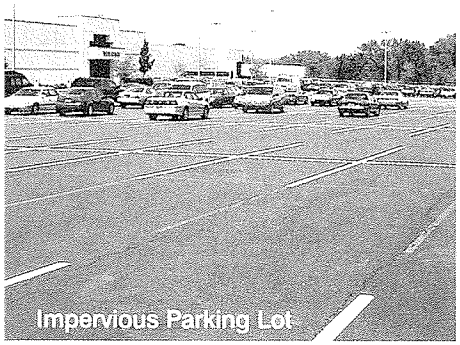
Land Use	Land Use Area (square miles)	Land Use Area (% of total)
Agriculture	316	42%
Commercial/Services	10	1%
Community Service	6	1%
Industrial	5	1%
Mining	2	0%
Parking	5	1%
Recreation	9	1%
Residential—High Density	3	0%
Residential—Multi-family	4	1%
Residential—Single Family	147	19%
Transportation/Utility	11	1%
Vacant	12	1%
Water	6	1%
Wooded	224	30%
Total	**760**	**100%**

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Figure 3-2:
Land Use (1995)



Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)


Impervious Parking Lot

Porous pavers in parking lot

Impervious Cover

One way to evaluate the impacts of land use on the health of a watershed is to evaluate the pervious and impervious land cover in the watershed. Generally, where impervious surfaces (pavement, concrete, rooftops, etc.) cover less than 10% of the land area, the watershed functions in a relatively natural pattern. As the percent of impervious surface area increases above 10%, impacts to both water quantity and quality begin to show. Watersheds with more than 20% of the land area covered with impervious surfaces often show flow patterns and water quality that are indicative of a degraded (or impaired) watershed.

The study watersheds were grouped into 3 categories based on their percent of impervious cover (corresponding to 1995 land use):

- Less than 10% impervious cover (sensitive, with limited impact from development): Elk Creek, French Creek, Northeast Creek, Octoraro Creek, Pequea Creek, Pickering Creek, and Pigeon Creek.
- Between 10% and 20% impervious cover (impacted watersheds): Brandywine Creek, Chester Creek, Conestoga Creek, Crum Creek, Red Clay Creek, Ridley Creek, and White Clay Creek, Schuylkill River Drainages, and Stony Run.
- Greater than 20% impervious cover (impaired streams): Christina River, Darby Creek, Gulph Creek, Trout Creek, and Valley Creek.

Figure 3-3 presents the estimated percent of impervious cover found in the subbasins of the study watersheds (based on 1995 land use data and assumed to generally represent 1998 conditions).

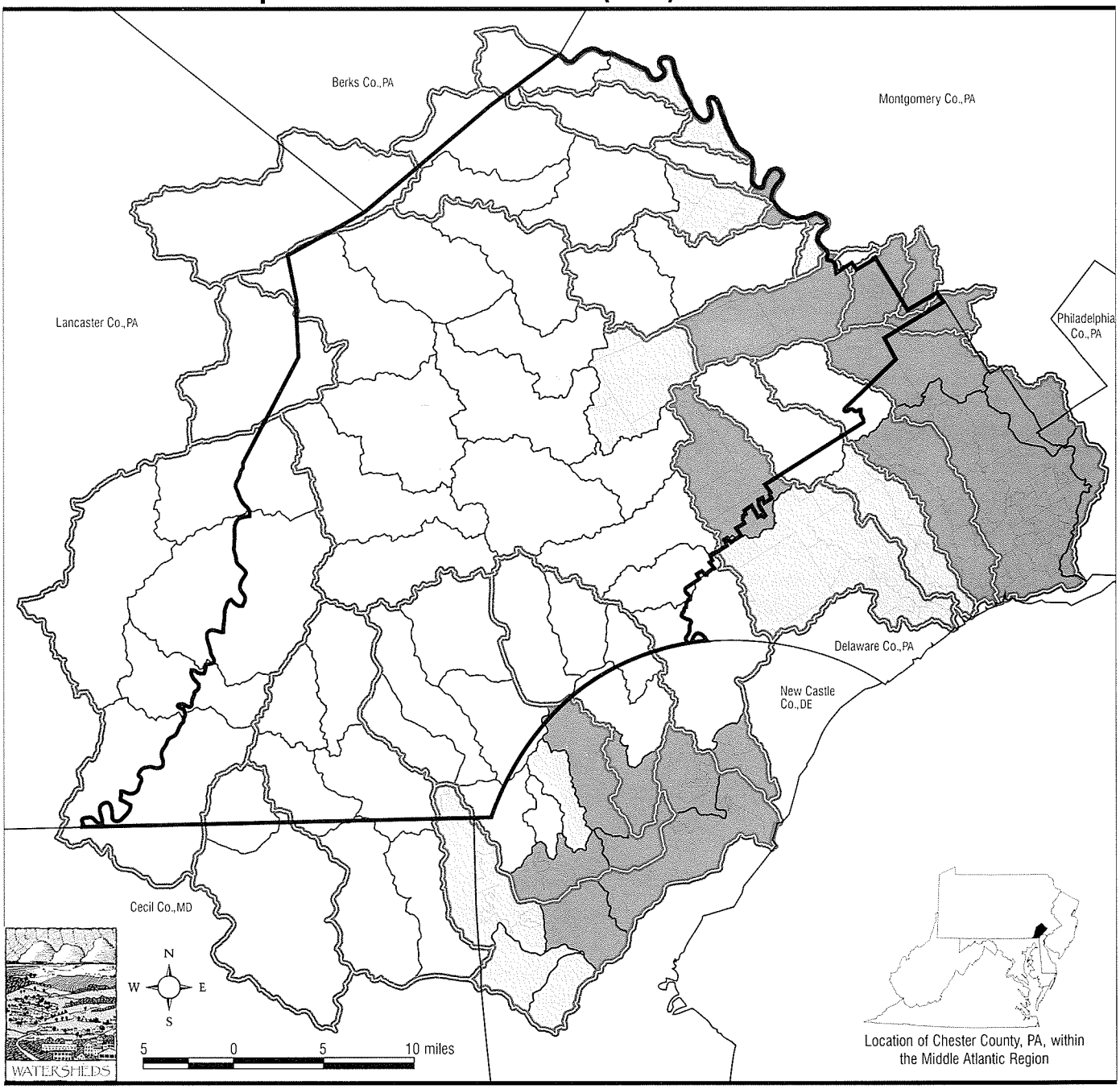
Ground Water Quality

Ground water is important because of its use for drinking water supply and for commercial and industrial purposes. In addition, ground water generally provides over 60% of the flow found in Chester County's streams. As such, any contamination or over-withdrawal of ground water could have wide consequences for streams and aquifers.

Pollutants entering the ground are often associated with surface land uses. Pollutants associated with various land uses may differ depending on whether the land is residential, agricultural, commercial/industrial, or undeveloped. Undeveloped land, in general, has little impact on ground water except for naturally occurring chemicals. Potential contaminants associated with agricultural lands (cash crops, nurseries, livestock, and mushroom farms) include pesticides, fertilizers and animal waste.

There are a wide array of potential contaminants associated with residential land use, among them are household solvents, detergents, nitrate, oils, chloride, bacteria from septic tank effluent, fertilizers and pesticides from lawn care, and pesticides for termite control. Land used for commercial development or industrial development can contaminate the ground water with solvents, metals, benzene, and other organic compounds. Abandoned contaminated sites (including 10 Superfund sites listed on the National Priority List). are scattered throughout Chester County. Runoff from roads and urban areas can also be a source of pollutants to the ground water

Figure 3-3:
Estimated Percent Impervious Cover in Subbasins (1998)



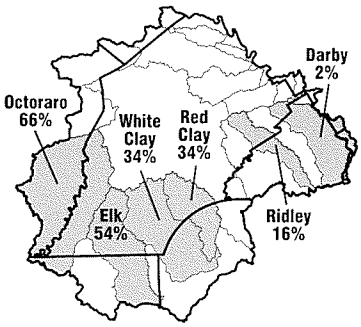
Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

in areas where stormwater is recharged to the ground without pre-treatment to remove pollutants.

All available information on ground water quality and problems were collected and synthesized to ascertain locations and priorities for improvements. Figure 1-2 presents the locations and extent of identified ground water problems. In general, existing ground water quality data indicate that the overall quality of the ground water in most of the study watersheds is good. This is encouraging for those areas dependent on ground water either through public supply wells or individual domestic wells. There are, however, areas of concern. Two of the primary ground water quality concerns are nitrate from septic systems and agricultural sources, and radon and radium from naturally occurring rock formations. While naturally occurring radon and radium cannot be dealt with except through water supply treatment, nitrate is better managed through source control measures.

Figure 3-4: Elevated Nitrate Levels

Watersheds with elevated levels of nitrate in ground water (and percent of land use in agriculture)



Nitrate concentrations in ground water appear to be generally above 5 milligrams per liter (mg/L) in 6 of the 21 watersheds (Elk, Darby, Octoraro, Red Clay, Ridley, and White Clay, see Figure 3-4). This is relatively high compared to the drinking water standard of 10 mg/L, and nitrate is typically not removed from the drinking water supply through treatment processes presently in place. Agricultural uses as a percentage of total land area in those 6 watersheds are 54%, 2%, 66%, 34%, 16%, and 34%, respectively. Octoraro Creek watershed has the highest percentage of agricultural land use and it has widespread elevated nitrate concentrations in ground water throughout the watershed.

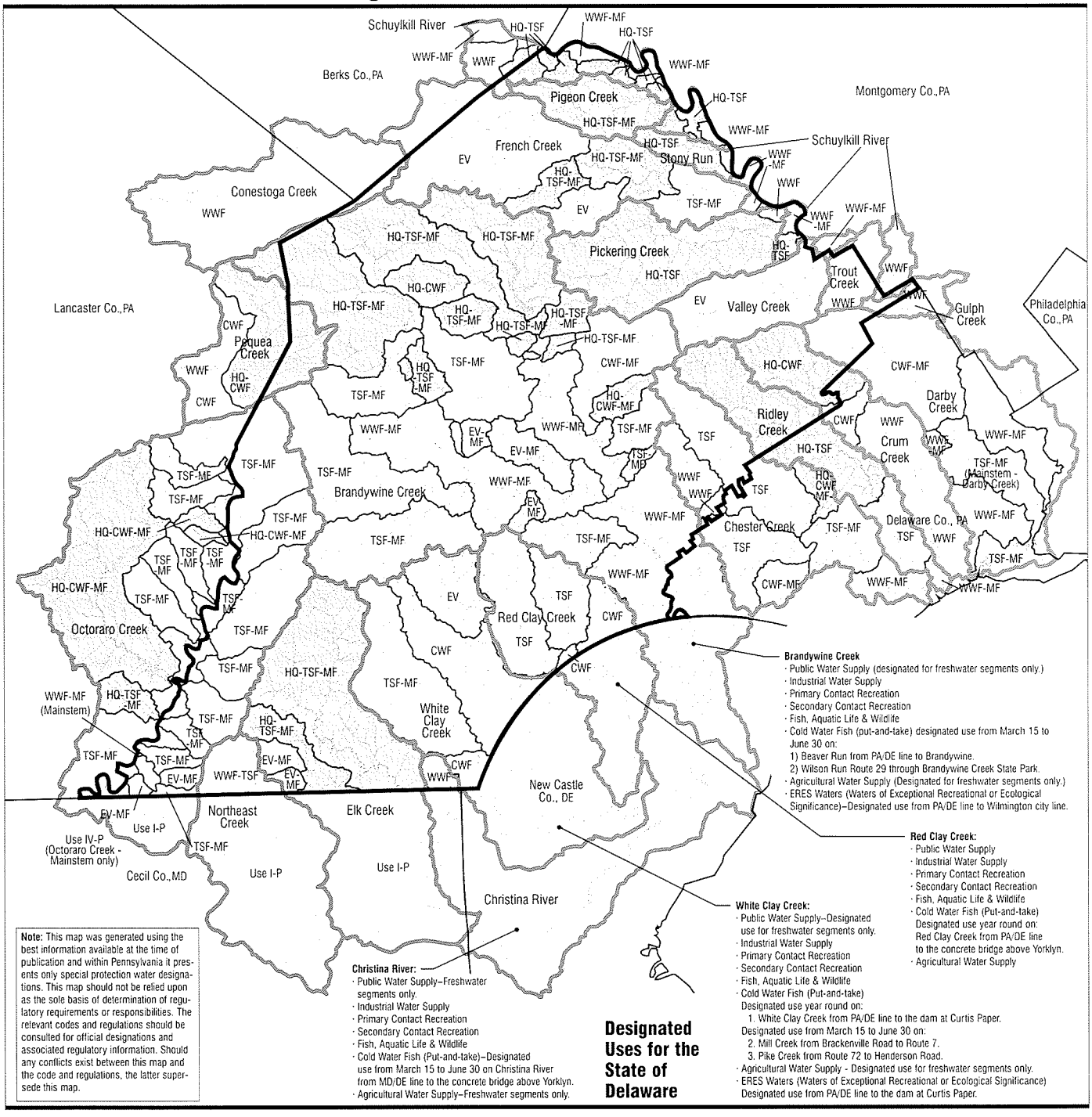
Undoubtedly some of the high nitrate concentrations are related to agriculture and some are not. For example, Pequea and Northeast Creek watersheds are both over 50% agricultural, and yet have lower nitrate concentrations. Ridley and Darby watersheds, which have high nitrate concentrations in the ground water, are not currently areas of agricultural activity. Clearly there are other sources of nitrate causing high ground water concentrations, such as septic systems.

Stream Water Quality

All surface waters have protected uses as designated by their respective states. Within Pennsylvania, those categories are: Aquatic Life, Water Supply, Recreation, and Special Protection. The designations for the Special Protection category are Exceptional Value (EV) and High Quality (HQ), which single out those streams that are highly valued for their water quality and relatively unspoiled character. These streams are given high priority when considering watershed protection measures. Pennsylvania also uses other designations, as shown on Figure 3-5.

States are also required to identify and list streams that are "impaired." These include streams that do not meet the water quality standards needed to support their designated uses. States must determine the cause of the impairment and the sources of that cause and develop a plan to address the impairment. In addition, they are required to calculate the pollutant quantity that the stream is capable of receiving and still meet the standards. This pollutant quantity is referred to as the wasteload allocation for the waterbody. In turn, a Total Maximum Daily Load (TMDL) approach is used to determine what quantity (or loading) of pollutants can be assimilated by the stream without impairing the designated use. The pollutants

Figure 3-5:
State Protected Water Use Designations



Chester County
Adjacent county

Watershed
Subbasin
Stream

Stream use designations for this map apply to the waterways shown. When there is one designation in a sub-watershed, that designation applies to all waterways within the sub-watershed. If there are multiple designations, the designation applies to the stream that it overlays.

Pennsylvania stream use designations

EV - Exceptional Value Waters
HQ - High Quality Waters
CWF Cold water fish
WWF Warm water fish
MF Migratory fish
TSF Trout stocking

Maryland stream use designations

Use I-P Water contact recreation, protection of aquatic life, and public water supply
Use IV-P Recreation and trout waters and public water supply

Delaware stream use designations

Specific information on designated uses in Delaware are presented adjacent to the map.

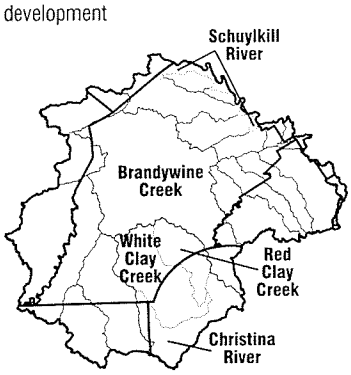
Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

that need to be addressed and the "allocation" of responsibility for reducing the existing pollutants to the TMDL level are then assigned across the pollutant sources.

Impaired streams are given high priority when developing programs of stream restoration and water quality improvement. Information on state stream designations (Figure 3-5) and state-listed impaired streams (shown on Figure 1-2) for the 21 watersheds were gathered and mapped to support the development of ***Watersheds*** and are presented in the *Compendium*.

Figure 3-6: TMDLs Under Development

Watersheds where TMDLs are under development



Of the 1,310 miles of streams within Chester County, approximately 1,132 miles have been assessed by the Pennsylvania Department of Environmental Protection (PADEP) as of July 2000. Of those assessed, approximately 276 miles of streams (or about 21%) have been listed on the Pennsylvania Section 303(d) (Federal Clean Water Act) list of impaired waters (see Figure 1-2). The primary sources of impairments are water/flow variability and alterations, nutrients, siltation, and turbidity (Table 3-3). TMDLs have been approved and others are currently under development for Brandywine Creek, Red Clay Creek, White Clay Creek, Christina River, and certain drainages to the Schuylkill River (Figure 3-6).

While portions of the study area have been studied extensively, others have not. Specific water quality data were compiled from the Chester County Health Department (CCHD), the Delaware Department of Natural Resources and Environmental Conservation (DE-DNREC), the U.S. Geological Survey (USGS), and U.S. Environmental Protection Agency's (USEPA) STORET database. The water quality data collected included biological oxygen demand (BOD), chemical oxygen demand (COD), nitrate (NO_3) and nitrite (NO_2), total copper (Cu), total Kjeldahl nitrogen (TKN), total and dissolved phosphorus (TP and TDP), total suspended solids (TSS), lead (Pb), and total zinc (Zn).

Numerous data points exceed the nitrate/nitrite drinking water standard of 10 mg/L. Watersheds with high nitrate levels include Brandywine Creek, Christina River, Chester Creek, Darby Creek, Elk Creek, Octoraro Creek, Pickering Creek, Pigeon Creek, Red Clay Creek, Ridley Creek, Trout Creek, Valley Creek, and White Clay Creek. Octoraro Creek has an average nitrate concentration above 6 mg/L, making it the most critical of the watersheds for nitrate concerns.

Dissolved phosphorus levels above 0.02 mg/L can be considered a threshold for causing eutrophication, an undesirable condition that encourages excessive growth of algae that depletes the oxygen in the water as it decays. Little dissolved phosphorus data are available; however, concentrations are above this threshold in Brandywine Creek and White Clay Creek watersheds. The Chester Creek, Darby Creek, Red Clay Creek, Ridley Creek, and White Clay Creek watersheds have total phosphorus averages above 0.1 mg/L, which may indicate that dissolved phosphorous concentrations are above the 0.02 mg/L threshold.

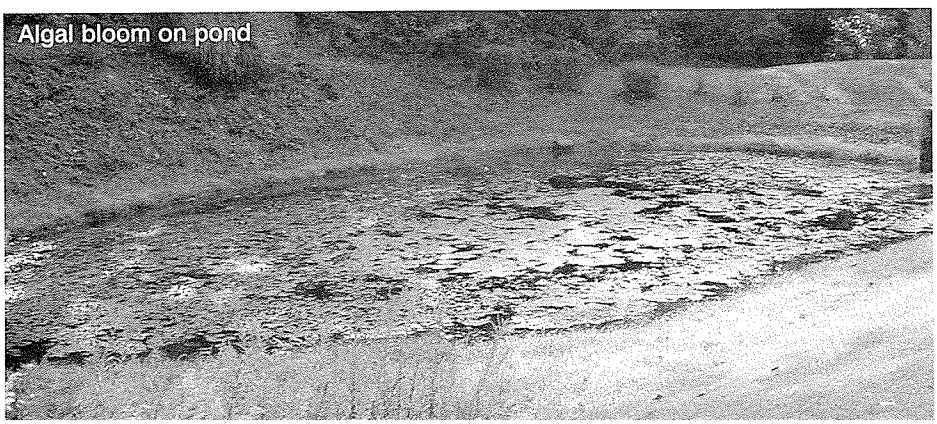
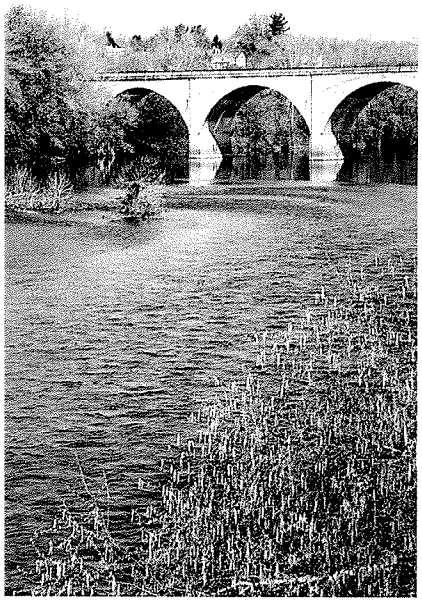

Algal bloom on pond

Table 3-3: Stream Miles and Impaired Stream Miles in Chester County

Watershed	Chester County Stream Miles	Chester County Impaired Miles	Impairments Included in PA 303(d) Listing
Brandywine Creek	507	102	Flow alteration; habitat alteration; nutrients; siltation; water/flow variability
Chester Creek	32	11	Flow alteration; habitat alteration; siltation; water/flow variability
Christina River	3	0	(No impaired streams in Chester County or PA)
Conestoga Creek	0.3	0.3	(No streams listed as impaired in Chester County chlorine; flow alterations; nutrients; organic enrichment/low DO; siltation; taste and odor impairments downstream of Chester County)
Crum Creek	24	<1	Excessive algal growth; flow alteration; habitat alteration; siltation; water/flow variability
Darby Creek	9	<1	Habitat alteration; siltation; water/flow variability
Elk Creek	95	0	(Unassessed by PADEP)
French Creek	95	0	(No streams listed as impaired in Chester County)
Gulph Creek	<1	<1	Metals
Northeast Creek	11	0	(Unassessed by PADEP)
Octoraro Creek	137	4	Nutrients; organic enrichment/low DO; siltation
Pequea Creek	9	6	Nutrients; organic enrichment/low DO siltation
Pickering Creek	62	2	Water/flow variability
Pigeon Creek	22	0	(No streams listed as impaired in Chester County)
Red Clay Creek	60	51	Organic enrichment/low DO; siltation; water/flow variability
Ridley Creek	32	0	(No streams listed as impaired in Chester County)
Schuylkill River	55	29	Excessive algal growth; flow alteration; nutrients; pathogens; siltation; water/flow variability
Stony Run	10	0	(No streams listed as impaired in Chester County)
Trout Creek	11	0	(No streams listed as impaired in Chester County)
Valley Creek	34	11	Flow alteration; nutrients; PCBs; siltation; turbidity
White Clay Creek	101	61	Nutrients; organic enrichment/low DO; pesticides; siltation; suspended solids; water/flow variability
Total	**1,310**	**276**	

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

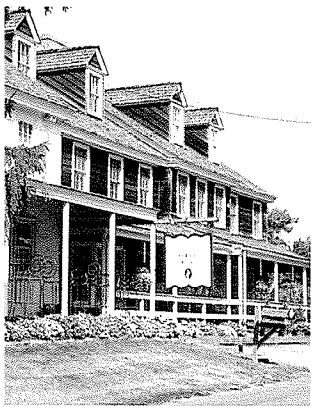
Cultural and Historical Resources

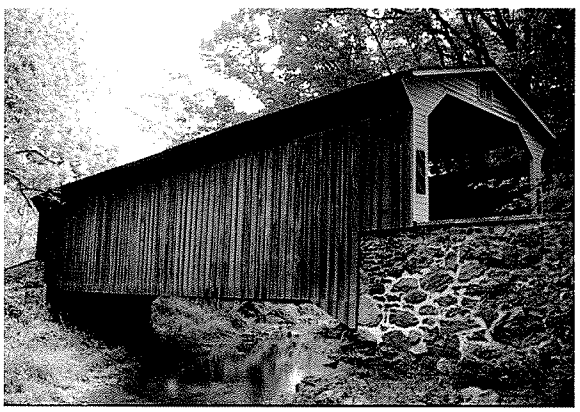


An important emphasis of *Watersheds* is to strengthen the connection between residents of Chester County and their water resources. Cultural and historical resources include the historic and covered bridges, as well as other historic structures, historic districts, and historic landmarks near or affiliated with water features. In some instances, water features themselves are considered cultural resources. These features are presented in Figures 1-3 and 3-7.

For example, French Creek, Lower Brandywine Creek, Octoraro Creek and Schuylkill River are part of the Pennsylvania Scenic Rivers System (Figure 1-3). The White Clay Creek watershed has been designated as a Federal Wild and Scenic River. The Schuylkill River watershed has also been designated as a National Heritage Area.

Recreational resources include Chester County's parks, state parks, nearby national parks, and identified recreational streams and their associated trails (Figure 1-3 and 3-7). In *Watersheds,* recreation is defined to include those activities related to water features, such as fishing, boating, swimming, and other water based activities.



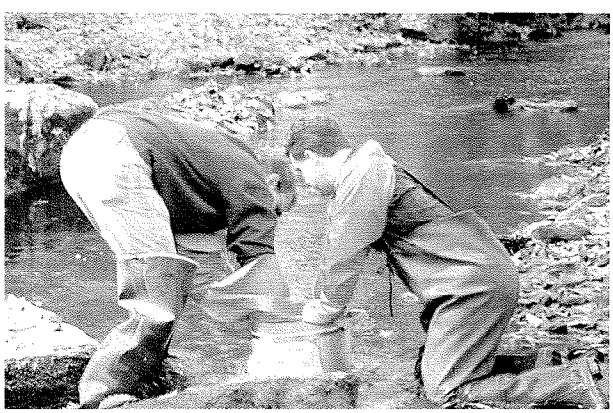


Within Chester County, an inventory of historic resources was compiled, based on a catalogue of resources from the Chester County Parks and Recreation Department (CCPRD). The number of inventoried resources is as follows (Figure 3-7):

- 15 Covered bridges.
- 21 Historic bridges.
- 7 Historic landmarks.
- 33 Historic districts.
- 199 Historic structures.

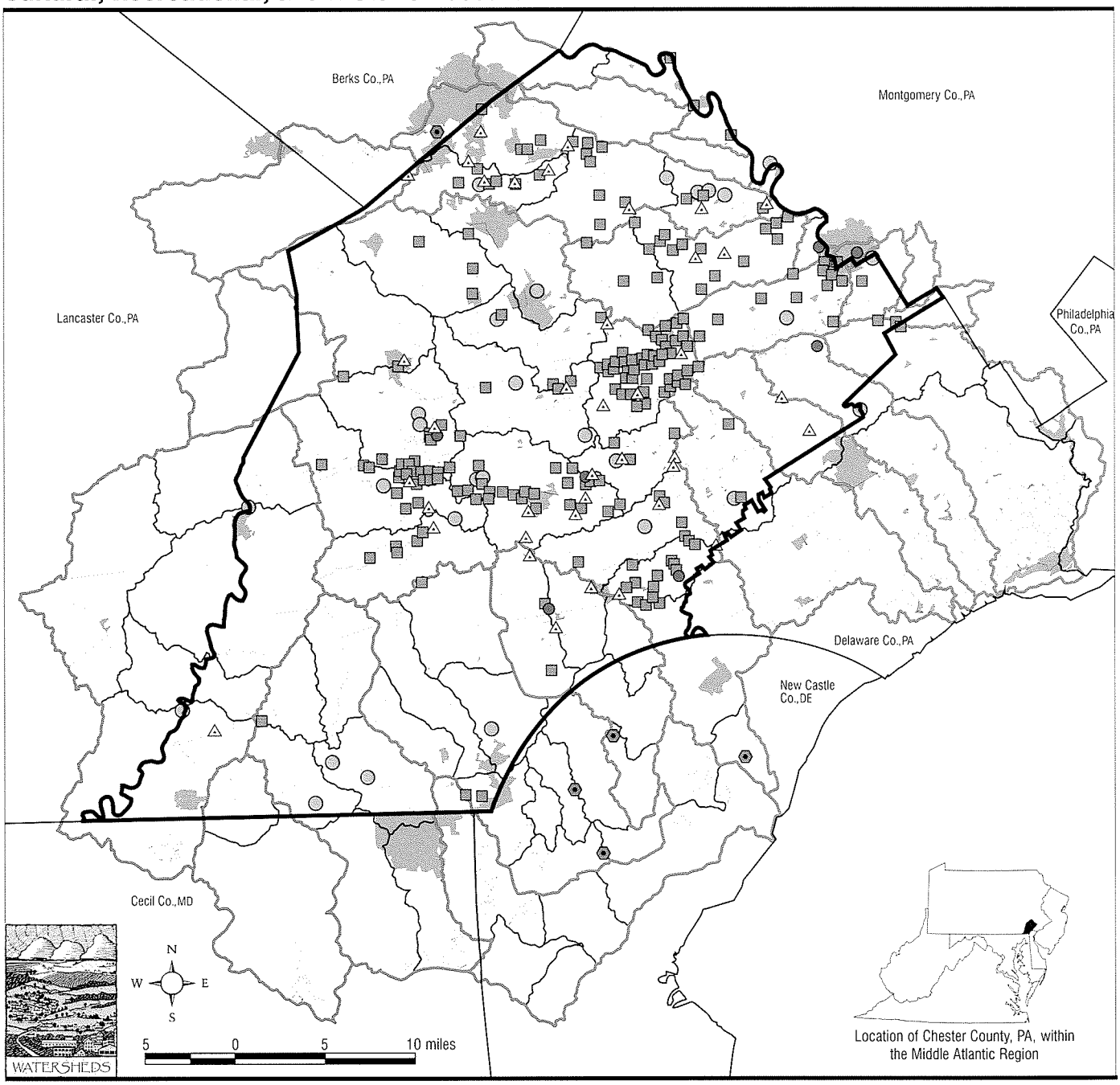
Biological Diversity

The rich natural and biological resources of Chester County's watersheds have been significantly altered with historical changes in land use. Industry, logging, farming, housing developments, transportation corridors, and other human activities have had dramatic impacts on the natural areas in the study area, leaving a few isolated pockets of rich diversity and unique species. When planning for future growth and development, it is essential to know the location and importance of these unique resources. Efforts must be made to protect and enhance these biologically rich areas.



The Pennsylvania Natural Diversity Index (PNDI) is Pennsylvania's primary catalog of information on outstanding natural habitats and sensitive plant and animal species. Several of the PNDI areas within the study watersheds are among the most rare and unique in the eastern United States. Among these is the Eastern Serpentine Barrens natural community, found in the central portion of the County and more significantly in the southwestern corner of the County. These areas are home to at least 20 species of "special concern." These PNDI sites are shown in Figure 1-3.

Figure 3-7:
Cultural, Recreational, and Historic Resources



Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

In addition to state-designated threatened, endangered and sensitive resources, biological diversity in streams is an excellent indicator of the cumulative impact of watershed influences on stream quality. Since 1969, the USGS, in cooperation with Chester County, has conducted a program to evaluate stream ecology and water-quality conditions using benthic macroinvertebrates and stream-water chemistry. The "Stream Conditions of Chester County Program" has sampled Chester County streams every fall for the past 32 years. Among the goals of the program are to monitor current conditions in response to changing land uses and to determine long-term trends.

Data describing existing biota and trends in diversity and stream health were collected and synthesized for the 21 watersheds. The "Stream Conditions of Chester County Program" has determined that the quality of Chester County streams has greatly improved since 1970. Current benthic macroinvertebrate communities are more diverse and contain more pollution sensitive species compared to communities sampled at the beginning of the program. Forty-five of forty-six sites analyzed between 1970 and 1986 had a statistically significant increase in diversity. Sites located in the Octoraro, Red Clay, White Clay, and Big Elk Creek watersheds are influenced by agriculture whereas sites in the eastern part of the County are influenced by urbanization. The increase in diversity at some sites has been smaller due to local pollution problems. The Red Clay Creek Basin has historically had a lower benthic macroinvertebrate diversity due to past PCB (polychlorinated biphenyls) spills and high pesticide levels. Little Valley Creek and Valley Creek also were affected by PCB contamination and had depressed benthic macroinvertebrate diversity. Recent results from this monitoring are generally in agreement with PADEP stream assessments, and provide additional insight into the physical, chemical and biological stresses within the watersheds.

Stormwater and Flooding

As precipitation falls onto the land surface, a portion becomes runoff that eventually flows directly into the streams. The amount of runoff depends on a number of factors, the most important being the amount of land surface that is impervious (usually pavement or buildings) or pervious (open, vegetated surfaces). If impervious, the majority of precipitation becomes runoff. If pervious, runoff rates are primarily affected by the intensity and duration of the storm, the soil type, the slope, and the type of vegetation. Each land use has a different percentage of impervious and pervious surfaces associated with it, and thus, each land use affects runoff differently.

Major flooding causing extensive property damage and potential loss of life is not a frequent occurrence within Chester County. Flooding is typically localized and often limited to incidental street flooding and road closures. This is largely due to the small size of most watersheds. Some locations experience more severe flooding that creates regional impacts, such as closure of regional transportation routes. An example of this is occasional flooding at Route 1 in the lower Brandywine Creek watershed.

Areas that are prone to flooding were identified through discussions with Chester County Department of Emergency Services (CCDES) following Hurricane Floyd (1999), as well as through results from municipal and public questionnaires. Based

on all information provided, the following areas are identified as prone to flooding with regional impacts (see Figure 1-2):

- Lower East Valley Creek.
- Trout Run.
- Darby Creek.
- Mainstem Brandywine Creek.
- East Branch Brandywine Creek at and below Downingtown (and Parke Run at Downingtown).
- Lower West Branch Brandywine Creek.
- West Valley Creek at Exton (Route 100).
- Lower French Creek near Phoenixville.

Stormwater and Pollutant Runoff

Analyses were conducted to estimate volumes of stormwater runoff based on current (1995 land use) and projected (2020) land use conditions. A key tool used for characterizing surface water quality impacts across the study area is a pollutant loading model called the Watershed Management Model (WMM). WMM was used to establish an overall "framework" for assessing relative runoff and pollution loading rates under existing and future land use scenarios. It was also used to develop conceptual approaches and identify priority areas for controlling impacts within the watersheds, subbasins, and municipalities.

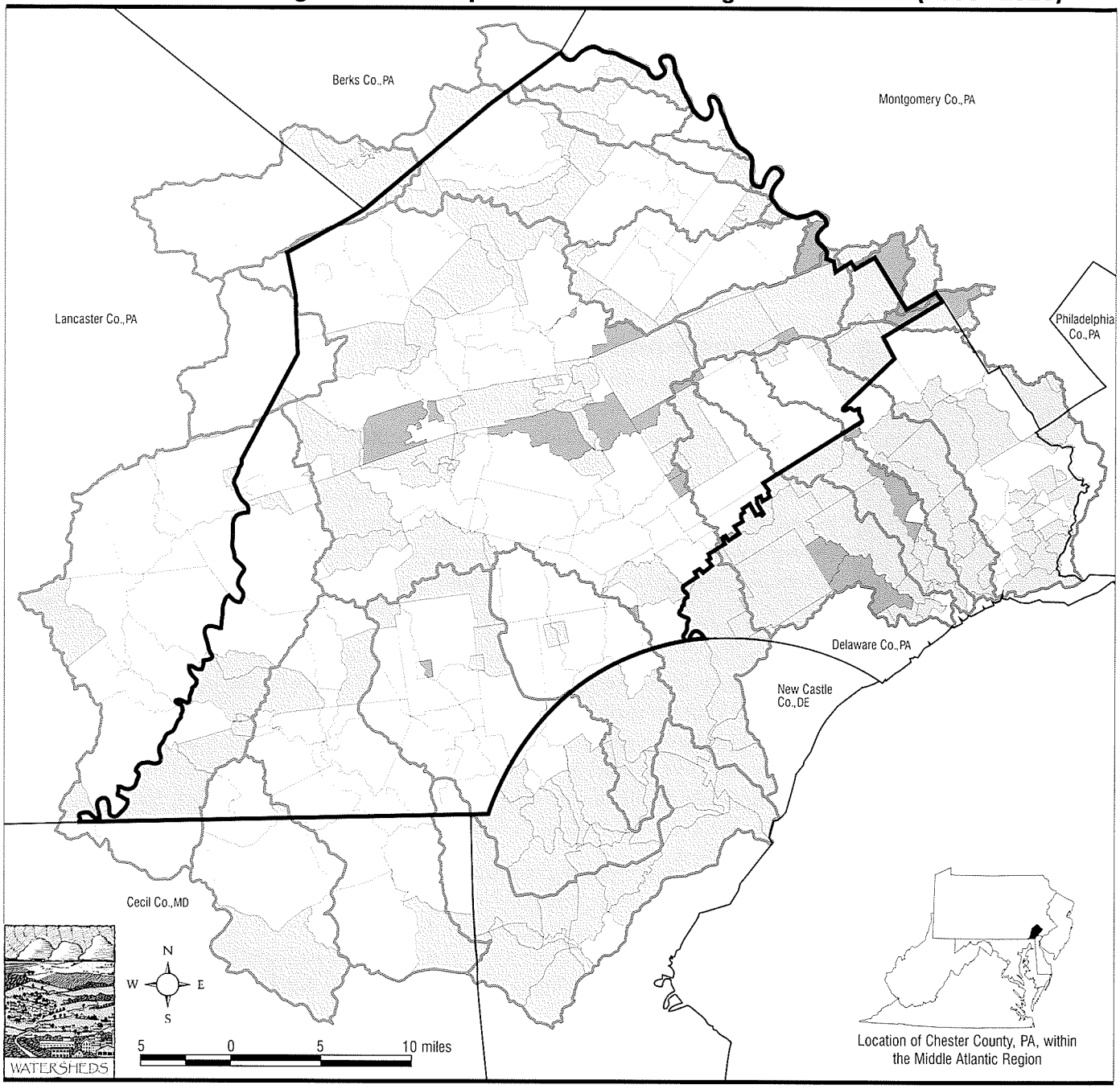
WMM was applied to the study watersheds for both present conditions and 2020 conditions based on population growth and land conversion. Results show that, while pollutant loads rise significantly when viewed simply on the basis of population growth and characteristic land use, the incorporation of best management practices (BMPs) can reduce impacts of pollutant runoff for 2020 land use conditions to levels below that of 1998 conditions. The following parameters were modeled for pollutant runoff and water quality impacts: surface runoff (inches per year, in/yr), BOD, COD, TSS, TKN, NO_2/NO_3, TP, TDP, cu, Pb, and Zn (pounds per year, lbs/yr).

The pollutant runoff modeling indicated that if no BMPs are installed and the study area continues to develop, pollutant loading will generally increase by the year 2020. Most contaminants will increase in the future as land is developed (e.g. BOD, metals, nitrate, and phosphorus). Some contaminants may stay relatively the same or even decrease slightly, assuming agricultural land without BMPs is converted to suburban land use (e.g. TSS).

BMPs make a big difference. The model provides insight into the potential to reduce pollutant loading if the entire study area were provided with the recommended BMPs. Reduced pollutant loading estimates range from substantial potential reductions in metals and TSS, to more modest but still significant reductions in nitrate and BOD.

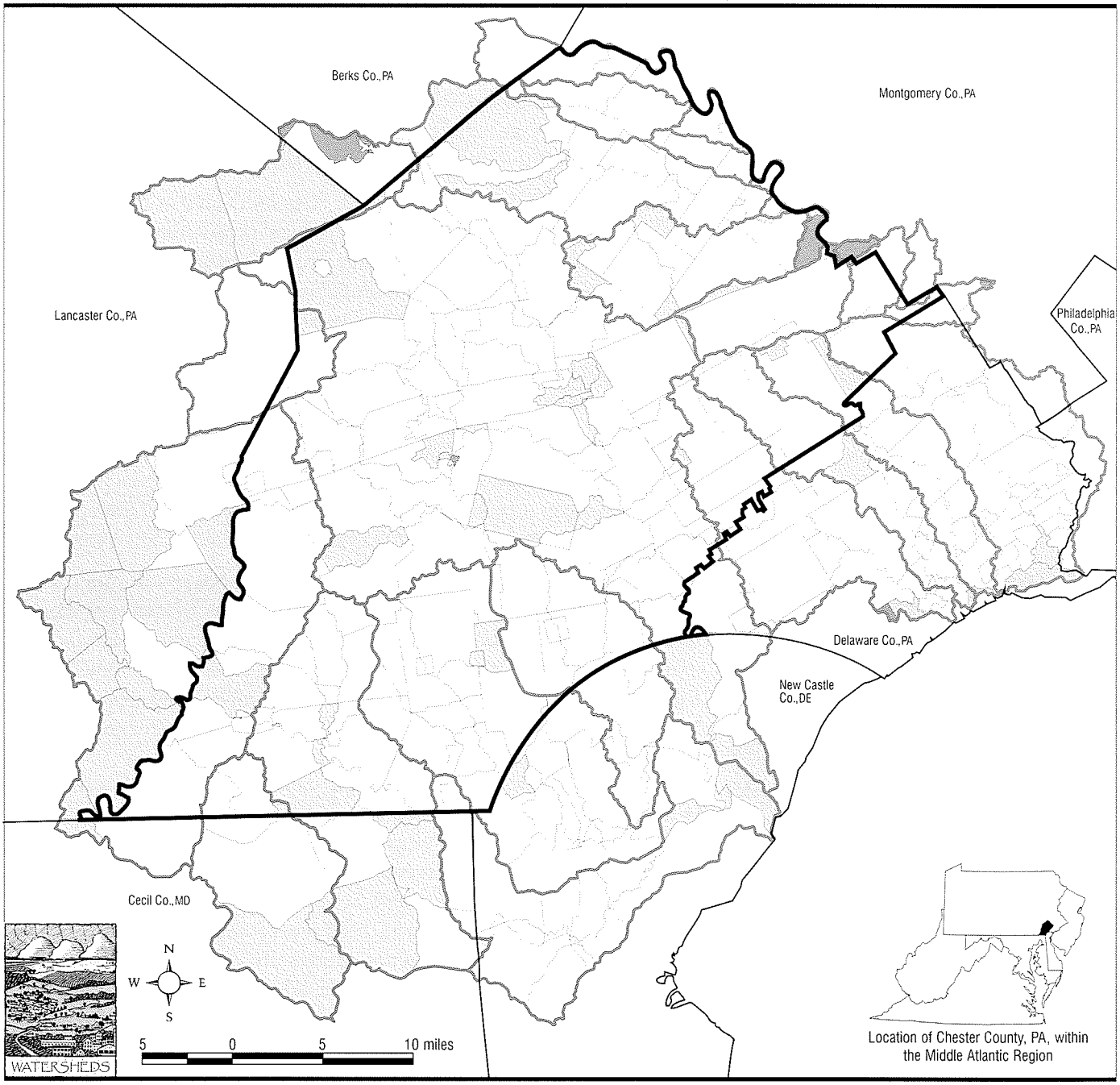
As an example, Figures 3-8 and 3-9 illustrate the potential change in sediment (TSS) loadings that could result from growth and development by 2020 without BMPs (Figure 3-8) and with BMPs (Figure 3-9). The use of BMPs can dramatically decrease the relative pollutant loads and thereby improve stream water quality.

Figure 3-8:
Estimated Percent Change in Total Suspended Solids Loadings without BMPs (1998–2020)



Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Figure 3-9:
Estimated Percent Change in Total Suspended Solids Loadings with BMPs (1998–2020)



Chester County
Adjacent county
Municipality

Watershed
Subbasin

Percent change in TSS loadings with BMPs (1998 to 2020)*

-82% to -50% (maximum reduction)
-50% to -25% (moderate reduction)
-25% to 0% (minimum reduction)

* Areas that resulted in increased loadings exist, but were too small to map at this scale.

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Stormwater Management Requirements

Contained within the *Compendium* is a summary of stormwater management requirements being used within the 21 watersheds of Chester County. In all, twenty-nine stormwater management ordinances were evaluated.

In reviewing the various ordinances, it became clear that many had similar themes. Such themes can generally be grouped under the categories of peak rate runoff control, volume control, infiltration/recharge, and quality control.

In addition, all of the ordinances vary to a greater or lesser degree in the design standards advocated for managing stormwater. In particular, different municipal engineers (presumably key players in the creation of the stormwater ordinances) place emphasis on different aspects of system design (e.g., depth or slope of detention basins, etc.). To some degree these differences likely reflect municipal preferences regarding aesthetics and safety, to name a few. While differences in these design parameters are certainly interesting, this summary focuses on the themes and criteria that are currently in place for management of stormwater.

Many of the ordinances only address peak rate runoff or volume control and peak rate runoff. Others addressed infiltration issues and quality control as well as a host of other issues. For example, several communities require an analysis of downstream impacts and several others require preparation of environmental impact assessments.

Rainfall runoff collecting in stormwater management ponds

An important factor in managing stormwater from developed sites is to generate as little runoff as possible. One opportunity that several municipalities are utilizing is called Conservation Development Design for new development. Conservation Development Design techniques lead to less impervious cover, less land disturbance, less stormwater, and the use of natural patterns of surface water flow and stormwater treatment to reduce the impact of development on the hydrologic cycle. Unfortunately, implementation of such practices is not merely a matter of including Conservation Development Design practices into municipal ordinances. Of significant importance is the need to eliminate older requirements that actually prevent Conservation Development Design from occurring. These may include overly restrictive building setbacks, road width requirements, drainage conveyance requirements, or various land use density and development pattern standards that were designed for reasons inconsistent with environmental protection and sustainable water resources.

In addition to local ordinances, Pennsylvania has current and pending stormwater management programs and regulations. PA Act 167 requires counties to prepare and municipalities to implement watershed specific stormwater management plans. Of the 21 watersheds in Chester County, Act 167 plans are underway for Chester Creek and Darby Creek, and will soon begin for Crum Creek and Valley Creek.

Under the Federal Clean Water Act, (CWA) stormwater management regulations known as Phase II of the NPDES (National Pollutant Discharge Elimination System) Stormwater Program were promulgated in November 1999. The Phase II Rule requires NPDES stormwater

discharge permits and other program elements to be implemented within most small, urbanized areas, including many of Chester County's municipalities.

Figure 3-10 identifies the municipalities within Chester County that have been preliminarily identified by USEPA and PADEP to be required to comply with NPDES Phase II regulations. The six elements of the municipal Phase II program, termed "minimum control measures," include:

- Public education and outreach.
- Public participation and involvement.
- Illicit discharge detection and elimination.
- Construction site runoff control.
- Post construction runoff control.
- Pollution prevention and "good housekeeping."

First Order Streams

A relatively high percentage of streams in Chester County's watersheds is comprised of "first order" streams. Protection of the stream corridor along these smaller, first order streams is a critical but often neglected aspect of watershed protection. First order streams are the "roots" of a watershed. They typically comprise over half of the total stream miles and drainage areas of any watershed. Yet individually they exhibit very small flows and are highly vulnerable to impacts of pollutants, stormwater flows, and ground water withdrawals. In an effort to provide information to assist in protecting these valuable resources, several analyses were conducted for first order streams.

Figure 3-11 shows the streams of the study watersheds and the land areas that contribute to these small first order streams. Throughout the County's watersheds, over 58% of the land area drains to first order streams. With over 72% of its land area supporting first order streams, Pigeon Creek watershed has the largest percentage of contributing land area in first order drainage areas.

It is estimated that there are 1,310 miles of streams within Chester County. Of those, approximately 713 stream miles (54 percent) are first order streams. Table 3-4 presents the breakdown of stream miles by watershed. In the Pigeon Creek watershed, 15 miles (67%) of the 22 stream miles are first order streams. On a watershed basis, this is the largest percentage of any watershed in the County or the study watersheds.

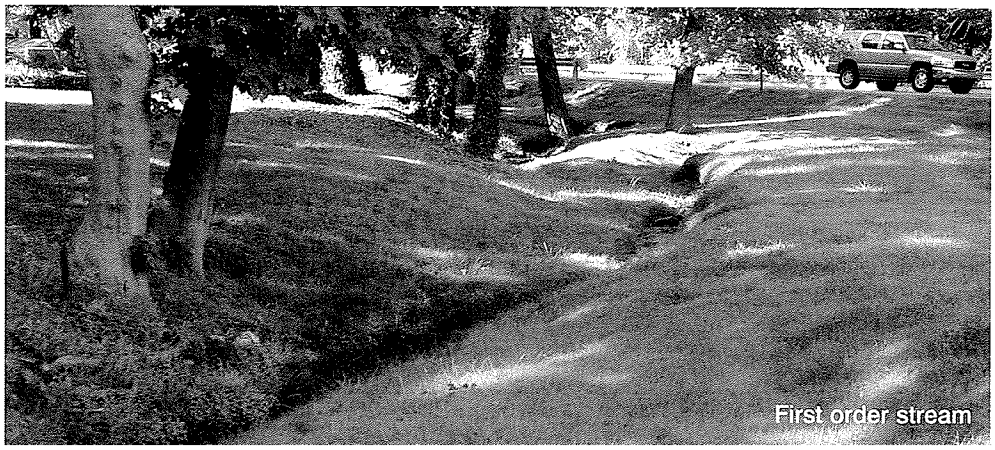
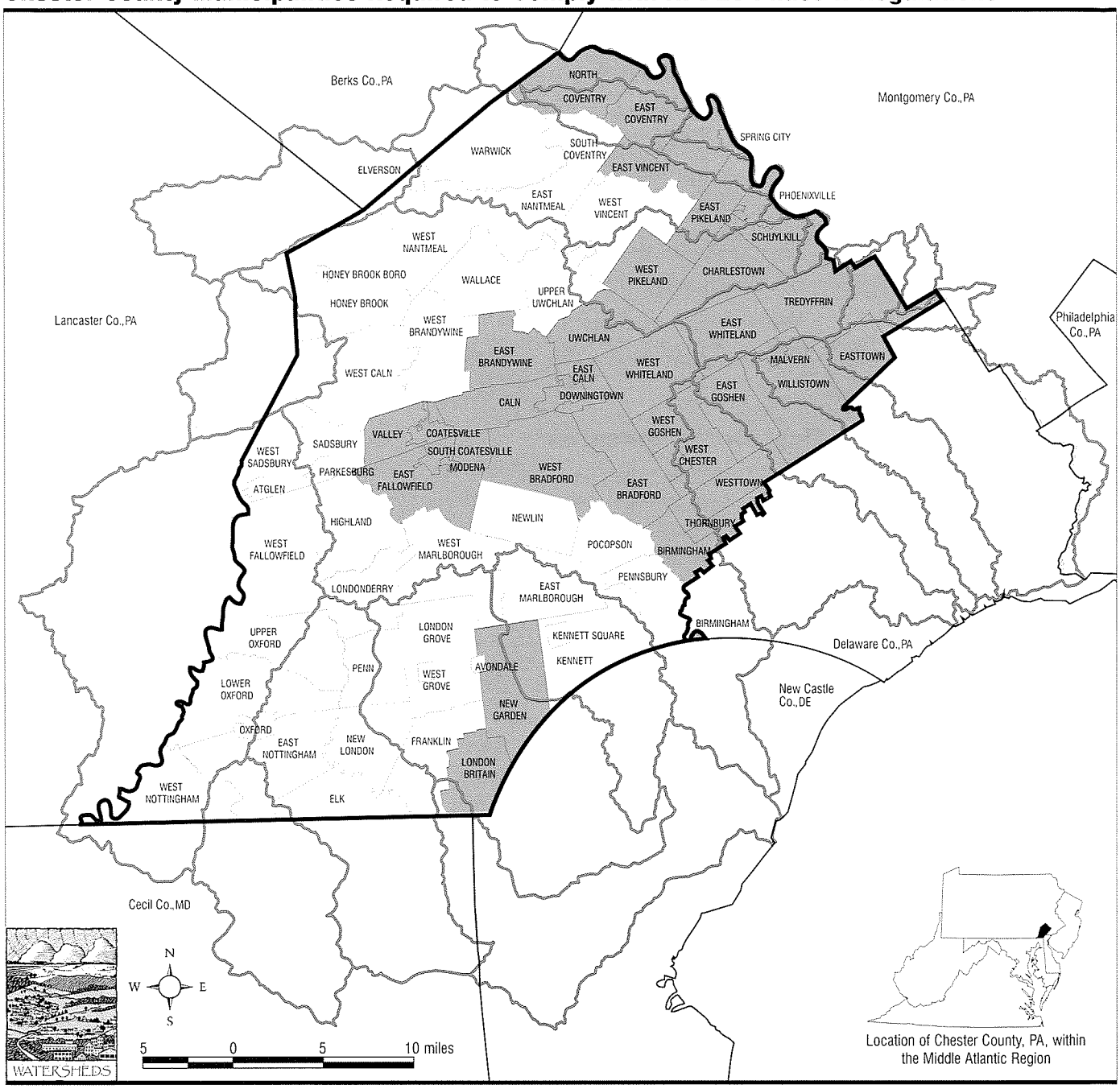

First order stream

Figure 3-10:
Chester County Municipalities Required to Comply with NPDES Phase II Regulations



Chester County
Adjacent county
Municipality

Watershed

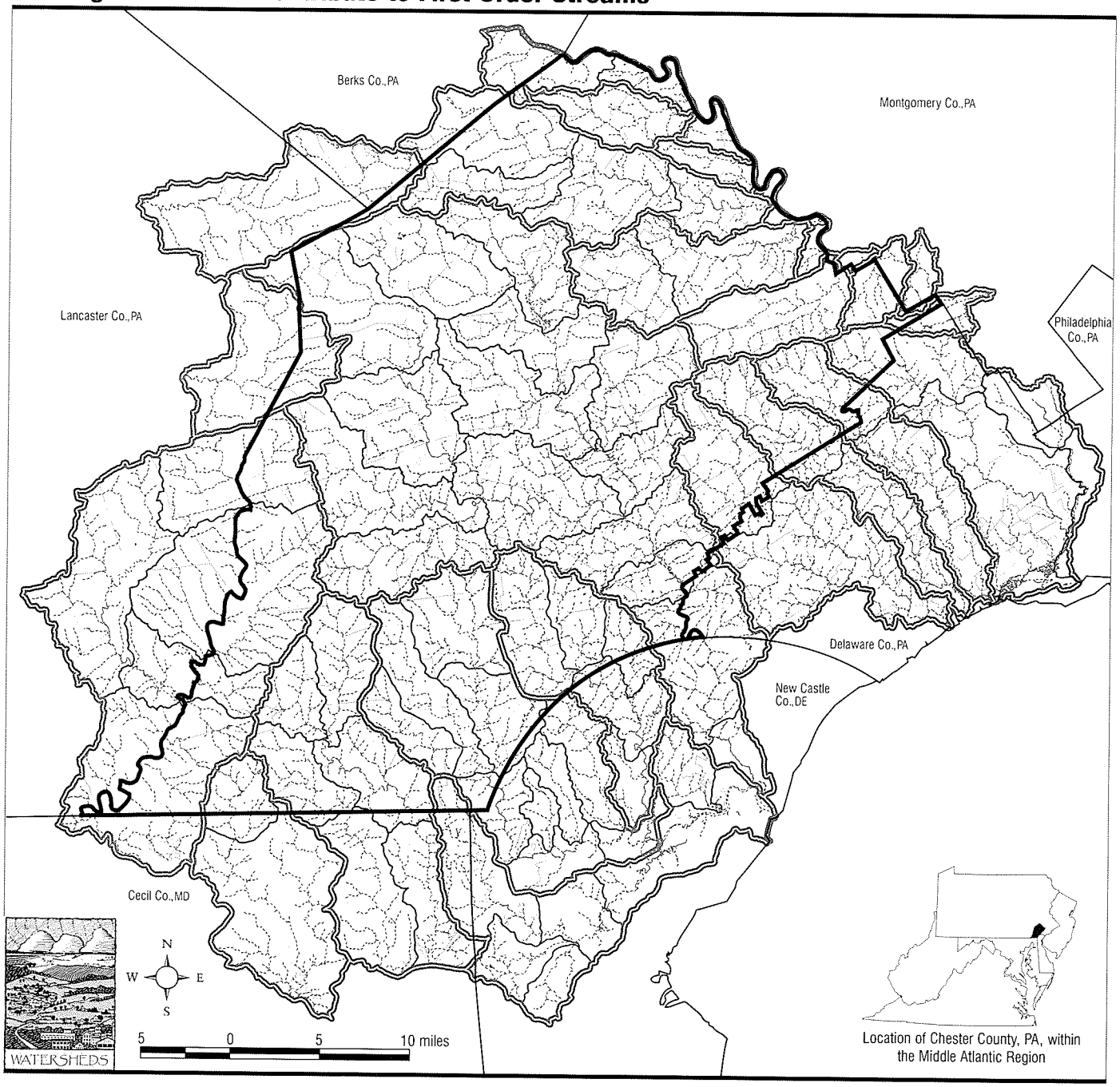
Expected to be subject to NPDES Phase II regulations (as of 2001)

No
Yes

Note: The information presented on this map have been interpreted from the best available data. The *Federal Register* should be consulted for the full determination of regulatory requirements.

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Figure 3-11:
Drainage Areas that Contribute to First Order Streams



Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Table 3-4:
Stream Miles and First Order Stream Miles in Chester County

Watershed	Stream Miles in Watershed (or study area portion of watershed)			Stream Miles in Chester County		
	Total Miles	First Order Miles	% of Total Miles	Total Miles	First Order Miles	% of Total Miles
Brandywine Creek	567	315	55	507	279	55
Chester Creek	128	67	53	32	18	56
Christina River	123	49	40	3	3	100
Conestoga Creek	63	32	51	<1	<1	<1
Crum Creek	72	41	57	24	15	61
Darby Creek	119	53	45	9	6	73
Elk Creek	164	92	56	95	51	54
French Creek	104	60	58	95	53	55
Gulph Creek	11	5	46	<1	<1	<1
Northeast Creek	86	43	50	11	7	61
Octoraro Creek	311	175	56	137	66	48
Pequea Creek	44	27	60	9	8	89
Pickering Creek	62	35	56	62	35	56
Pigeon Creek	22	15	67	22	15	67
Red Clay Creek	102	61	60	60	38	63
Ridley Creek	80	36	45	32	18	57
Schuylkill River	78	26	33	55	15	28
Stony Run	10	5	53	10	5	53
Trout Creek	15	9	63	11	8	70
Valley Creek	34	19	55	34	19	55
White Clay Creek	176	97	55	101	54	53
Total Study Area	**2,373**	**1,262**	**53**	**1,310**	**713**	**54**

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Stream Corridor Land Use

Land use in proximity to a stream can greatly affect the water quality of that stream. Different land uses affect streams in different ways. For example, parking and urban areas will result in high run-off velocities as well as high solids, oil and grease and increased water temperature of runoff. Residential areas can contribute household solvents, detergents, nitrate, chloride, oil, grease, lawn chemicals and pesticides. Industrial and commercial uses can add suspended solids, solvents, metals, volatile organic compounds, oil, and grease. Some types of recreational areas tend to have low impacts, although they may contribute lawn chemicals and fertilizers used on grass fields. Agricultural lands, particularly if care is not taken to avoid field runoff and erosion, can cause high amounts of suspended solids, and the runoff can often contain phosphorus, nitrate/nitrite, potassium, and pesticides.

To provide an indication of the degree of stream vulnerability to land use, an analysis of the land corridor within a quarter mile (1,320 feet) of each side of both first

order and higher order streams was performed. To do this analysis, a geographic information system (GIS) was used to calculate the corridor width along the streams. First order streams are the stream segments at the very top portion of the watershed before any confluence with another stream segment. For this analysis higher order streams are all stream segments downstream of the intersection of two first order streams.

The analysis of land use in the stream corridors and detailed results are presented in the *Compendium*. The results indicated that 16 of 78 subbasins in the study watersheds have heavily developed first order stream corridors (with the percent of impervious cover over 20%), and 19 subbasins have heavily developed higher order stream corridors. These subbasins are high priorities for riparian buffer creation, wherever feasible. Furthermore, there are 40 subbasins with agricultural land uses above 33% within the corridors of first order streams, and 37 subbasins with agricultural land uses above 33% in corridors of higher order streams. These subbasins are high priorities for inclusion in agricultural BMP programs. Finally, there are 9 subbasins with urban land uses above 15% within the stream corridor of first order streams, and 15 subbasins with urban land uses above 15% along higher order stream corridors. These areas are high priorities for waterfront redevelopment, urban riparian buffer restoration, and urban stormwater control programs.

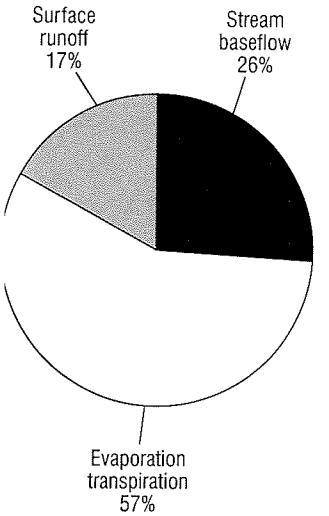
Watershed Water Budgets

Water budgets are used to quantify and understand the movement of water through the hydrologic cycle of an individual watershed (see Figure 2-2). The main elements of the total water budget include:

- Precipitation: the total rain and snowfall that occurs in the watershed.
- Recharge: that portion of the precipitation that infiltrates through the unsaturated soils and recharges the ground water system.
- Runoff: that portion of the precipitation that flows over the land surface and into the streams.
- Evaporation/Transpiration (ET): Evaporation is that portion of the water that evaporates into water vapor and returns to the atmosphere. Transpiration is water that reaches the roots of plants and is returned to the atmosphere via water loss through stems and leaves.

igure 3-12:
'atershed Water Budget

erage water budget for Chester County
ıtersheds



The USGS has performed several watershed water budget studies and has estimated the annual average contribution of each component to the overall water budget for Chester County (Figure 3-12). Water budgets are presented as a portion of the total annual precipitation:

- Precipitation averages 46 to 47 inches per year.
- Surface runoff averages about 7 to 8 inches per year (approximately 17% of average annual rainfall).
- Stream baseflow from ground water averages about 12 to 14 inches per year (approximately 26% of total average annual rainfall).
- Evaporation and transpiration of water back to the atmosphere averages about 23 to 27 inches per year (approximately 57% of total average annual rainfall).

Ground Water Balances

Ground water balances were calculated to gain an understanding of the stress that water consumption may be putting on the aquifers and stream baseflows. Ground water balances total the volume of water withdrawn from and recharged to the aquifers by society.

Baseflow in streams is the water flowing during dry weather periods, and represents the discharge of ground water to the streams. This flow occurs throughout the year. Ground water on average contributes about 60 percent of the total annual flow of streams in Chester County, depending on the stream and watershed characteristics.

Low baseflow in streams can be described in a number of ways, based on the period of time selected to describe the flow. One such method is the 1 in 25 year average annual baseflow, or the annual low flow anticipated to occur on average once in every 25 years. The 1 in 25 year average annual baseflow is used as a guide for assessing ground water balances and impacts of ground water withdrawals.

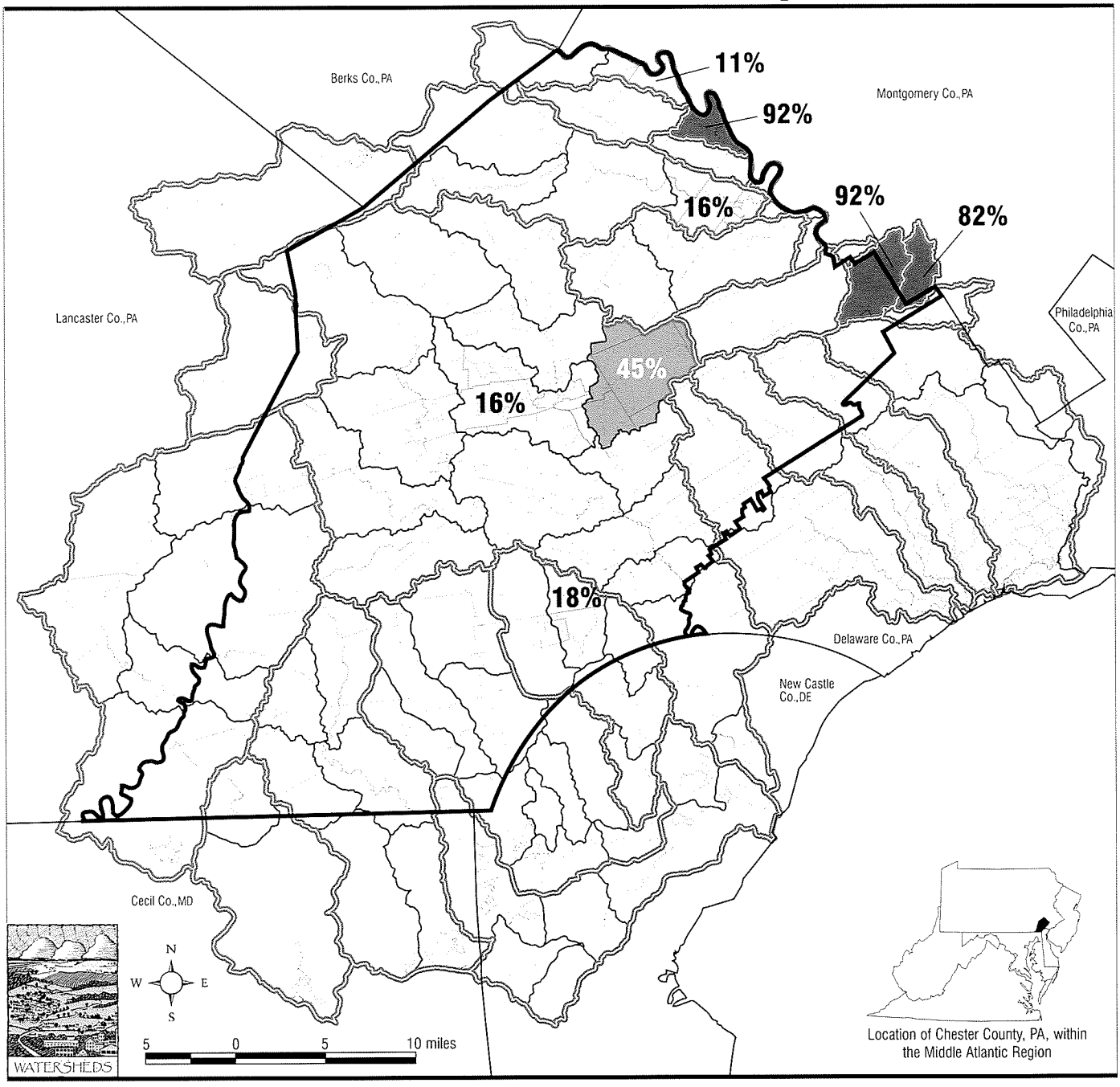
The 1 in 25 year average annual baseflow was adopted for use in developing ***Watersheds.*** All subbasins in the 21 watersheds were analyzed to calculate this statistical flow rate as a relative measure of sustainability of cumulative ground water withdrawals. Estimates of the amount of ground water consumed (withdrawn and not returned to the ground water) were compared to the 1 in 25 year average annual baseflow to provide an indication of the relative stress that water consumption has placed on the ground water resources of the watersheds and subbasins.

Figures 3-13 and 3-14 show the subbasins in the study watersheds and estimates of their net ground water withdrawals for 1998 and 2020 as a percent of the volume of their 1 in 25 year average annual baseflow. With the exception of Trout Run, one Schuylkill River drainage, Crow Creek, and West Valley Creek (Brandywine Creek watershed), the net ground water withdrawals for 1998 and 2020 are relatively low throughout the study watersheds as compared to their corresponding 1 in 25 year average annual baseflows. This indicates that substantial ground water is available for future use in Chester County. Volumes of the 1 in 25 year average annual baseflow, and net withdrawals (by volume and as a percent of the 1 in 25 year average annual baseflow) are presented for all subbasins in Part 6.

Turf Irrigation

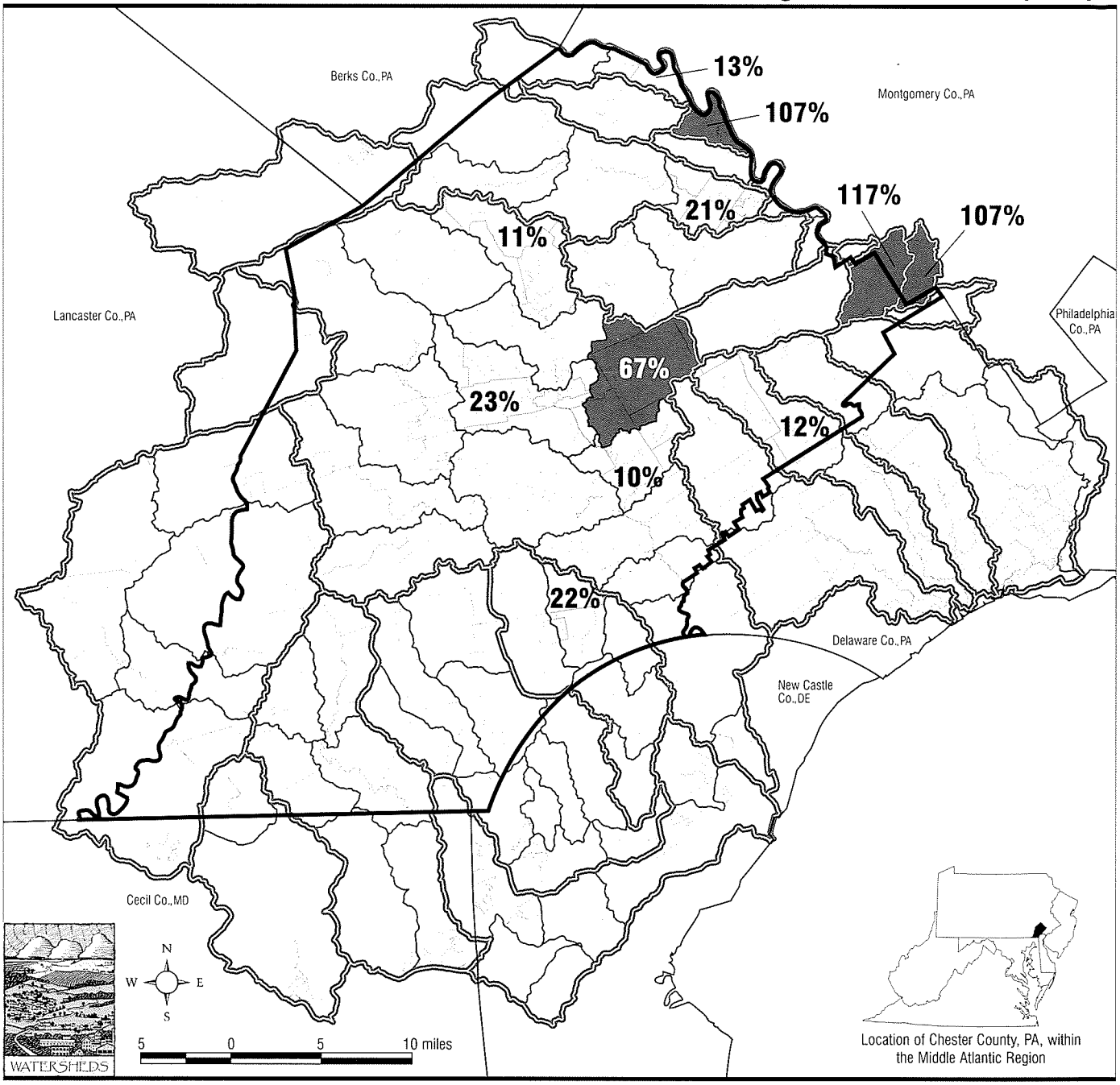
Drilling of residential well

Figure 3-13:
Net Ground Water Withdrawals as a Percent of 1 in 25 Year Average Annual Baseflow (1998)

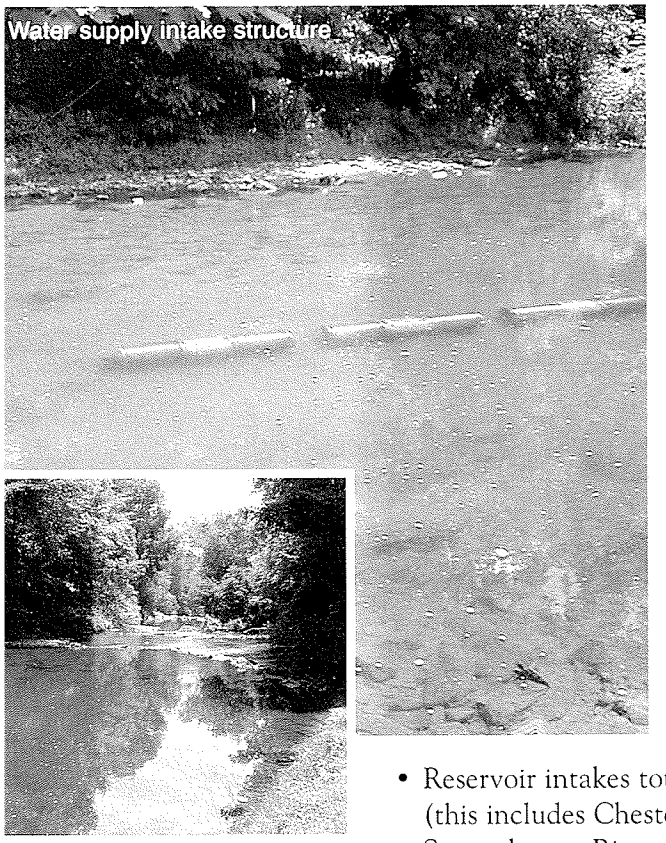


Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Figure 3-14:
Net Ground Water Withdrawals as a Percent of 1 in 25 Year Average Annual Baseflow (2020)



Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)



Water Withdrawals and Discharges

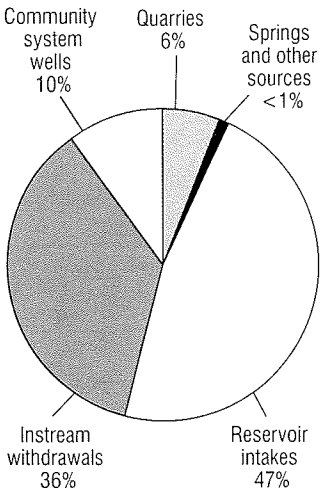
Withdrawal points, ground water recharge points and stream discharge points that are within the watersheds were identified and inventoried. Much of the data were compiled by the USGS, based on data from the PADEP, Delaware River Basin Commission (DRBC), and the Christina River Basin Water Quality Management Committee, and Water Resources Agency (University of Delaware).

Over 650 water intake points (both surface water intakes and ground water wells, but not including residential wells) were identified that withdraw a total of over 58.3 billion gallons per year from the study watersheds (as documented in the Compendium). The withdrawal points are owned or operated by public community suppliers, industries, mobile home parks, apartment complexes, schools, and other public and private water users. Surface water comprises the bulk of the water withdrawn in the study area. The following categories of sources are used for water supply in the study watersheds (Figure 3-15):

- Reservoir intakes total over 27.3 billion gallons per year (47% of the total) (this includes Chester Water Authority withdrawals transferred from the Susquehanna River and stored in their Octoraro Reservoir).
- In-stream withdrawals from streams total nearly 21 billion gallons per year (36 % of the total).
- Community water supply wells account for over 6 billion gallons per year (10% of the total).
- Quarries total nearly 3.5 billion gallons per year (6% of the total).
- Springs total over 0.1 billion gallons per year (0.2% of the total).
- Other unidentified sources account for 0.3 billion gallons per year (0.5% of the total).

Figure 3-15: Water Withdrawals

Sources of water withdrawals from 21 watersheds



A total of approximately 125 surface water discharge points from industrial and municipal sources that discharge at least 100 gallons per day have been catalogued. Also, an additional 190 recharge points from industrial and municipal sources were identified in the *Compendium* datasets that recharge at least 100 gallons per day.

It is estimated that there are roughly 26 billion gallons per year discharged to the streams in the study watersheds each year. Artificial recharge of treated wastewater effluent to land and ground water accounts for an additional 1.6 billion gallons per year. When compared to the total estimated water withdrawals (58.3 billion gallons per year) there remains a shortfall of approximately 30 billion gallons per year of water in this accounting. This is largely attributed to the lack of complete wastewater disposal permit data, water discharged through septic systems, and exports of water discharged to other watersheds.

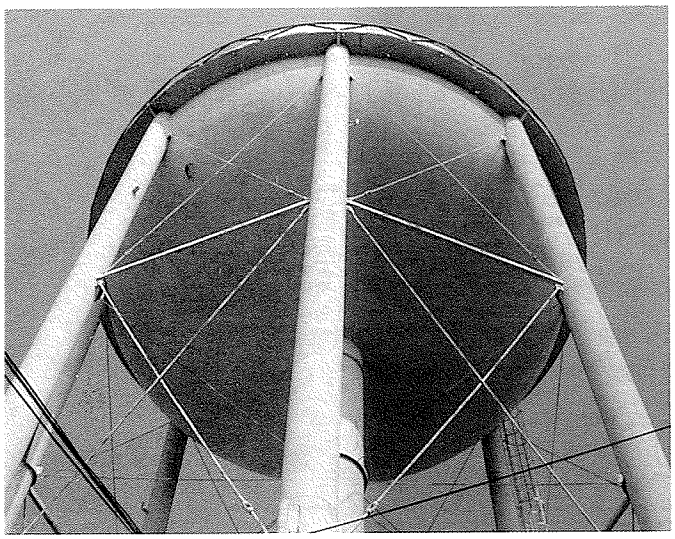
Sustainability of Present and Future Water Needs

Present and projected water supply needs are surprisingly modest when compared with the availability of surface and ground water in the study area. Perhaps the most important finding is that projected water needs can generally be met on a sustainable basis when viewed either on a watershed or subbasin scale. For example, ground water withdrawals are estimated to generally be less than 3% (1998) and 10% (2020) of the estimated 1 in 25 year average annual baseflow for most watersheds and subbasins, with some exceptions (Schuylkill River drainages, Trout Creek, Crow Creek, and West Valley Creek,) as shown in Figures 3-13 and 3-14.

The 1 in 25 year average annual baseflow is a statistical measure used by the DRBC to assess the potential impact of ground water withdrawals on low flows in streams. On a local scale, due to geology, ground water availability and depth vary from place to place. Local impacts can occur if large withdrawals are not carefully located.

It is important to understand that water is usually removed from one location to serve the needs of a wider area. Thus, the selection of an area over which to assess need versus availability affects the calculation of relative stress. At an extreme, the water balance for a 100 square foot area around a large well will look very bad, but if the area served is several square miles, the water balance for the service area will be much more favorable. The ground water balances done on the watershed and subbasin level clearly indicate a substantial volume of water transfers is occurring (obviously the smaller the scale, the more likely and the greater the relative transfer). In general, however, ground water withdrawals and discharges are similar in size, indicating that ground water withdrawal is being replaced in most subbasins or watersheds.

A second important finding is that agricultural water use is relatively substantial, but taken collectively with all other uses, it represents an insignificant contribution to total water use within the study watersheds. Although little actual data are available, rough estimates show that agricultural uses (nurseries, farms, dairy farms) appear to be less than 1 percent of the total water use in the watersheds of Chester County. Estimates suggest that agricultural use is only about 0.1 MGD (million gallons per day) of the estimated 42 MGD average annual demand presently occurring in the County's watersheds. Water use by golf courses may represent a higher demand, with rough estimates indicating about 1 MGD on an average, annual basis.



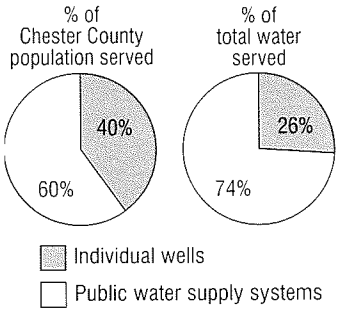
Water Supply

Water supply systems in the study watersheds range from single wells serving private homes to large public supply systems with many surface and ground water sources and extensive interconnected piping systems. While many homes have meters to measure water use; many homes are unmetered. Questionnaires were sent to public water utilities (both water suppliers and wastewater purveyors) to learn their principle needs and concerns. Estimated areas of utility service were mapped to estimate current and projected population served by public water and the current and projected population that rely on individual domestic wells. The estimated populations served were then used to estimate water supply demand for 1998 and 2020.

It was estimated that in 1998 approximately 60% of Chester County's population relied on public water systems and 40% relied on individual water wells (Figure 3-16). Total estimated water use for Chester County for 1998 was 42.1 million gallons per day (MGD) and is estimated to increase to about 52.5 MGD by 2020 (Figure 3-17). Of this total volume used, it was estimated that in 1998, 74% was delivered by public water systems and 26% was delivered by individual wells. This breakdown shifts slightly in 2020 to an estimated 77% of total volume provided by public water systems and 23% provided by individual wells. These estimates are presented in detail in the *Compendium* and in Part 6 of ***Watersheds.***

Figure 3-16
Public Water Systems and Wells

998 water served by public systems and individual wells in Chester County

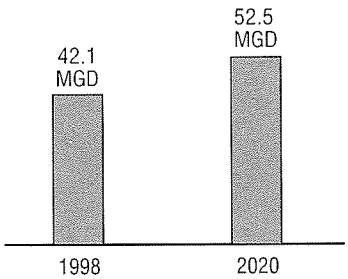


In general, the existing water supply systems appear to be providing safe and reliable water supplies. An evaluation of existing problems in water supply systems was conducted, based on the results of surveys received from water utilities. System operators identified several key issues and impediments they are facing, including new regulatory water quality standards and protection of source waters from pollutants.

Another key issue identified through the municipal surveys is the need to integrate the planning for new sources and infrastructure for expansion with local land use planning. Coordination between water supply planning by utilities and land use planning by municipalities needs to be improved. There is presently a gap between the approaches followed by utilities to optimize their sources and distribution systems to meet demand, and the vision of Chester County and its municipalities on how best to manage the expansion of land development and infrastructure patterns. To fully address this situation, changes in statutes and ordinances (partially addressed through the passage of PA Acts 67 and 68, of 2000) will be required; however better mechanisms for coordination and cooperation are available and are beginning to be implemented.

Figure 3-17:
Estimated Water Demands

Estimated 1998 and 2020 water demands



Protection of the sources of public drinking water supplies is rapidly gaining attention as an important need. Most of the watershed areas in Chester County are sources of public water supplies, with stream intakes or reservoirs present on several streams. This includes Octoraro, White Clay, Brandywine, Chester, Ridley, Crum, and Pickering Creeks, as well as the Schuylkill River.

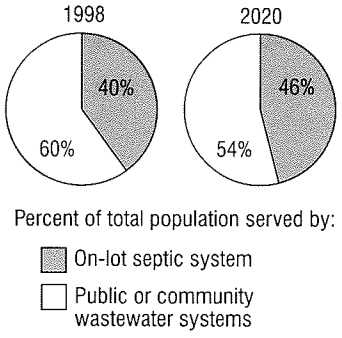
Wastewater Disposal

According to the Chester County "Sewage Facilities Inventory, 1991," approximately 60% of the Chester County population used public sewage facilities for the collection, treatment and disposal of their wastewater. The 1991 Inventory categorized the municipal and private sewage systems into four types: public or municipal treatment facilities, package plants with stream discharge, community on-lot disposal systems, and spray irrigation sites.

In developing ***Watersheds,*** most municipal Act 537 Plans were reviewed and summarized in the *Compendium.* Historically, most of the wastewater disposal within the study area has been through discharge to streams. Yet, in the majority of the Act 537 Plans in Chester County that were reviewed, municipalities stated they preferred ground water recharge as the route of wastewater discharge for all future wastewater disposal systems. Land application allows some of the wastewater to percolate into the soil and recharge to the ground water. Since the Sewage Facilities Inventory in 1991, which listed only one spray irrigation site, the number of sites in Chester County has increased to at least 16, including one drip irrigation site.

Figure 3-18: Estimated Wastewater Disposal

Estimated 1998 and 2020 wastewater disposal by public and on-lot systems in Chester County



Specific information on public and private wastewater and septic systems was difficult to collect and organize. Regulatory agencies provided information on the very large systems, but data for numerous medium and small discharges were unavailable. Although some efforts have recently begun, as of 1998, no agency electronically tracked the number of private septic systems, nor were there data on actual amounts of water or pollutants discharged from these systems. Available permit data for wastewater discharges were collected and used in the water balance analyses. Estimates of septic system discharges were calculated using assumed gallons per capita per day values.

In general, areas where physical conditions may limit the effectiveness of on-lot septic systems, public sewer systems have already been constructed or are planned. As previously mentioned, data for wastewater systems was very limited. Available data and analyses (presented in the *Compendium*) estimated that approximately 60% of the 1998 population of Chester County relied on public wastewater systems, dropping to approximately 54% by 2020 (Figure 3-18).

Goals and Objectives
Achieving the Vision

Because the key elements of any watershed (its land, ground water, streams, biological resources, climate, and people) are inter-dependent, it is critical to have a set of integrated goals and objectives that strive to balance human activities with the preservation of the watershed resources.

The seven goals of *Watersheds*

1. Engage and educate individuals, communities and governments in watershed stewardship.
2. Enhance water-based recreational and cultural resources.
3. Preserve natural resources.
4. Improve water quality.
5. Reduce stormwater runoff and flooding.
6. Protect watershed water balances.
7. Integrate utility and municipal planning to meet future water supply and wastewater needs.

The goals and objectives represent the guiding principles and philosophy for the activities and decisions of the communities of Chester County's watersheds. The goals and objectives are intended to apply to all members of these communities and all members of these communities have an important role in watersheds stewardship. These communities collectively include the municipalities, non-government conservation organizations, land-owners and managers, developers, utilities (of all types and ownership), regulators, government agencies, homeowners, and all other entities and individuals responsible for use of the watershed lands and resources.

The goals and objectives are designed to accommodate existing land uses and planned growth in a manner that is consistent with the natural characteristics of the receiving watershed systems and that sustains:

- Ground water recharge,
- Stream baseflows,
- Stable stream channel processes,
- Flood carrying capacity of the streams and their floodplains,
- Water quality of the streams and ground water, and
- Riparian and aquatic living resources.

Presented below are the objectives developed to achieve the *Watersheds* goals and a discussion of the rationale for these objectives. Key implementation strategies for each objective are presented in Part 8. Specific detailed guidance for municipal implementation is provided in the *Compendium*.

Goal 1: Engage and Educate Individuals, Communities and Governments in Watershed Stewardship

Objectives:

Objective 1-1
Engage the public at all levels to accept individual responsibility for implementing watershed stewardship and "good housekeeping" practices on private, commercial, industrial, institutional, and public lands and roads.

Objective 1-2
Expand and sustain public education at all levels to achieve widespread public understanding of the inter-relationship of human activities and natural resources, and the economic, public health, environmental, and community benefits of preserving the integrity of the natural watershed ecosystems.

Objective 1-3
Engage governments at all levels to implement all appropriate goals and strategies in their regulations, programs and activities.

Rationale: Watershed management is fundamentally about modifying human behavior and activities to better protect our natural resources for the benefit of society. To be successful, this requires the direct involvement of all individuals and entities that work, live or recreate within a watershed. Effective watershed management requires the commitment and active participation of everyone. Much like recycling and energy conservation, watershed stewardship requires each individual to implement

"good housekeeping" practices in their land use and management activities — whether it be cleaning out stormwater inlets from a commercial parking lot or a residential homeowner properly disposing of household hazardous wastes. This effort includes all levels of communities and all types of land uses. Achieving this goal will require a number of long-term public education and outreach programs on watershed stewardship for decision-makers, land owners and operators, and the general public.

Stream clean-up event

The role of government in watershed management should be to provide standards and guidance, facilitate watershed protection and management activities, and, most importantly, to lead by example. All levels of government with lands or activities within the watersheds should make the commitment and assume the responsibility of watershed stewardship in their activities. This would include implementing appropriate controls through municipal ordinances or other regulations to address the strategies presented in this Plan, educating local residents as to the importance of resource protection, and undertaking audits of their own land and facilities management practices to assess opportunities to improve conservation or protection of water resources.

Goal 2: Enhance Water-Based Recreational and Cultural Resources

Objectives:

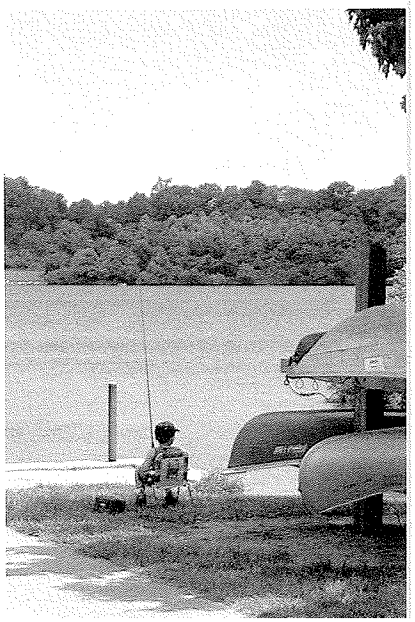
Objective 2-1
Provide and maintain access to streams at multiple locations in all watersheds.

Objective 2-2
Maintain stream, pond and lake conditions necessary to support water-based recreational uses including canoeing, kayaking, fishing, swimming, tubing, and sailing.

Objective 2-3
Preserve and/or support re-use of water-based historic features where increased flooding and impacts to aquatic systems can be mitigated or avoided.

Objective 2-4
Pursue opportunities to restore abandoned waterfront development.

Rationale: Keeping the public "connected" to the natural water resources of Chester County and fostering their commitment and care for the well being of these resources is essential to sustaining the resources. Engaging the public requires direct and easily accessible links to the streams and related resources. As development expands across the watersheds, many streams are becoming isolated from public view and access. It is the highest priority of the objectives and strategies to maintain and enhance the public's access, enjoyment and recreational uses of the watersheds' natural resources, and to enhance their understanding of our historic and present connection with and inter-dependence on these resources.



Goal 3: Preserve Natural Resources

Objectives:

Objective 3-1
Protect and enhance ground water recharge and quality.

Vegetated riparian buffer

Objective 3-2
Protect and enhance the natural instream resources of streams, including stable stream channel processes and geomorphology conditions, aquatic living resources, stream baseflows, and water quality.

Objective 3-3
Protect and enhance first order perennial streams to recognize their vulnerability to low streamflows and water quality impairments.

Objective 3-4
Protect and enhance streams supporting "sensitive resources" to recognize their vulnerability to low stream flows and water quality impairments. "sensitive resources" as used in *Watersheds* include:

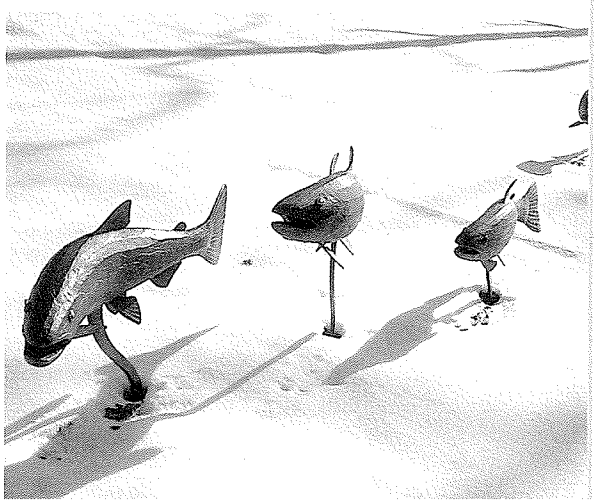
- Exceptional Value watersheds and High Quality streams as designated by Pennsylvania.
- Instream sources of community water supplies and reservoirs.
- State-designated water-based habitats—including State Verified Naturally Reproducing Trout Waters, Class A Wild Trout Waters, "cold water fishes" waters, and sites identified in Pennsylvania Natural Diversity Index (PNDI).

Objective 3-5
Protect wetlands for their hydrologic and ecological functions, and pursue opportunities to mitigate, restore or create wetlands.

Objective 3-6
Create and enhance a network of protected forested riparian buffers along ponds, lakes, wetlands, and baseflow-fed perennial and intermittent streams to protect water bodies from erosion and pollutants, to provide infiltration, to stabilize stream channel processes, and to provide shading, food and habitat for aquatic species.

Objective 3-7
Consider the cumulative impacts on and benefits of proposed land development to natural resources and identify alternatives to avoid or mitigate impacts.

Objective 3-8
Prioritize riparian buffers, 100-year floodplains, first order streams and their drainage areas, and wellhead protection areas for land and/or woodland preservation efforts to protect ground water recharge and water quality of ground water and streams, and to provide for safe conveyance of flood flows and natural migration of stream channels.

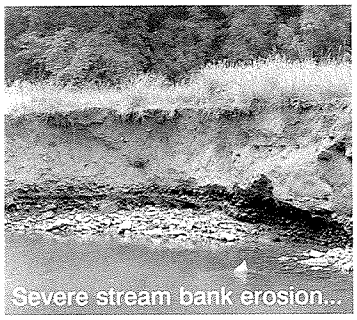


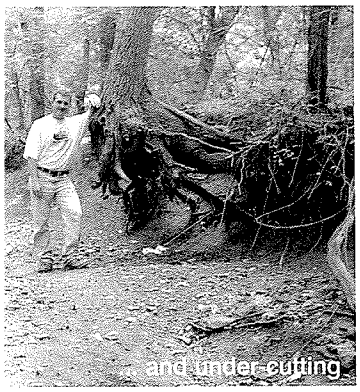
Rationale:

Protecting Ground Water Recharge

Protecting ground water recharge is the single most important objective for protecting the natural characteristics of watersheds. Ground water provides the baseflow in streams and water for drinking water wells throughout the year. In Chester County's watersheds, about 60% of the annual stream flow is from ground water. Therefore, the protection of ground water recharge is essential to protect and support all instream habitats and stream uses. In addition to providing baseflow to streams, ground water recharge also helps to offset the impacts of ground water withdrawals from wells, and reduces the volume of water contributed to flooding.

Reducing and disconnecting impervious cover, making beneficial use of pervious areas for infiltration of stormwater, and utilizing land application technologies (i.e., spray and/or drip irrigation, etc.) for disposal of treated wastewater are key opportunities for protecting ground water recharge.


Severe stream bank erosion...


... and under-cutting

Protecting Instream Resources

Maintaining the stability of natural stream channel geomorphology processes is essential to sustaining the stream's flood carrying capacity, its aquatic resources and habitats, and its water quality. The physical process of a healthy stream system—known as stream (or fluvial) geomorphology—involves a dynamic balance between the water, the stream channel bottom and banks, the bed and load material (sediment, gravel, rock), the channel slope and geometry, and the adjacent land. Some stream channel erosion is desirable and indicates a balanced and "stable" stream system.

The most destructive force to a stream is the high and frequent volumes and velocities of stormwater runoff. This condition dramatically upsets the balance (or stability) of the total stream system. Unstable streams experience accelerated channel erosion, excessive downcutting of the channel bottom, dangerous undercutting of the channel banks, straightening of the stream channel, excessive downstream sediment loads, increased flooding, and loss of aquatic habitats and species.

These objectives strive to achieve and maintain stable stream channel processes. This balance can be achieved through careful design of discharge rates and volumes, careful design of instream structures (such as bridges, culverts, etc.), and measures aimed at protecting riparian areas along streams.

Protecting First Order Streams

The "roots" of a watershed are the small tributaries that exist in the highest reaches of the watershed. These small tributaries form the headwaters of a stream system and are called the "first order" streams. Typically, these small streams comprise over 50% of the total stream miles in a watershed. Similarly, the land areas draining to these first order streams (referred to as the drainage areas of first order streams) comprise over 50% of the total land area of a watershed, as shown in Figure 3-11. These streams are very small with very small stream flows, narrow widths, and shallow depths. They are highly vulnerable to impairments caused by pollutants and over-withdrawal of ground water from their drainage area.

The objectives include first order streams among the priorities for protection from stormwater runoff, pollutant sources, over-withdrawal of ground water and stream flows, and for establishment of forested riparian buffer networks and land preservation efforts. Like the roots of a tree, these small tributaries perform crucial functions.

Impairments to first order streams can quickly accelerate the impairment of their larger receiving streams. It has been observed by field biologists that when first order streams are buffered and protected, their receiving streams are generally in good health as well.

Different entities and resource management agencies define "first order" streams in different ways. To avoid confusion, first order streams as used in *Watersheds* are defined as the first order perennial tributaries shown on USGS 7.5 minute topographic quadrangle mapping.

Protecting "Sensitive Resources"

Many streams are used for multiple—and often competing—purposes, such as sources of water supply, recreational uses, and ecological habitats, as shown in Figure 1-3. The ecological resources that rely on these streams are dependent upon certain flow and water quality conditions. Similarly, much of the population within the study area relies on surface waters for their drinking water supplies. Streams that comprise the source waters for these drinking water supplies must be protected from pollutants, high sediment loads and excessive low streamflows.

Objective 3-4 establishes a list of "sensitive resources" that are highly sensitive and vulnerable to low streamflows, pollutants and sediments in the stream. These "sensitive resources" are identified as priorities for protection from stormwater runoff, other pollutants, and over-withdrawal of ground water and streams. Chester County's watersheds contain numerous sensitive resources including: nearly 60,000 acres of land included in 6 watersheds designated as Exceptional Value, 11 surface water supply intakes, state scenic and federal wild and scenic streams, and numerous state-designated water-based habitats.

Instream public water supply intakes are included because they are dependent on sustained stream flows, particularly during drought events, and are highly susceptible to water quality problems from uncontrolled pollutants in their source waters. By balancing the priorities of ground water withdrawals and stream withdrawals in a subbasin, both ground and surface water resources may be less vulnerable to depletion in drought events.

Forested riparian buffer

Establishing Forested Riparian Buffer Networks

This objective strives to establish an inter-connected forested riparian buffer network throughout the County's watersheds. This network is essential for a healthy and thriving ecosystem. The benefits of forested buffers cannot be mimicked by any other engineered system or management practice. Forested buffers along stream banks protect stream waters from direct sunlight and resulting high temperatures, provide detritus in the stream that serves as food and shelter for aquatic species, and stabilizes stream banks, stream channels and floodplains from the erosion and scour of high velocity flood flows. These forested buffers also serve as the link between terrestrial wildlife and their source of water, food and cover as well as provide a transition zone

Planting riparian buffers

between aquatic and terrestrial habitats. The roots absorb and "take up" nutrients and other pollutants from ground water as it migrates through the root zone. Plant stems and leaves filter sediment and pollutants from overland flow of stormwater through the buffer.

A substantial body of scientific research documents the need, functions and benefits of forested riparian buffers (see Figure 2-7). Based on this information, forested riparian buffer widths of 100 feet on each side of a stream or waterbody are recommended for implementation in Chester County's watersheds. Where conservation design practices and "comprehensive stormwater management" practices have been fully applied, an average width of 75 feet (each side of water body) can be considered, with no less than a minimum of 50 feet width at any one point.

The objective for agricultural lands and lands undergoing urban development or redevelopment should be to achieve the maximum width practicable given the site conditions and use. In these cases, the 100 foot buffer width may be impractical and a reduced width may be more achievable. Flexibility should be applied to avoid discouraging re-development or in-fill of urban areas. A minimum of 35 foot forested buffer (on each side of the water body) may be more reasonable for these conditions.

Scientific research has also confirmed that the ecological and water quality functions of buffers are significantly improved as the length of the buffer is extended. Thus, extending and inter-connecting buffers are strongly recommended to create a "network" of buffers along streams and water features.

Assessing Cumulative Impacts to Natural Resources

The impacts and benefits of proposed land or water development projects can be evaluated along with those of other significant stream or land uses along a common stream. By evaluating the "cumulative impacts," project designers and decision-makers can more fully evaluate design alternatives and employ resource protection and conservation design practices while ensuring that their intended project objectives are achieved. This allows for closer consideration of site design alternatives to protect wetland and riparian resources, steep slopes, and ground water, among others, and helps minimize the volume of stormwater runoff generated from the site. It also allows for consideration of alternatives that improve rather than further impair the natural characteristics of the receiving watershed.

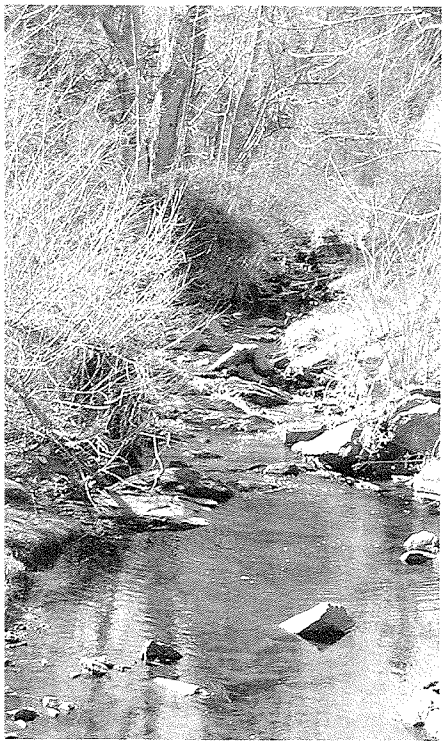
Prioritizing Land Preservation Opportunities

Including water resource protection objectives in land preservation and open space planning can accommodate multiple objectives. Many types of land serve important watershed functions. Drainage areas of first order streams, woodlands, riparian buffers, 100-year floodplains, and wellhead protection areas are recommended to be prioritized for land preservation efforts.

Goal 4: Improve Water Quality

Objectives:

Improving Surface Water Quality



Objective 4-1
Achieve state designated use water quality standards in all streams.

Objective 4-2
Where supported by stream conditions and uses, petition for upgrades in state stream designations.

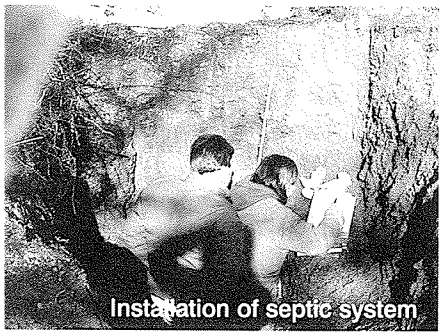
Objective 4-3
Reduce or eliminate the introduction of unnecessary chemicals, and nutrients into the environment.

Objective 4-4
Reduce or eliminate movement of sediment from lands into streams to conserve the soil resources and reduce instream siltation and pollutants.

Objective 4-5
Accelerate implementation of agricultural nonpoint source management training, planning and best management practices (BMPs).

Objective 4-6
Remove pollutants from stormwater discharges prior to release to waterways.

Objective 4-7
Reduce pollutant loadings from point source discharges.


Installation of septic system

Improving Ground Water Quality

Objective 4-8
Protect ground water from contamination from all sources.

Objective 4-9
Protect recharge areas of public water supply wells from sources of pollution.

Objective 4-10
Reduce pollutant loadings from treated effluent of land applied wastewater disposal systems, including on-lot septic systems.

Rationale:

The highest priority for improving water quality is to restore streams and watersheds to achieve the state water quality standards for their designated use (as presented in Figure 3-5) where these standards are currently not being met (as shown in Figure 1-2). The objectives strive to raise the standards and to improve or maintain higher water quality standards in waters supporting "sensitive resources" and sources of drinking water supplies. Stream segments not meeting state water quality standards have been listed as "impaired waters" on the Pennsylvania's "303(d)" list (developed under Section 303(d) of the Federal Clean Water Act) and require remedies to eliminate the impairments through the TMDL process. The *Watersheds* objectives support the fair and equitable implementation of the TMDL programs.

The objectives also strive to eliminate future contaminants from being introduced into streams and ground water. By reducing or eliminating chemical application

and improving chemical management procedures, spills and over-application of chemicals can be avoided. Individual responsibility of all homeowners and land owners and operators is important to achieving this objective.

Removing sediments, nutrients and pollutants from stormwater runoff prior to its release to streams is the most promising and widespread approach needed in Chester County's watersheds. By using effective BMPs to capture the runoff from rainfall events up to the 1-inch storm, between 85% and 90% of the total annual average rainfall runoff can be handled through BMPs for pollutant reduction prior to release to streams. These objectives are consistent with the emerging PADEP stormwater management policies and have been implemented in land development regulations within the County's watersheds.

Extensive experience over the past 20 years with built systems has documented the pollutant removal benefits of numerous BMPs. The *Compendium* contains a list of "recommended" BMPs that have been shown to achieve significant pollutant reduction. Many of these BMPs have been incorporated into regulatory and restoration programs in the County's watersheds. By implementing these "recommended" BMPs on a widespread basis, the area could achieve region-wide improvements and contribute to achieving the reduction goals of 80% of annual sediment loads and 40% of nutrient loads of the Chesapeake Bay Agreement of 2000, and contribute to similar reductions in the Delaware Estuary.

Goal 5: Reduce Stormwater Runoff and Flooding

Objectives:

Objective 5-1

Achieve post-development hydrologic conditions that are consistent with the natural hydrologic characteristics of the receiving stream system and that sustain and enhance:

- Ground water recharge and subbasin ground water balances,
- Stream baseflows,
- Stable stream channel processes,
- Flood carrying capacity of the receiving streams and their floodplains, and
- Water quality conditions necessary to meet state water quality standards, support natural aquatic species and their habitats, and protect sources of public drinking water supplies.

Objective 5-2

Implement comprehensive stormwater management requirements in all municipalities that incorporate each of the following ten principles:

- Reduce the volume of stormwater generated by:
  a) Maximizing the use of pervious areas for infiltration of rainfall and stormwater.
  b) Utilizing conservation development design (conservation subdivision design) techniques and low impact development designs.
  c) Eliminating unnecessary requirements for impervious cover and incorporating conservation development design techniques within municipal subdivision and land development ordinances.

- Design new developments and their stormwater management systems so that net post-development conditions achieve "open meadow condition" hydrologic characteristics.
- Protect ground water recharge through infiltration of rainfall and stormwater.
- Remove pollutants from stormwater runoff prior to release to protect water quality of streams and ground water.
- Protect stable stream channel processes and geomorphology conditions.
- Reduce flood peak runoff rates to reflect "open meadow condition," and further reduce flood peak runoff rates for areas contributing to frequently floodprone urban/developed areas.
- Insure that stormwater management facility operation and maintenance occur on a permanent basis.
- Protect adjacent lands that are receiving stormwater runoff from developed sites.
- Establish forested riparian corridor networks.
- Protect wetlands and floodplains to reduce runoff and flooding.

Objective 5-3
In urban areas and areas designated for concentrated (urban) growth, provide flexibility in stormwater quantity control requirements and prioritize implementation of stormwater quality controls.

Objective 5-4
Design stormwater infiltration and conveyance systems in karst (limestone) terrain to minimize the risk of sinkhole formation and aquifer contamination.

Objective 5-5
Design and/or retrofit transportation and urban stormwater systems to achieve the principles of comprehensive stormwater management everywhere practicable.

Objective 5-6
Protect 100-year floodplains from development to allow unimpeded passage of flood flows.

Objective 5-7
Pursue opportunities to attenuate or mitigate flood flows, giving preferential consideration to nonstructural approaches and alternatives.

Objective 5-8
Implement flood warning and mitigation/reduction methods to help protect communities located in floodplains and below major reservoirs.

Objective 5-9
Prepare and implement watershed-based comprehensive stormwater management plans that implement the *Watersheds* goals and strategies and fulfill the requirements of state stormwater management programs.

Objective 5-10

Develop and implement comprehensive stormwater management programs within all municipalities and transportation agencies to include:

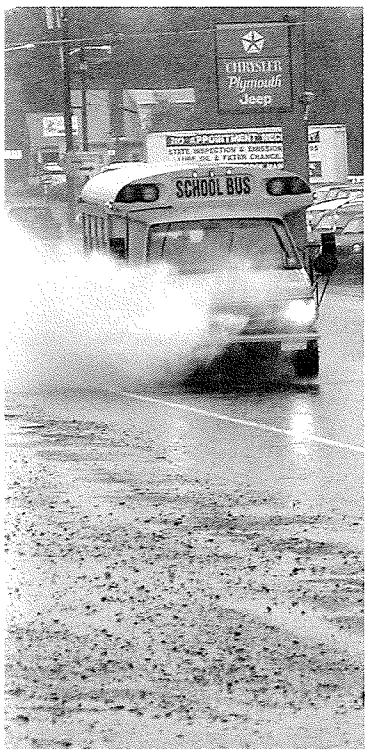
- Public education and participation.
- Illicit discharge detection and elimination.
- Construction site runoff control.
- Post-construction stormwater management for new projects and development.
- Maintenance and proper operation of existing stormwater facilities.
- Pollution prevention and "good housekeeping" practices.

Rationale:

Ten Principles of "Comprehensive Stormwater Management"

The ultimate and collective purpose of these objectives is to accommodate planned growth in a manner that protects public safety and maintains (or re-establishes) the natural hydrologic characteristics of the watersheds and sustains ground water recharge, stream baseflows, stable stream channel processes and geomorphology conditions, the flood carrying capacity of streams and their floodplains, and ground water and surface water quality—to the maximum extent practicable. This can be accomplished through municipal implementation of "comprehensive stormwater management," which includes the 10 principles listed in Objective 5-2.

It will take many years to complete and adopt Act 167 stormwater management plans for all 21 watersheds of Chester County. Thus, it is essential to implement strategies that will effectively address stormwater runoff problems in the meantime. This set of collective "10 principles" was designed to more comprehensively address stormwater runoff problems that can result from new development. It will be a top priority to have these "10 principles" implemented by municipalities throughout Chester County within their stormwater management ordinances for the interim period, and to revisit and revise the ordinances as necessary upon completion of Act 167 plans.



The stormwater runoff objectives represent a collection of stormwater requirements currently in place within the study area, mostly within Pennsylvania municipalities. Many are found in ordinances of various municipalities located in Chester County; others are consistent with stormwater runoff criteria that have been applied on a widespread basis elsewhere within the 21 study watersheds in Maryland and/or Delaware. The primary intent of these objectives can be achieved by incorporating the "ten principles of comprehensive stormwater management" within municipal ordinances.

Stormwater management must effectively handle stormwater from the development site and minimize the cumulative impacts of stormwater discharges to the stream in a manner that maintains the stability and flood-carrying capacity of the stream. The ten principles of comprehensive stormwater management represent a holistic approach to watershed management. They are intended to be implemented collectively through an integrated design process that will result in the minimum net stormwater runoff volumes and velocities, and minimum site disturbance.

Grassed cul-de-sac

Reducing Requirements that Generate Stormwater

The single most important element of effective stormwater management is to design the development in such a way that it does not create stormwater. Many municipalities inadvertently require stormwater to be generated by requiring impervious cover where it may not be necessary. By removing these requirements (where unnecessary) from ordinances, and incorporating conservation development design criteria, municipalities can contribute greatly to reducing the amount of stormwater generated.

Leaving pervious areas undisturbed to the maximum extent practical for infiltration of rainfall or for use as part of infiltration BMPs also reduces the amount of stormwater generated. By incorporating designs that disperse runoff flows through vegetated lands and swales, the water can be infiltrated and does not need to be collected, conveyed, stored, discharged, or undergo pollutant removal in an engineered stormwater control system.

Infiltrating Stormwater to Support Stream Baseflow and Ground Water Recharge

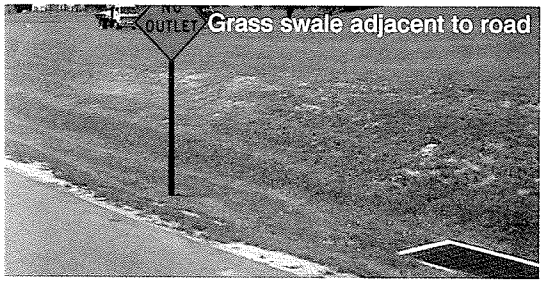
To sustain stream baseflows, the volume of water infiltrated into the ground (and the corresponding volume of ground water recharge) must be maintained at or near that expected from undeveloped land (i.e., open meadow condition). This can be generally achieved by infiltrating the net increase in runoff from the 1-inch storm event (or net increase in runoff from the 2-year storm event, where conditions allow). This will address nearly 90% of the number of rainfall events that occur in the region, and based on available information and accounts of previous experience, should be achievable throughout most if not all land areas of the County's watersheds. In addition, stormwater infiltration will contribute to achieving the stormwater quality controls, and to some extent, the peak flood discharge rate controls. These criteria reflect extensive consideration of the general soils and geologic characteristics of Chester County's watersheds, demonstrated experience with various infiltration criteria by others in the watersheds, and consideration of their practical application.

Infiltrating Stormwater in Limestone (Karst) Areas

Stormwater infiltration has been successfully demonstrated in limestone (karst) areas of Chester County's watersheds and elsewhere in Pennsylvania, Florida, Wisconsin, and other areas of the U.S. However, care must be taken to locate and design these systems to minimize the risk of sinkhole formation. Avoiding concentrated flows and dispersing runoff for infiltration are primary requirements for avoiding sinkhole formation from stormwater management design. Some limestone formations are more resistant to sinkhole formation than others. A thorough understanding of the site is needed to design infiltration and stormwater management systems to achieve the principles of comprehensive stormwater management in limestone areas.

Attenuating Runoff to Protect Stable Stream Channel Processes and Geomorphology Conditions

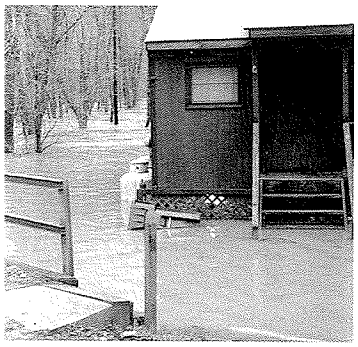
These objectives strive to protect the stability of stream channels from excessive and frequent flow rates and erosion based on demonstrated experience and techniques implemented in the County's watersheds. Their experience indicates that temporarily attenuating the 1-year 24-hour storm event on site for a period of 12 to 24 hours can reduce the flow rates and volumes received by streams to that



which is in better balance with the other stream processes. This helps reduce the amount of instream erosion, downcutting, straightening, and, ultimately, flooding that unnecessarily results from traditional stormwater runoff. This attenuation can be achieved by routing runoff through the site via grassed swales, wetlands, riparian buffers, or retention ponds. Implementing the other "principles" will significantly reduce the net volume of runoff required to be attenuated to protect the receiving stream.

Removing Pollutants Prior to Discharge

Removing sediments, nutrients and pollutants from stormwater runoff prior to its release to streams is the most promising and widespread approach needed to protect stream water quality in Chester County's watersheds. By using effective BMPs to capture the runoff from rainfall events up to the 1-inch storm, between 85% and 90% of the total annual average rainfall runoff can be handled through BMPs for pollutant reduction prior to release to streams. Numerous BMPs have been demonstrated to effectively reduce pollutant loadings in stormwater in the County's watersheds.



Reducing Flood Peak Runoff Rates

The objectives reflect the need to reduce flood peak rates to achieve the balance between post-developed site conditions and the natural capacity of the stream and its floodplain. By reducing the post-development peak rates of runoff for the 2-year through 100-year events to be equal to the corresponding peak rate for an "open meadow condition," the total flood volume received by the stream system can be more efficiently conveyed within the natural channel and floodplain. This reduces the risk of property damage or bodily harm downstream while protecting instream habitat and stream channels. Where stormwater runoff contributes to flooding of urban and developed areas, further reductions in release rates are recommended (as described in the strategies, Part 8) to help reduce the magnitude of flooding. When completed, release rates resulting from Act 167 stormwater planning analyses should supersede the release rates recommended in Part 8. Further reduction of peak rates to 90% of meadow condition peak rates are recommended in areas that contribute runoff to urban/developed areas known for frequent flooding.

Planning for Stormwater Management

Based on the results and prioritization presented in *Watersheds,* Chester County will embark on conducting watershed-based comprehensive stormwater management plans for the watersheds of Chester County. The first "pilot" study for this comprehensive approach will be conducted for East Valley Creek. Other plans are underway for Chester Creek and Darby Creek and will soon begin for Crum Creek, in cooperation with Delaware County, PA.

Implementing Municipal NPDES Phase II Stormwater Regulations

Taken collectively, the objectives for reducing stormwater runoff and flooding also support the pending NPDES Phase II requirements that face many of the municipalities in Chester County's watersheds. The new regulations will require that regulated municipalities (see Figure 3-10) establish programs that address the six elements listed in Objective 5-10, including stormwater quality and maintenance and operation of facilities. It is recommended that all municipalities consider developing similar programs to insure consistency in implementation of management strategies across individual watersheds.

Goal 6: Protect Watershed Water Balances

Objectives:

Objective 6-1
Achieve post-development hydrologic conditions that are consistent with the natural hydrologic characteristics of the watershed and stream system and that sustain and enhance:

- Ground water recharge and subbasin ground water balances,
- Stream baseflows,
- Stable stream channel processes,
- Flood carrying capacity of the receiving streams and their floodplains, and
- Water quality conditions necessary to meet at least state water quality standards, support natural aquatic species and their habitats, and protect sources of public drinking water supplies.

Objective 6-2
Reduce peak daily and average annual per capita water withdrawals through water conservation and re-use.

Objective 6-3
Develop and coordinate planning for new or expanded water and/or wastewater facilities and water sources in conjunction with the affected municipalities and counties.

Objective 6-4
Consider individual and cumulative impacts of withdrawals, discharges and recharges on natural resources and existing water users.

Objective 6-5
Protect and maintain natural stream flows during low flow and drought periods.

Objective 6-6
Protect aquifers and stream baseflows by applying net cumulative ground water withdrawal management targets.

Objective 6-7
Balance the use of ground water and surface water sources to support planned growth while protecting aquifers and stream baseflows from over-withdrawal.

Objective 6-8
Plan water supply and wastewater sources and facilities that seek to maintain the natural watershed water balance of each subbasin.

Objective 6-9
Locate large water withdrawals and wastewater effluent disposal facilities where they provide the greatest benefit and least impact to watershed aquifers and streamflows.

Objective 6-10
Protect aquifers and stream baseflows from unnecessary withdrawals during periods of low flow and drought events by reducing water use.

Rationale:

Protecting Natural Characteristics of Watersheds

Protecting ground water recharge on all lands is essential to sustaining the natural hydrologic characteristics of the watersheds and their stream systems and is critical to protecting the water balances of individual watersheds. The objectives strongly encourage consideration be given to options that return water to aquifers, such as spray irrigation, drip irrigation and stormwater infiltration. However, these options should be fully evaluated for overall benefits and implications and water returned to the land should be of sufficient quality to not contaminate ground water.

Increasing Water Conservation and Re-Use

It is important for the general public and water users to understand that the source of their tap water is a stream or ground water. Thus, every effort to conserve the use of water (or re-use water) translates into a reduction in the need for additional water withdrawals. Improved technologies are providing more options for re-use of treated wastewater and should be applied where practicable. Increases in both conservation and re-use hold substantial opportunity to minimize water supply withdrawals from natural resources. Adopting (where they have not already been adopted) and enforcing requirements for the inclusion of water conservation fixtures in new construction can provide substantial increases in water conservation.

Reducing the amount of water lost through aging water supply infrastructure also contributes to reducing the volume of water withdrawn from source waters and reduces the cost of public water supplies. Reducing the volume of ground water that infiltrates into wastewater collection pipes also provides several benefits, including reducing the volume of water that must be conveyed and treated, and increasing the volume of ground water left to support the aquifers and stream baseflows.

Coordinating Planning and Evaluation

Involving the municipalities, counties and other affected stakeholders of the community in the planning process helps insure that the needs of all water users are balanced. Understanding and considering the needs of environmental and aquatic resources, agricultural users, individual residential, commercial and industrial water users, recreational uses, cultural resources, local comprehensive planning and zoning, and other water users are important when evaluating options for selection of sources and disposal options. Evaluating the cumulative impacts of withdrawals and discharges on the natural resources is recommended as the combined effects may create impacts (or benefits) not otherwise understood when evaluating only a single project or option.

Protecting Instream Flows During Periods of Drought and Low Streamflows

Protecting low stream flows from instream withdrawals is particularly critical during prolonged drought events. Pennsylvania and river basin commission regulations have addressed this need in the past, generally requiring instream withdrawals to cease or be replaced by reservoir releases and/or wastewater discharges when stream flows are at or below $Q_{7\text{-}10}$ levels. This is a statistical stream flow expected to occur over a period of 7 consecutive days on average once every ten years. As the understanding of instream flow needs has evolved, there is now substantial debate as to whether the $Q_{7\text{-}10}$ level provides sufficient protection to sustain instream resources, particularly in smaller streams. The PA Fish and Boat Commission (PAFBC) and PADEP have been evaluating the use of instream flow studies or higher thresholds as more appropriate protection levels.

The objectives stress the urgent need for the PAFBC and other agencies to complete instream flow analyses for the southeast Pennsylvania's Piedmont streams as quickly as possible to provide necessary information for determining instream flow protection requirements. Such studies will help quantify the volume and flow rate of water needed within the streams to support the existing aquatic resources. Different types of fish have different instream flow needs to support their habitat requirements. Until such studies are available, decisions regarding future water withdrawal requests will be subject to extensive debate.

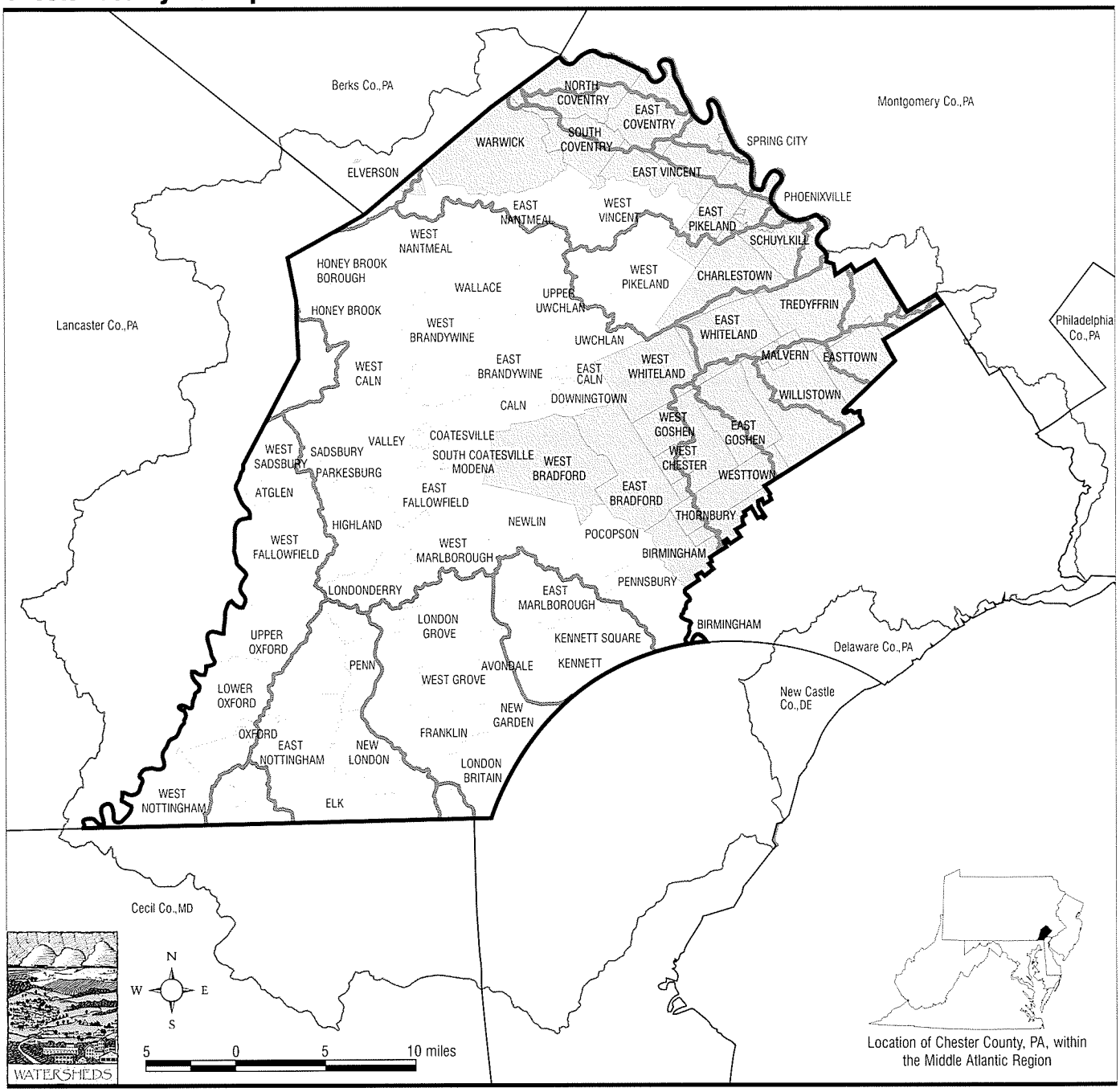
Applying Net Cumulative Ground Water Withdrawal Management Targets

In addition to the need for definitive instream flow studies discussed above, it is also necessary to obtain more definitive science regarding the direct impacts of ground water withdrawals on instream flows. A pilot study is underway by USGS for DRBC and PADEP to evaluate the impacts of ground water pumping and discharge on the stream baseflow of French Creek. Once the relationship of increasing ground water pumping to decreasing instream flow is understood and combined with the understanding of the minimum baseflows necessary to sustain the aquatic resources, decisions regarding future withdrawals and discharges can more definitively consider the cumulative impacts on the stream resources.

In the absence of these two scientific tools for southeast PA streams, other strategies have been developed. The DRBC regulations for the Southeast PA Ground Water Protected Area (GWPA) established limits of net cumulative ground water withdrawals for all subbasins located within the GWPA. These withdrawal limits are set equal to the corresponding 1 in 25 year average annual stream baseflow volume for the corresponding subbasin, and those values are given in the regulations. The effect of these regulations is to limit the cumulative net volume of ground water withdrawn from each subbasin to no more than the specified volume. The "net volume" of withdrawals considers the volume of water recharged to the ground water. The regulations also encourage management practices that help sustain the natural ground water resources, such as conservation, re-use, conjunctive use of ground water and surface water sources, etc.

The current DRBC ground water withdrawal limits are mandated only for the municipalities located within the designated Southeastern Pennsylvania Ground Water Protection Area, as shown in Figure 4-1. However, there is increased understanding of the need to manage ground water withdrawals throughout the study area. ***Watersheds'*** objectives build on the approach used by DRBC and recommend management targets to be used on a voluntary basis to assist in evaluating the potential impacts of net ground water withdrawals.

Figure 4-1:
Chester County Municipalities Located within the DRBC Southeastern PA Ground Water Protected Area



Municipalities within Ground Water Protection Area

- Chester County
- Adjacent county
- Municipality
- Watershed

- No
- Yes

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Because many of the stream segments in the study watersheds have multiple competing uses and needs, the Water Resources Task Force recommended that the following ground water withdrawal management targets be used on a voluntary basis to evaluate water planning decisions:

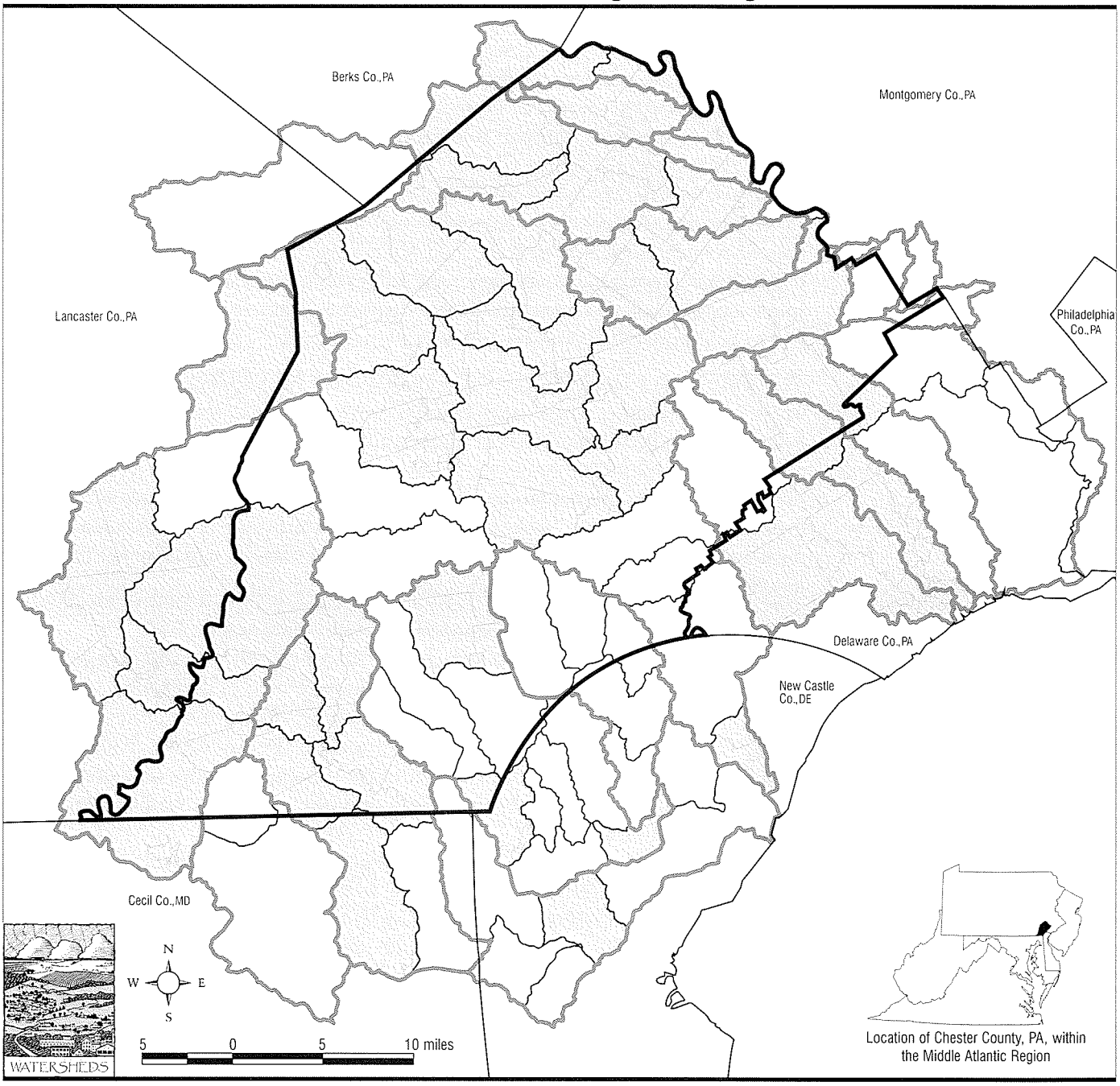
- For protection of first order streams: maintain the net volume of cumulative ground water withdrawals BELOW 50% of the volume of the 1 in 25 year average annual baseflow within each first order stream drainage area, unless a more detailed hydrogeologic analysis or instream flow study for the drainage area determines that a larger net withdrawal volume can be safely taken while sustaining the ground water and instream resources of that drainage area.
- For protection of baseflow-sensitive resources: maintain the net volume of cumulative ground water withdrawals BELOW 50% of the volume of the 1 in 25 year average annual baseflow in each subbasin that contains streams designated as Exceptional Value and High Quality, instream sources of community water supplies (where instream withdrawals are not directly and continuously supported by reservoir storage), and state designated instream fisheries, unless a more detailed hydrogeologic analysis or instream flow study for the subbasin determines that a larger net withdrawal volume can be safely taken while sustaining the ground water and instream resources of that subbasin.
- For all other areas: maintain the net volume of cumulative ground water withdrawals BELOW 100% of the volume of the 1 in 25 year average annual baseflow within all other subbasins.

Figure 4-2 highlights the subbasins that contain baseflow-sensitive resources and that are recommended to be considered for the more protective ground water withdrawal targets of 50% of their 1 in 25 year average annual baseflows. These withdrawal management targets are recommended to be applied for two purposes: 1) to protect aquifers and their streams' baseflows from over-withdrawal, and 2) to guide decisions on the use of ground water versus surface water sources for meeting future needs.

The lower management target of 50% of the 1 in 25-year average annual stream baseflow volume was selected because it would protect and theoretically maintain at least 50% of stream flow during a 1 in 25-year dry weather event. In addition, it would not appreciably restrict future withdrawals, as projected 2020 withdrawals in most subbasins would not exceed this threshold. Further, this volume of flow is generally within the range of $Q_{7\text{-}10}$ flows. Maintaining $Q_{7\text{-}10}$ flows is essential to assimilate wastewater discharges without impairing water quality during drought conditions. These $Q_{7\text{-}10}$ flows are used as the basis for regulatory permits for point source discharges and development of low-flow TMDLs for impaired streams.

First order streams comprise over 50% of the total stream miles of Chester County's watersheds. These streams are very small and are highly vulnerable to water quality impacts and flow reductions. These net cumulative ground water withdrawal targets will need to be calculated on a case by case basis using information available from the databases developed as part the *Compendium*. If this management target is considered too restrictive, a detailed site specific analysis can be conducted to more definitively establish the relationship of ground water withdrawals to sustaining aquifer and instream resources.

Figure 4-2:
Recommended Net Ground Water Withdrawal Management Targets



Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Balancing the Use of Ground Water and Surface Water Sources

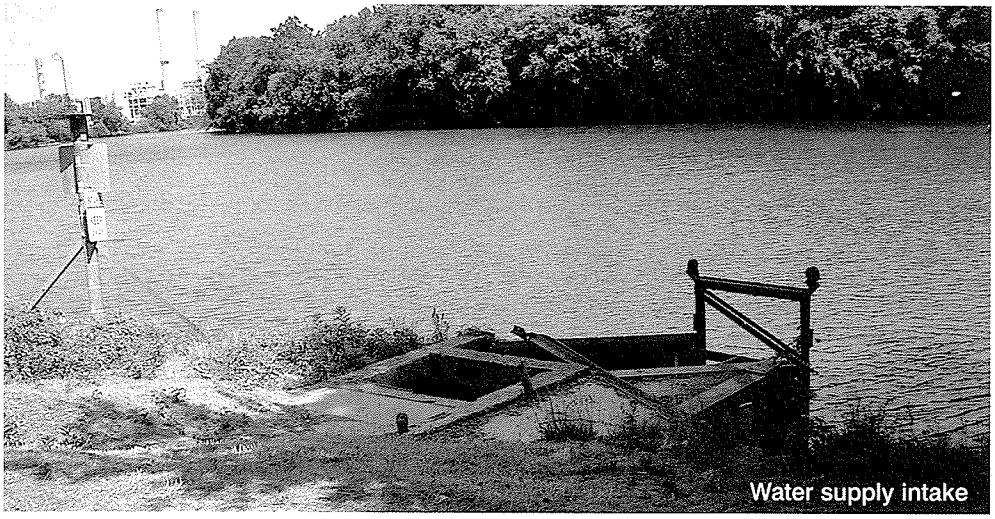
Chester County's watersheds have substantial sources of water available for use, both ground water and surface water. The availability of reliable surface water sources can provide benefits in supporting areas where ground water sources are insufficient. However, over-reliance on surface water sources can inadvertently cause local ground water resources to be underutilized, and can create unnecessary expansion of infrastructure to transport water supplies from surface water sources to the service area. Presented in Part 6 is a series of decision guidelines for assisting municipal and water planners to best utilize ground water and surface water sources individually or in a combined (or conjunctive use) manner. These recommend applying the net cumulative ground water withdrawal management targets (discussed above) to manage and evaluate ground water use and to help determine when or if surface water supplies should be introduced into the planning area based on the relative stress of existing withdrawals on ground water resources.

The *Watersheds* strategies suggest that ground water be considered for meeting new water supply demands when the net ground water balance of the subbasin is well below the withdrawal management target for the subbasin. A combination of ground water and surface water (i.e., conjunctive use) is recommended for meeting new demand when the net ground water balance is approaching the withdrawal management target of the subbasin. Surface water sources are recommended for meeting new demand when the net ground water withdrawal management target has been reached or exceeded in the subbasin.

Maintaining Natural Watershed Water Balances

Wastewater disposal options can be located to provide significant benefits to the receiving watershed. Considering alternatives that return treated wastewater to the land and ground water is important for protecting ground water recharge and stream baseflows. Returning the treated wastewater to the same subbasin where the water supplies were originally withdrawn contributes to maintaining the watershed water balances by avoiding removal of the water to other subbasins or watersheds. Maximizing the use of existing facilities prior to development of new facilities reduces the need for additional withdrawals and discharges. Avoiding any additional future transfer of water through water supply and wastewater pipelines across river basin boundaries is consistent with the policies of the Susquehanna River Basin Commission (SRBC) and the DRBC at the river basin level.

The Water Resources Task Force recommended that the concepts of avoiding or managing inter-basin transfers be applied at a smaller drainage basin level. Specifically, the consensus was to avoid increases in the net inter-basin transfers of water among the drainage basins defined in this study area as the Schuylkill River Basin, Delaware River Basin, Christina River Basin, Chesapeake Bay Basin, and the Susquehanna River Basin. It is also recognized that such inter-basin transfers are essential in some circumstances and may represent the best alternative for meeting future needs. In these cases, it is critical that all planning and management principles be applied to the transfer to minimize the impacts to the source of the withdrawal and maximize the benefits of the imported water or ultimate discharge or recharge to the receiving watershed.


Water supply intake

Locating Large Withdrawals and Discharges

The objectives for protecting stream baseflows strive to manage instream withdrawals and discharges. It will be essential to allow withdrawals and discharges, but guiding them to the most appropriate locations and limiting their impacts on water quality and low stream flows is critical. The location of these facilities can be guided to consider the maximum benefit to the subbasin and watershed. Emphasis needs to be placed on locating large withdrawals near the mouth of the subbasin and large discharges as far upstream as practicable. However, the potential water quality impacts of discharged effluent must be taken into account in making decisions regarding location of wastewater discharges, particularly when considering locations above drinking water supply intakes. Discharge sites should be located so as to provide maximum water quality protection for drinking water supply intakes. Without sufficient treatment, such effluent can contribute pollutant loads—both regulated and unregulated—that can impact water supply treatment processes, increase the need for additional water supply treatment, cause serious taste and odor problems, and/or contribute to public health concerns.

Reducing Water Use During Droughts

Reducing water use and demand during droughts is the individual responsibility of all water users to respect the sources of their water. By reducing demand and improving the efficiency and integrity of the infrastructure, instream and ground water withdrawals can be minimized. This is particularly important during dry weather and drought events. It is also important for the watershed communities to understand that during prolonged and severe drought events, the use of reservoir and stream waters for essential water supply needs must take priority over recreational uses.

Water supply utilities are required under state regulations to prepare and provide to the PADEP emergency management plans for operating under drought conditions. These plans address how the utility will operate its system to optimize its available water resources, and encourage or require water conservation by its customers, as necessary, to insure adequate water supplies are provided during periods of water shortages. Providing the plans to the affected municipalities and county(ies), and coordinating with those entities can help insure that the plans are implemented effectively.

Goal 7: Integrate Utility and Municipal Planning to Meet Future Water Supply and Wastewater Needs

Objectives:

Objective 7-1
Provide a safe, clean, long-term supply of water that meets the needs of all users.

Objective 7-2
Concentrate planned utility service areas to support designated growth areas.

Objective 7-3
Coordinate planning among municipalities, counties and utilities (including municipal, municipal authority, private, and investor-owned utilities) using an Integrated Water Resources Planning (IWRP) process to insure consistency of system development and infrastructure expansion with local land use plans, ordinances, adopted resource management plans, and *LANDSCAPES*.

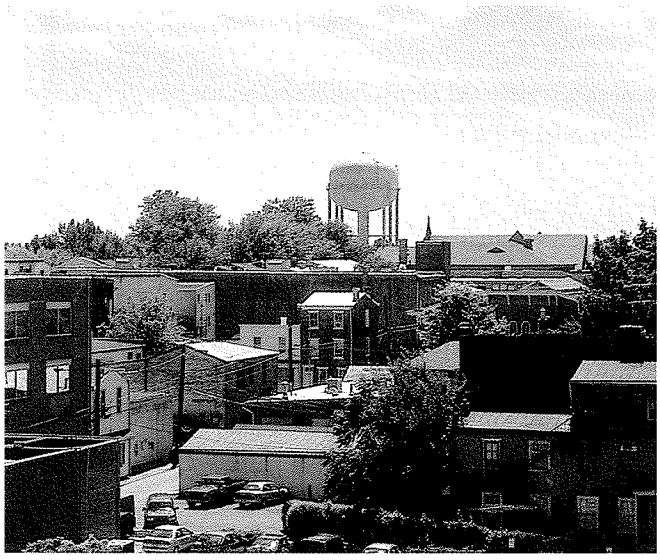
Objective 7-4
Plan treatment/disposal facilities and select sources of water supply and locations and methods of discharges based on a thorough evaluation of alternatives involving affected municipalities and counties in the process.

Objective 7-5
Identify and prioritize sources of public drinking water supplies for protection from pollutants.

Rationale:

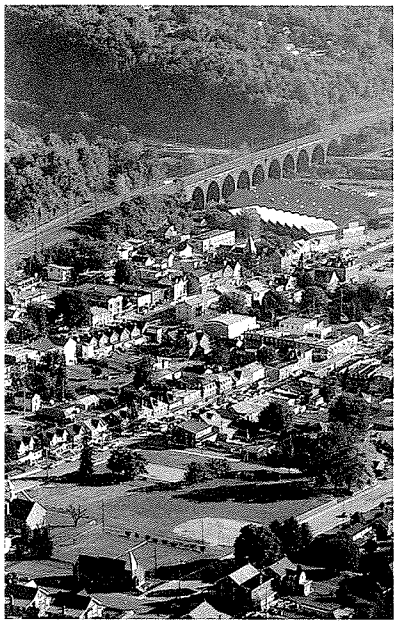
Providing for the Safe, Clean, Long-Term Supply of Water for All Users

Protecting a safe and long-term supply of water that is adequate for all uses is among the most important objectives of the *Watersheds* planning effort. Critical to achieving that objective is sustaining the quality and quantity of water in the aquifers and streams to support their use by nature and society. Collectively, all of the objectives contained herein aim to achieve this objective and improve coordination of land use and utility planning. Presented in Part 6 is a framework and information to assist municipalities in planning to meet future water and wastewater needs.



Delineating Municipal Planned Public Water/Wastewater Service Areas

It is essential that municipalities delineate and adopt "planned service areas" that demarcate areas planned by the municipality as suitable for future public water and wastewater service. Delineation of these areas should originate from and remain consistent with municipal comprehensive plans and *LANDSCAPES*. It is a premise of *Watersheds* that municipalities implement the *LANDSCAPES* vision, policies and objectives of guiding growth to the most appropriate areas. As such, areas designated for the greatest growth should be used as the delineation of areas to be provided public water and wastewater service to support that growth. The planning guidance and strategies presented in Part 6 of *Watersheds* define other areas to be considered in delineating planned service areas to protect public health.



Watersheds' goals and objectives carry through and build upon the *LANDSCAPES* policies regarding the extension and location of water and wastewater infrastructure. The extension of water supply and wastewater facilities are encouraged in areas designated for growth, and restricted in rural and natural areas, except in the limited situations where an Integrated Water Resources Plan (IWRP) or other evaluation of alternatives by the municipality and utility have jointly determined such a rural extension to be necessary and where the rural pipeline corridor is protected from service connections by zoning and joint agreements between the municipality(ies) and the utility. This approach will help insure that municipal comprehensive planning and utility planning are coordinated and consistent.

Specifically, it is recommended that municipalities enter into agreements with the utilities operating within their jurisdiction to establish a clear understanding of the coordination and approvals that will be obtained prior to expansion of infrastructure and service connections by the utility. This also provides an opportunity for the municipality and the utility to become acquainted with their respective planning objectives and interests, and other administrative, technical, planning and business aspects.

Agreements between the municipality and utilities can also provide some protection against undesired service connections to rural pipelines. These agreements should be developed during the utility's planning process and submitted to the PA Public Utilities Commission (PUC) (when involving PUC-regulated utilities) for inclusion in the project file. The agreements must also be supported by enforcement of municipal zoning along the pipeline corridor. The combination of agreements, adopted Integrated Water Resources Plans, and enforced zoning will provide the municipalities and the utilities with the strongest planning and tools to provide needed water and wastewater services, guide growth into designated and desired growth areas, and protect rural pipeline corridors from undesired growth. Throughout *Watersheds,* the term "utility(ies)" is used to refer to any public water or wastewater system regardless of ownership by municipality, municipal authority, investors, or private entity.

Integrated Water Resources Planning

The recent amendments (Act 67 and 68, in 2000) to the Municipalities Planning Code (MPC) provide the opportunity — and responsibility — for municipalities to address water supply planning within their comprehensive plans. Municipalities are encouraged to conduct their water supply planning using the Integrated Water Resources Planning approach. This approach is suggested in the amendments of the Municipalities Planning Code and is the approach being pursued by the DRBC for managing ground water and water supply sources within the Southeast PA Ground Water Protection Area.

Integrated Water Resources Plans combine utility planning and municipal comprehensive planning into one process. This allows planners to evaluate more specifically the resource protection needs in their subbasin and identify strategies to provide for water use to support future planned growth within the limitations of the natural resources of the subbasin.

Evaluating Infrastructure Alternatives

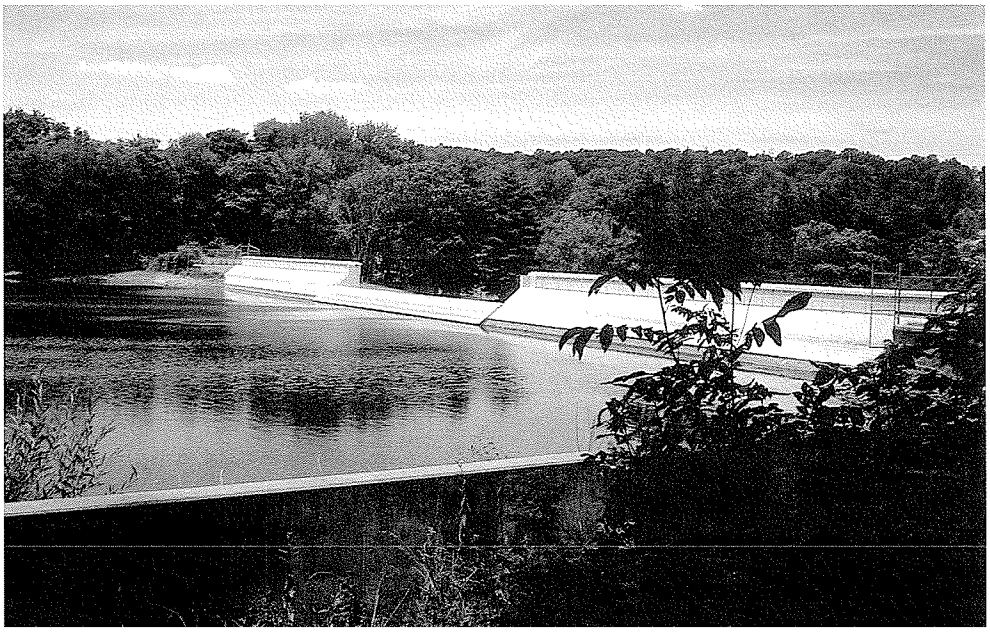
Given the numerous water use needs and land use planning objectives that must be accommodated in developing plans and proposed facilities to meet future needs, it is important that all viable alternatives be considered and fully evaluated. Satellite systems were previously considered undesirable because of historic experience with poor operation and reliability. Satellite systems are recommended here for consideration as a key alternative for use in meeting localized needs in rural areas. However, these systems should be designed and operated by an entity that has sufficient capability and resources to insure the system is operated to provide safe and reliable service to the customers and to meet the applicable regulatory requirements.

Protecting Sources of Public Water Supplies

Approximately 70% of the land areas of Chester County contribute runoff directly to sources of surface water intakes used for public drinking water supplies. All land use activities contribute pollutants of some type and magnitude to their receiving streams during runoff of rainfall, through septic system releases, wastewater discharges, and other sources. Municipalities have the local authority through the MPC to help reduce the amount of chemicals unnecessarily introduced into the environment from some land uses through ordinances and zoning. *Watersheds* includes many strategies that if implemented through municipal ordinances will help to protect sources of drinking water supplies.

It is also important to establish and maintain emergency notification systems at the municipal, County and state levels to insure that water supply plants are immediately notified if a hazardous substance is released upstream of their water supply intake. This provides the utility with the opportunity to turn off their intake, if necessary, or take other precautions to avoid introducing the pollutant into the treatment plant.

Protection of water supply intakes from contaminants discharged in treated wastewater is also recommended. This includes careful planning and design of wastewater discharges in general, as well as voluntary removal of constituents in treated wastewaters that are not harmful to the environment or human health but that may cause taste and odor problems in public water systems.



Priorities for Watershed Management *Where to Begin*

5

The Need for Priorities

The seven goals of ***Watersheds*** are inter-related and inter-dependent. Each goal involves aspects of water quality, water quantity, and protection of existing sensitive resources. To identify the most pressing needs in each watershed and across the region, a series of multi-criteria evaluations and prioritization exercises were conducted.

The results indicate which of the 21 watersheds have the greatest restoration and/or preservation needs; within each watershed, which of its subbasins have the greatest needs; and, across all 78 subbasins studied, which subbasins have the greatest needs. The watersheds and subbasins were prioritized within each of five categories of management needs, as discussed below.

The watersheds and subbasins were evaluated to:

1. Identify regional priorities among the 21 watersheds.
2. Identify priorities among the subbasins within each watershed.
3. Identify priorities among the 78 subbasins across the study region.

Restoring Stream Water Quality
(water quality conditions and resources at risk)

Federal and State Laws mandate three major programs dealing with reducing polluted stormwater runoff. These are: the development of TMDLs for water quality impaired stream segments, the new NPDES Phase II Stormwater Permitting Program, and the Section 319 (Federal Clean Water Act) Nonpoint Source Management Program. Because 70% of the watersheds are source waters for public water supply intakes, prioritization for source water protection planning and implementation is also critical. This prioritization exercise considered water quality conditions as well as "sensitive resources" (as defined in Part 4) and cultural features that are at risk from increased stream impairments. Both watersheds and subbasins were prioritized for water quality restoration.

Restoring Stream Water Quality
(water quality conditions only)

This prioritization is similar to the one described above except that the criteria representing the value of sensitive resources or cultural/recreational values were not included. This prioritization focused solely on water quality parameters, with more highly impaired streams ranked higher in the priority list. It provides information to help prioritize watersheds for implementation and funding for water quality related programs. Both watersheds and subbasins were prioritized for water quality restoration.

Reducing Stormwater Runoff and Flooding

If conventional development following the historical sprawl pattern continues, the rate and volume of stormwater runoff will continue to increase, the magnitude and frequency of flooding will increase, and the destruction of streams by the force of these waters will be exacerbated. Municipal comprehensive stormwater management is needed in all areas to minimize these problems. The study area watersheds and subbasins were prioritized to identify those areas in most critical need of stormwater management programs to reduce the rate and volume of runoff. This prioritization will also assist Chester County in determining the sequence of conducting stormwater management plans under Act 167.

Protecting Stream Resources

Because of the extensive number of "sensitive resources" (i.e., designated habitats and special protection waters, etc.), the regional importance of the aesthetic, recreational and cultural values of the watersheds, and the widespread use of the streams for public water supply, it is important to focus preservation and protection efforts to maintain these vital resources. Thus, the study watersheds and the subbasins were also prioritized for protecting resources.

Protecting Ground Water (used for subbasin prioritization only)

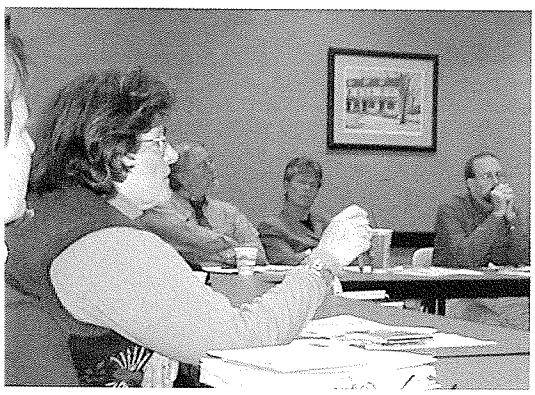
Because of the high reliance on ground water to support water supply needs and stream baseflows throughout the region, ground water protection efforts are extremely important. This includes managing water use decisions to protect against over-withdrawal, protecting ground water from contamination attributable to land uses and septic system wastewater disposal, and source water protection of public water supply wells. Only subbasins were prioritized for ground water protection because subbasins provide a more appropriate size of land area for evaluating impacts of ground water withdrawals.

The Prioritization Process

Subbasin and watershed prioritizations were carried out using decision support software. In brief, this software, called EVAMIX, is a matrix based, multi-criteria evaluation program that makes use of both quantitative and qualitative criteria within the same evaluation, regardless of the units of measure. This feature gives the software great flexibility and allows the evaluation to consider all of the data available in its original form.

The prioritization process compared each of the watersheds or subbasins against the other watersheds or subbasins using relevant evaluation criteria. Because of the number of criteria selected and the inherent subjectivity in attempting to weight criteria, all criteria were considered equally important and therefore were assigned equal weight. Final priorities were assigned based on the evaluation results and several discussions held with the Water Resources Task Force. Each evaluation resulted in a comparative ranking of the watersheds or subbasins, with those ranked highest recommended for immediate attention and funding.

The *Compendium* describes in detail the sets of criteria that were developed for the evaluations and prioritizations of all watersheds and/or subbasins as well as the EVAMIX model. Only the results are presented here.



The *Compendium* presents the results of the evaluations in three groups. The first group represents those watersheds (or subbasins) that should be considered as having the highest priority for water quality improvement actions. The second group lists those watersheds (or subbasins) that fall in the medium priority range. Finally, the third group represents those watersheds (or subbasins) that fall in the low priority range. The priorities are intended as a guide for deciding which watersheds should be targeted first. A "low" priority only means that other watersheds (or subbasins) may require more pressing action, not that the "low priority" watershed (or subbasin) should not come into consideration for restoration or protection measures.

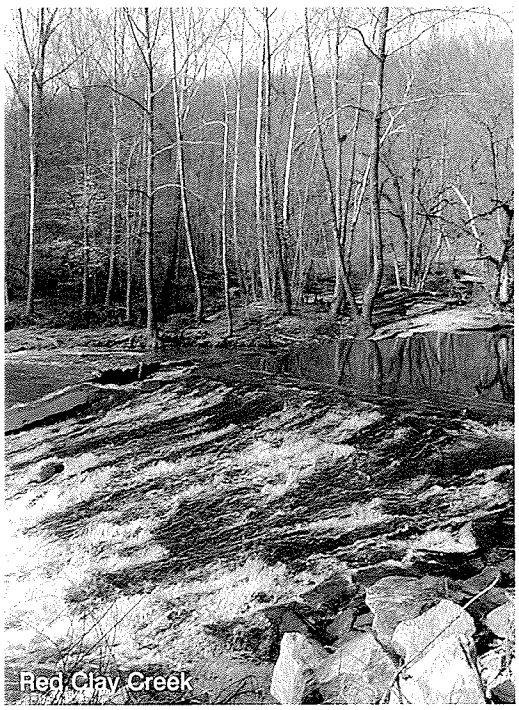


Figure 5-1: Overall Highest Priorities

Watersheds ranked as highest priorities for overall management needs

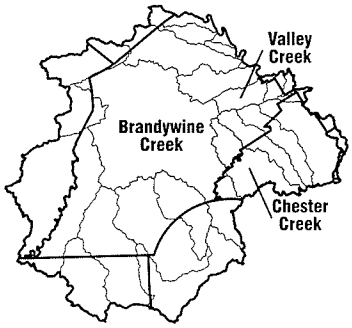
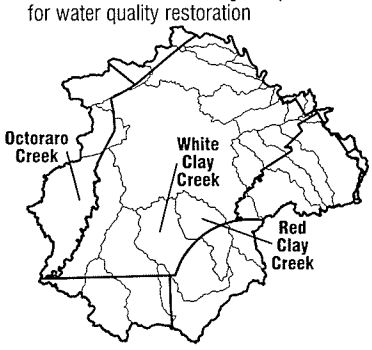


Figure 5-2: Water Quality Restoration

Watersheds ranked as highest priorities for water quality restoration



Regional Watershed Priorities

Table 5-1 presents the results of the prioritization exercises conducted for the 21 watersheds. Included in Table 5-1 are the watersheds of Chester County that ranked as "high priority" in each of 4 categories, as well as those that ranked as medium and low priorities.

The prioritizations for restoring stream water quality provide insight into the watersheds that would gain the most benefit from actions such as nonpoint source pollution reduction and management. The prioritization for reducing stormwater runoff and flooding provides guidance on which watersheds should be targeted for stormwater management planning.

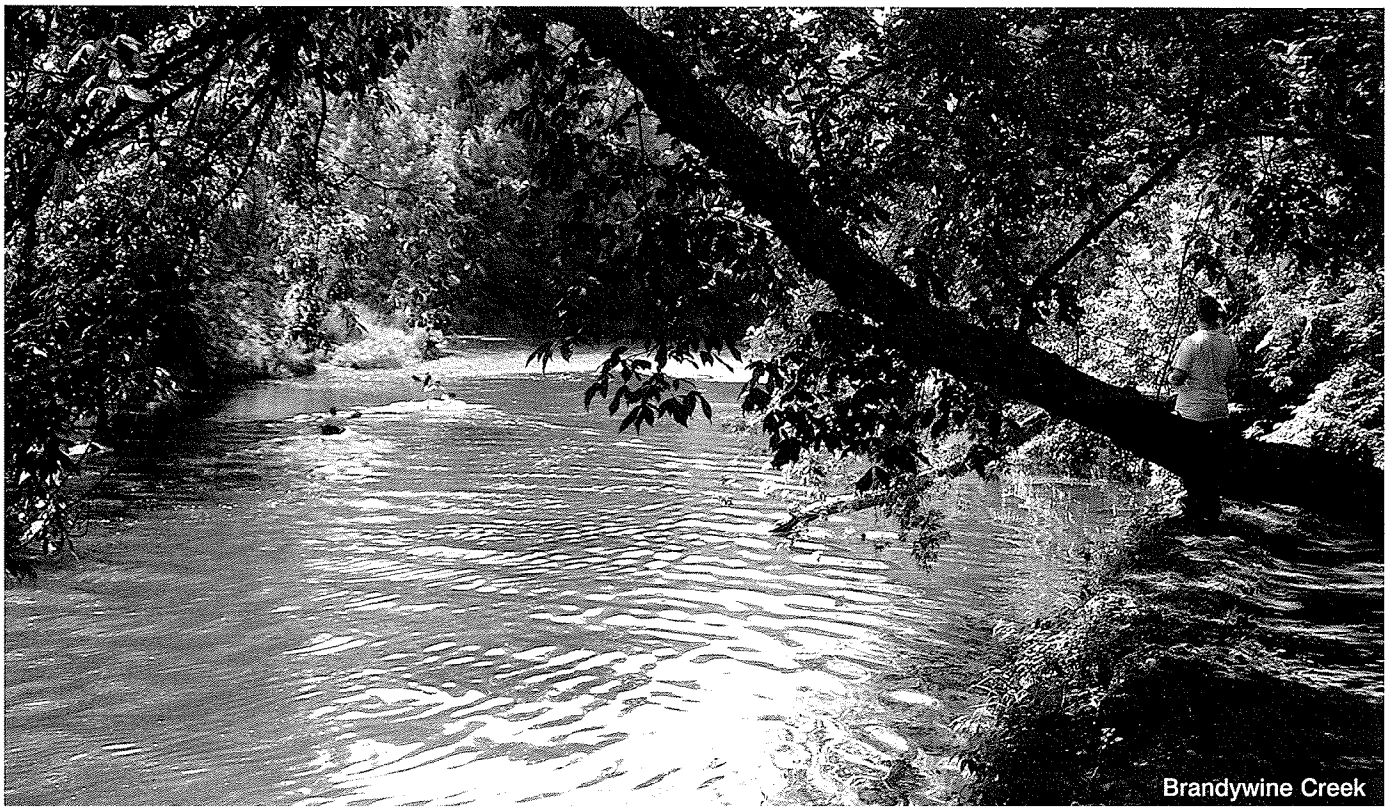
Stormwater management planning and implementation of stormwater quality BMPs would also contribute to restoration of water quality. Thus, considering the combined results of the water quality restoration and stormwater categories can help to further focus priorities. Valley Creek, Chester Creek and Brandywine Creek each ranked as high priority watersheds in all three of the restoration and stormwater reduction categories, providing a rationale for placing overall priority on those three watersheds (Figure 5-1).

Red Clay Creek, Octoraro Creek, and White Clay Creek ranked as high priority watersheds in both of the water quality restoration categories, providing a rationale for priority implementation of nonpoint source BMPs and management actions (Figure 5-2). Trout Creek, Darby Creek and the Schuylkill River drainages all ranked as high priorities in the water quality restoration (conditions only) and stormwater runoff categories. This provides a rationale to address these three watersheds as priorities for improved management of stormwater runoff.

Table 5-1:
Results of Prioritization of Chester County Watersheds

Ranking	Restoring Stream Water Quality (conditions and sensitive resources)	Restoring Stream Water Quality (conditions only)	Reducing Stormwater Runoff and Flooding	Protecting Stream Resources
High Priority	Valley Creek (East) Red Clay Creek Chester Creek Brandywine Creek Octoraro Creek White Clay Creek	Christina River Octoraro Creek White Clay Creek Valley Creek (East) Chester Creek Trout Creek Darby Creek Red Clay Creek Brandywine Creek	Brandywine Creek Trout Creek Chester Creek Darby Creek Christina River Valley Creek (East) Schuylkill River drainages	Brandywine Creek French Creek White Clay Creek Octoraro Creek Pickering Creek Stoney Run
Medium Priority	Ridley Creek Trout Creek Christina River Elk Creek Schuylkill River drainages Darby Creek French Creek Stony Run	Elk Creek Schuylkill River drainages Ridley Creek Gulph Creek Conestoga Creek Stony Run Pequea Creek	Crum Creek Octoraro Creek White Clay Creek Red Clay Creek Pickering Creek French Creek	Valley Creek (East) Chester Creek Ridley Creek Elk Creek Pigeon Creek Schuylkill River drainages Pequea Creek Christina River
Low Priority	Pickering Creek Conestoga Creek Crum Creek Gulph Creek Pequea Creek Pigeon Creek Northeast Creek	Pickering Creek Crum Creek Northeast Creek French Creek Pigeon Creek	Conestoga Creek Ridley Creek Gulph Creek Stony Run Creek Elk Creek Pequea Creek Pigeon Creek Northeast Creek	Crum Creek Northeast Creek Conestoga Creek Gulph Creek Red Clay Creek Trout Creek Darby Creek

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)



Brandywine Creek

Regional Subbasin Priorities

The same prioritization process was used for ranking the 78 subbasins that comprise the 21 watersheds. Subbasins were prioritized for the same four categories used for the watershed prioritizations, and also were prioritized for a fifth category of ground water protection. To the extent possible, the same or similar criteria were used as those in the watershed prioritizations. For some of the evaluation criteria, data were not available on a subbasin level (e.g. water quality for ground water and surface water), and substitute criteria were developed or the criteria were not applied. In other cases, new criteria more relevant to the subbasins were applied (e.g. percent of land area within first order drainage areas). Table 5-2 presents the subbasins that ranked as high priorities and that are located entirely or partly within Chester County for each of the five categories. The location of the subbasins are shown in Figure 5-3. The detailed rankings of all 78 subbasins are presented in the *Compendium*.

The results of the first water quality restoration rankings (water quality conditions and resources at risk) can be used to identify those subbasin(s) that are most in need of water quality management activities, considering both the resources at risk and the degree of degradation of water quality. The results of the second water quality ranking (water quality conditions only) provide a useful guide for prioritizing impaired streams for TMDL implementation, based solely on water quality degradation.

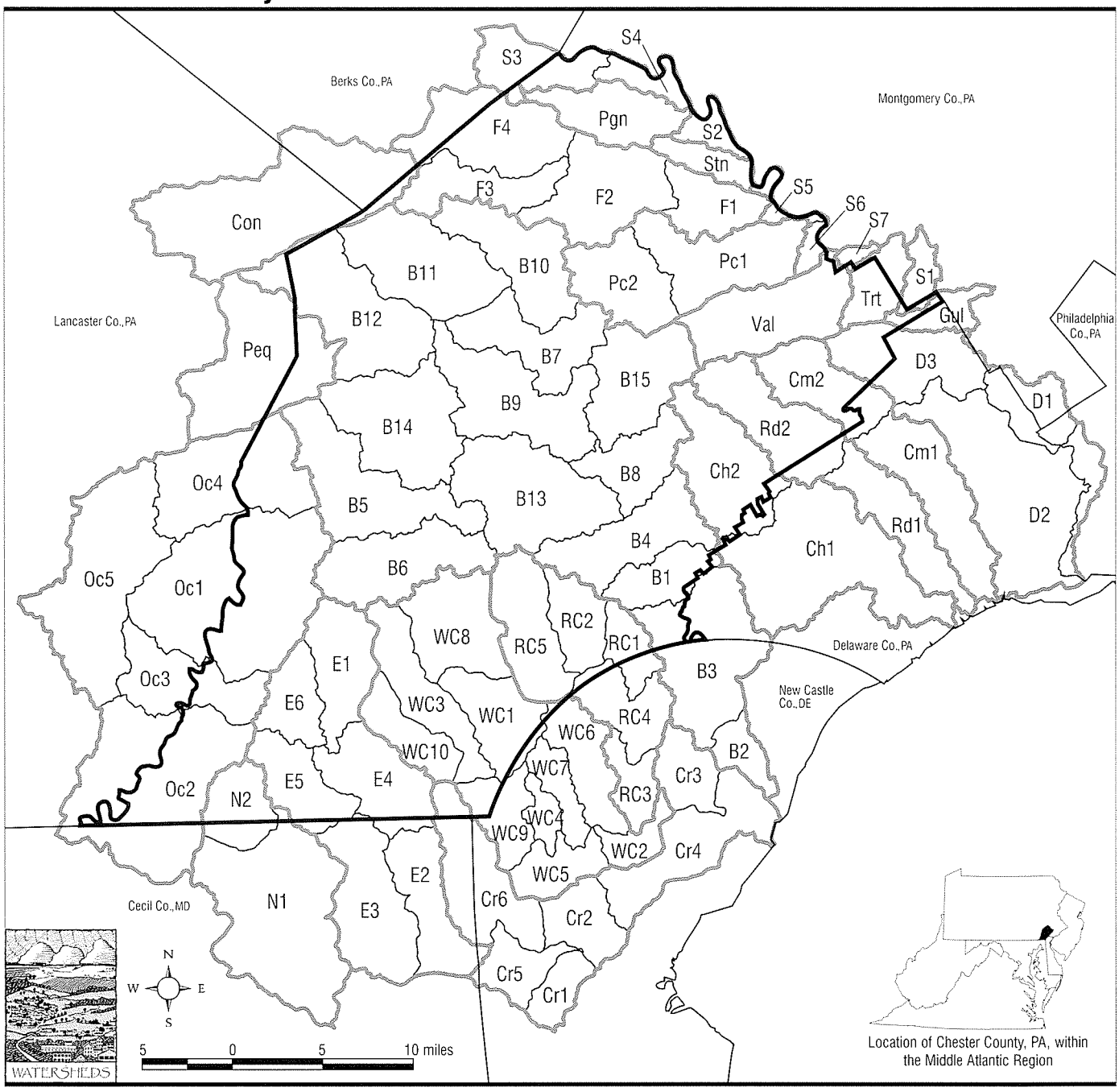
The stormwater ranking identifies those subbasins that appear to be most stressed by impacts of stormwater runoff. This prioritization can assist in targeting local areas for implementation of municipal comprehensive stormwater management ordinances and programs.

Table 5-2:
Highest Priority Subbasins Located Within Chester County

Restoring Stream Water Quality (conditions and sensitive resources)	Restoring Stream Water Quality (conditions only)	Reducing Stormwater Runoff and Flooding	Protecting Stream Resources	Ground Water Protection
West Valley Creek (B15)	Lower East Branch Octoraro Creek (Oc1)	Middle French Creek (F2)	West Valley Creek (B15)	West Valley Creek (B15)
West Branch Brandywine Creek/ Rock Run/Sucker Run (B14)	West Valley Creek (B15)	West Valley Creek (B15)	Brandywine Creek/ Pocopson (B4)	Marsh Creek (B10)
Upper East Branch Octoraro Creek (Oc4)	West Branch White Clay Creek (WC10)	Trout Creek (Trt)	Upper Pickering Creek (Pc2)	Brandywine Creek/ Pocopson (B4)
East Valley Creek (Val)	Lower White Clay Creek (WC2)	Lower White Clay Creek (WC2)	Lower Octoraro Creek (Oc2)	Brandywine Creek above Chadds Ford (B1)
Lower Octoraro Creek (Oc2)	Middle Branch White Clay Creek (WC3)	East Valley Creek (Val)	Marsh Creek (B10)	Upper Pickering Creek (Pc2)

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Figure 5-3:
Subbasins in the Study Watersheds



Chester County
Adjacent county

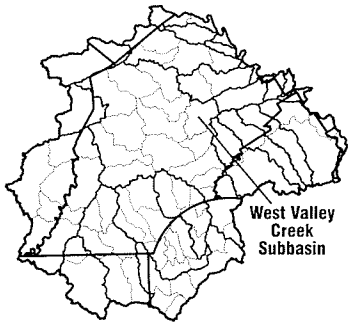
Watershed
Subbasin

RC3 The labels within each subbasin correspond to the Subbasin Code, which is listed in Tables 5-2, 6-4 and 6-5.

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Figure 5-4: West Valley Creek Subbasin Ranked Highest

West Valley Creek subbasin ranked as the highest priority for overall management needs



The ranking of stream preservation can be used to prioritize subbasins for efforts focused on protection of stream resources, riparian corridor protection, land conservation and acquisition programs, and other habitat protection programs.

The ground water protection ranking is intended as a first guide to priorities for measures to protect ground water from over-withdrawal and to protect ground water sources of public drinking water supplies.

West Valley Creek subbasin consistently ranked first or second among all 78 subbasins in each of the 5 categories (Figure 5-4). This provides a rationale for focusing on this subbasin as an overall priority area for stormwater management, nonpoint source pollution management, ground water protection, and resources protection.

Priority Management Objectives and Action Plans

The results and conclusions drawn from the various analyses and data collection efforts summarized in Part 3, combined with the results and conclusions drawn from the prioritization exercises presented above were synthesized to prepare an inventory of specific watershed management needs for each of the 21 watersheds. These inventories are presented in Part 10. From these inventories, a set of priority management objectives were prepared, as presented in Table 5-3. The inventory of management needs, and listing of priority management objectives set the framework for implementing restoration, protection and other management actions within each watershed.

To assist municipalities and conservation organizations in addressing these management needs and priorities, individual "watershed action plans" have been published separately for each of the 15 largest watersheds within Chester County. The individual watershed action plans were developed to:

- Assist in implementing the recommendations and conclusions of *Watersheds* within each watershed.
- Recommended specific priorities for implementation within each watershed.
- Support local watershed planning and implementation of Rivers Conservation Plans, Wild and Scenic River management plans, etc.
- Assist municipalities, watershed associations, water suppliers, and other stakeholders, managers and decision-makers to establish land and water management strategies that address the priorities of each watershed.

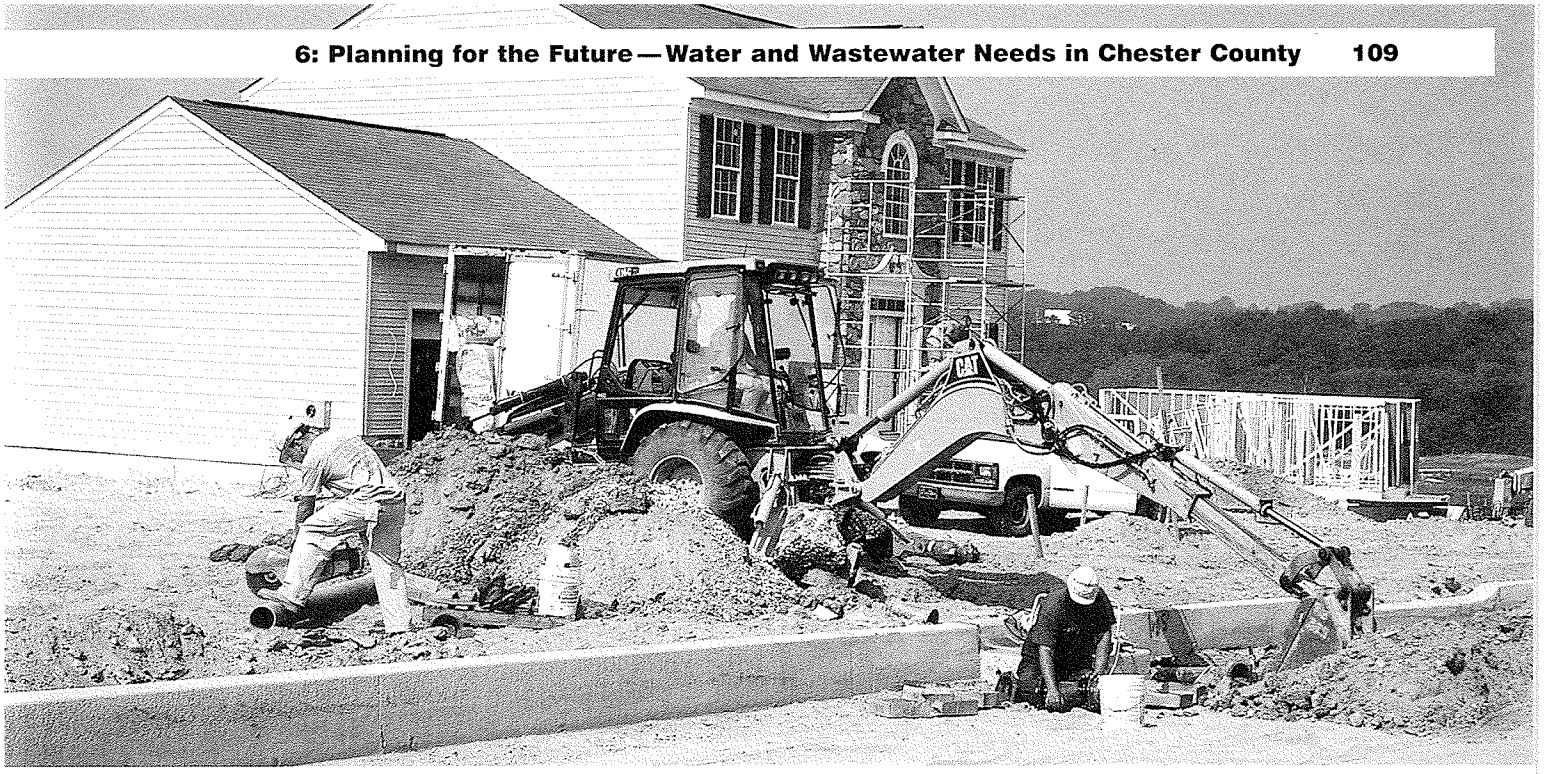
These watershed action plans present the relevant data, information, mapping, and results for each watershed. They also present the management needs, priority management objectives, and recommended actions to be undertaken in each watershed. Recommendations of which entities should be involved and generalized implementation costs are also included in the action plans. Recommendations for Integrated Water Resources Planning to address future water supply and wastewater issues are also included.

Table 5-3:
Priority Management Objectives for 21 Individual Watersheds

Watershed	Priority Management Objectives
Brandywine Creek	1) Reduce stormwater runoff. 2) Restore water quality of "impaired" streams. 3) Protect vegetated riparian corridors. 4) Increase public access to streams. 5) Undertake integrated water resources planning for growth areas. 6) Implement other source water protection measures for water supply intakes,reservoirs and wells. 7) Protect/enhance water-based cultural, historic and recreational resources.
Chester Creek	1) Reduce stormwater runoff. 2) Restore water quality of "impaired" streams. 3) Protect vegetated riparian corridors. 4) Increase public access to and recreational use of streams. 5) Implement other source water protection measures for water supply intakes, reservoirs and wells.
Christina River	1) Restore water quality of "impaired" streams. 2) Reduce stormwater runoff. 3) Protect vegetated riparian corridors. 4) Protect/enhance water-based recreation and public access.
Conestoga Creek	1) Restore water quality of "impaired" streams. 2) Protect ground water quantity.
Crum Creek	1) Reduce stormwater runoff. 2) Restore water quality and channel stability of "impaired" streams. 3) Protect vegetated riparian corridors. 4) Increase public access to and recreational use of streams. 5) Protect/enhance water-based historic, cultural resources. 6) Implement other source water protection measures for water supply intakes and reservoirs.
Darby Creek	1) Reduce stormwater runoff. 2) Restore water quality of "impaired" streams. 3) Increase public access to and recreational use of streams.
Elk Creek	1) Protect ground water resources. 2) Implement comprehensive stormwater management. 3) Protect vegetated riparian corridors. 4) PADEP assess streams. 5) Increase public access and recreational use of streams. 6) Reduce nonpoint source pollutant runoff. 7) Undertake integrated water resources planning for growth areas.
French Creek	1) Implement comprehensive stormwater management. 2) Protect water quality from nonpoint source pollutants. 3) Protect vegetated riparian corridors. 4) Protect first order streams. 5) Protect/enhance water-based cultural, historic, recreational resources and public access. 6) Undertake integrated water resources planning for growth areas.
Gulph Creek	1) Reduce stormwater runoff. 2) Restore ground water balance.
Northeast Creek	1) Protect ground water resources. 2) Implement comprehensive stormwater management. 3) Protect vegetated riparian corridors. 4) PADEP assess streams. 5) Protect first order streams. 6) Reduce nonpoint source pollutant runoff.

(Table 5-3 continued)

Watershed	Priority Management Objectives
Octoraro Creek	1) Restore water quality of "impaired" streams and ground water. 2) Reduce agricultural nonpoint source pollutants. 3) Implement comprehensive stormwater management. 4) Protect vegetated riparian corridors. 5) Increase public access and recreational use of streams. 6) Implement other source water protection measures for water supply intakes, reservoirs, and wells. 7) Protect/enhance water-based cultural, historic resources.
Pequea Creek	1) Implement comprehensive stormwater management. 2) Restore water quality of "impaired" streams. 3) Protect first order streams.
Pickering Creek	1) Implement comprehensive stormwater management. 2) Protect vegetated riparian corridors. 3) Protect first order streams. 4) Increase public access to and recreational use of streams. 5) Undertake integrated water resources planning for growth areas. 6) Implement other source water protection measures for water supply intakes and reservoirs. 7) Protect/enhance water-based cultural, historic resources.
Pigeon Creek	1) Implement comprehensive stormwater runoff management. 2) Protect vegetated riparian corridors. 3) Protect first order streams. 4) Protect ground water quality and quantity. 5) Undertake integrated water resources planning for growth areas.
Red Clay Creek	1) Reduce stormwater runoff. 2) Restore water quality of "impaired" streams. 3) Protect vegetated riparian corridors. 4) Protect first order streams. 5) Increase public access to and recreational use of streams. 6) Undertake integrated water resources planning for growth areas.
Ridley Creek	1) Reduce stormwater runoff. 2) Protect vegetated riparian corridors. 3) Protect/enhance water-based recreation, cultural, historic resources and public access. 4) Implement other source water protection measures for water supply intakes and reservoirs.
Schuylkill River Drainages	1) Implement comprehensive stormwater management. 2) Restore water quality of "impaired" streams. 3) Protect vegetated riparian corridors. 4) Increase public access to and recreational use of streams. 5) Protect ground water balances.
Stony Run	1) Implement comprehensive stormwater management. 2) Protect ground water quality and quantity. 3) Protect vegetated riparian corridors. 4) Undertake integrated water resources planning for growth areas.
Trout Creek	1) Reduce stormwater runoff. 2) Protect first order streams. 3) Protect ground water quantity and quality. 4) Implement other source water protection measures for water supply wells.
Valley Creek	1) Reduce stormwater runoff. 2) Restore water quality of "impaired" streams. 3) Protect/enhance historic, cultural and recreational resources. 4) Implement other source water protection measures for water supply wells.
White Clay Creek	1) Reduce stormwater runoff. 2) Restore water quality of "impaired" streams. 3) Protect vegetated riparian corridors. 4) Increase public access and recreational use of streams. 5) Undertake integrated water resources planning for growth areas. 6) Implement other source water protection measures for water supply intakes and wells. 7) Protect/enhance historic, cultural resources.



Planning for Future Water and Wastewater Needs

Integrated Water Resources Planning

The Need for "Integrated" Planning

The 2000 amendments to the Municipalities Planning Code (MCP) (Acts 67 and 68) call for water supply planning as part of local comprehensive plans, and provide for multi-municipal planning and zoning. The limitations of available water resources to support water supplies for planned growth are to be considered in the municipal water supply planning. Collectively, these legislative provisions encourage and support municipalities in preparing plans to address the inter-relationships between natural water resources, future water supply needs, and land use planning on a multi-municipal basis. This planning also provides the opportunity to guide the placement of infrastructure to support growth in desired areas, and protect rural areas from undesired growth, consistent with municipal land use planning objectives and policies.

The existing urbanized areas of Chester County are scattered and relatively small. There is no single center of growth as is found in many other counties. Growth areas extend across subbasin boundaries and often rely on resources from adjacent subbasins that are shared with other municipalities for water supply or wastewater disposal. Thus, planning for efficient and economically viable future water and wastewater expansion by utilities sometimes includes extending infrastructure through areas where growth is not desired or appropriate. This type of expansion can create conflicts with growth management planning that attempts to protect these rural and natural areas from undesired growth. Through integrated planning, such conflicts can be avoided and/or resolved.

It is critical that municipal and utility planning be done in a closely coordinated manner to concentrate growth in the most appropriate areas, protect rural areas from undesired growth, provide for reliable and economic water and wastewater service, and maintain the integrity of the natural resources of the supporting subbasins. The concept of "Integrated Water Resources Planning" has recently been introduced as a process that can address these inter-related issues and it is recommended here for use by municipalities.

Water and wastewater utilities operating in Chester County have and continue to conduct a significant amount of planning to insure safe and reliable service to meet future needs. It is important to recognize the valuable role utilities have played in infrastructure planning in years past and incorporate such efforts into future planning activities. In addition to planning for future water and wastewater needs, such utility planning has addressed troubled rural water systems, protection of source waters and riparian lands, and renovated and upgraded failing sewage systems. The term "utilities," as used throughout ***Watersheds,*** refers to all public water and/or wastewater systems, regardless of ownership by municipality, municipal authority, investors, or private entity.

The intent of integrating the utility and municipal planning processes is not to circumvent the work of either the utilities or the municipalities, but rather to enhance the coordination between them to jointly provide for growth management in an organized and consistent manner and to respect their shared values (by the public, municipality[ies], and utility[ies]) of the natural resources.

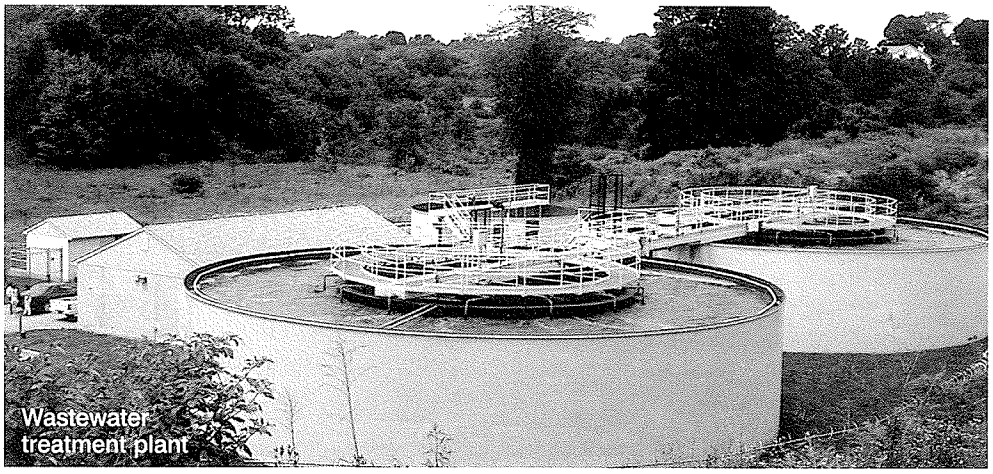
What Is "Integrated Water Resources Planning?"

Integrated Water Resources Planning can bring together the utilities and the municipalities' planning objectives into one process. This allows planners to evaluate more specifically the resource protection needs in their subbasin(s) and identify strategies to provide water and wastewater service to support future planned growth. *Watersheds* was developed as a County-wide Integrated Water Resources Plan to establish a framework and guidance for similar planning at the municipal level. The Integrated Water Resources Planning process allows for consideration of:

- Ground water and surface water availability and limitations.
- Whether or not new sources of supply are needed and, if so, how to evaluate and select such sources.
- The quality and quantity of water available.
- The implications of selected alternatives for achieving planning goals and for the quality and quantity of the natural resources.

Because water supply and wastewater planning must be done in concert with local planning objectives, interests and needs, it must be accomplished at the municipal level, and in close coordination with the utilities that operate within or plan to operate within those municipalities. Thus, Integrated Water Resources Planning must:

- Be done as a multi-municipal effort involving all municipalities that share the resources of common subbasins for water supply and/or wastewater disposal.
- Involve the water supply and wastewater utilities operating within or planning to operate within those municipalities.



- Include the geographic area of the subbasins whose resources are shared by the municipalities and be based upon maintaining the quantity (e.g., ground water balances and dry weather stream baseflows, etc.) and quality (e.g., protection of sources of water supplies from pollutant runoff, etc.) of the water resources of those subbasins.
- Address the growth and land use management objectives of the municipalities as well as the objectives of the utility(ies).
- Consider all reasonable options for meeting new needs, including expanded conservation management practices, available capacity in existing systems, and development of new sources.
- Guide the placement of infrastructure to concentrate growth in designated growth areas and restrict growth in designated rural areas.

The following discussions provide information and general guidance as a framework for municipalities and utilities to integrate water supply and wastewater planning with local comprehensive planning. Presented are the components of the Integrated Water Resources Planning process to assist municipalities with water supply planning. Included are estimates of future demand for public and private water supply for each municipality and subbasin in Chester County. Potential alternatives of sources of water to meet future water demands are discussed. Mapping is presented of areas where public water and wastewater service and *LANDSCAPES* growth areas exist, as well as areas where localized problems were identified that may need to be addressed. Municipalities that choose to initiate Integrated Water Resources Plans are encouraged to contact CCWRA for additional information regarding the planning process.

The focus of this planning discussion is to provide information and guidance to the municipalities of Chester County; however it is also recommended for consideration by the utilities operating within the County. While this planning discussion emphasizes water supply, certain components of wastewater planning and their implications are also considered.

Integrated Water Resources Planning Areas

The geographic area addressed by Integrated Water Resources Planning must extend beyond individual municipal boundaries and is, in fact, defined by subbasin boundaries. This is because ground water and streams function within watershed (or subbasin) boundaries, not municipal boundaries. Figure 6-1 illustrates the extent of geographic areas and municipalities that share the same subbasin resources. Municipalities should consider these areas and contiguous municipalities when defining the area to be included in an Integrated Water Resources Planning effort.

The areas shown in Figure 6-1 consider municipalities that share common resources and the subbasins that provide those resources. Shared infrastructure systems and growth patterns were also considered in these delineated areas. Because there are over 50 subbasins within Chester County, and because all municipalities rely on multiple subbasins for water supply and wastewater disposal, it is not practical to prepare Integrated Water Resources Plans on an individual subbasin basis. By this grouping of subbasins based on shared resources, uses and growth patterns, the County is divided into 12 areas. However, final planning areas should be determined by those involved in the effort and may be larger or smaller than the areas shown in Figure 6-1.

Basic Components of Integrated Water Resources Planning

The Basic Components of Integrated Water Resources Planning are

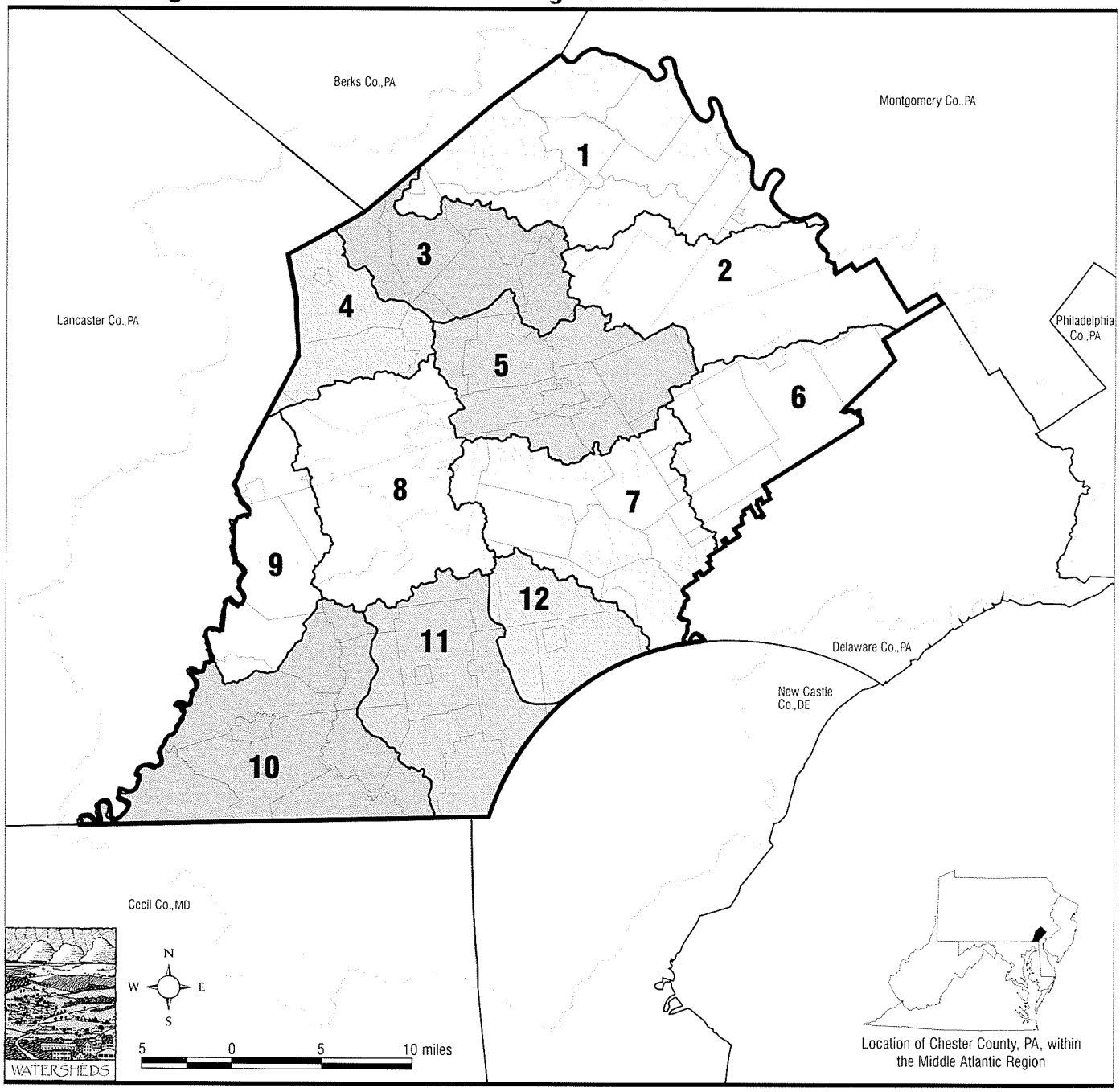
- Identifying planning area and partners.
- Projecting future growth in population and employment.
- Identifying planned public water and wastewater service areas.
- Estimating current and future water demand.
- Identifying potential alternatives for meeting future water demand.
- Identifying constraints.
- Evaluating, selecting and planning for implementation of the alternative(s) that best meet(s) the collective needs and interests of the municipalities, utilities and other stakeholders.

The fundamental purpose of water supply planning and Integrated Water Resources Planning is to determine how much water will be needed, where it will be needed, and the best sources and distribution patterns to use to meet those needs. The following discussions present a sequence of basic steps that form that process. These require the input and participation of both the municipality(ies) and utility(ies). It may be necessary and appropriate to involve other stakeholders in the planning process as well. The individual watershed action plans (discussed in Part 5) recommend priority management objectives and actions that should be considered within Integrated Water Resources Plans.

The planning time frame is also important. Planning to meet future water and wastewater needs must occur well in advance of the time of anticipated shortfall to allow sufficient time for the planning, design, permitting, and construction processes. Such planning periods can range from 1 year (for needs that can be easily addressed by a small system or an inter-connection with a nearby existing utility system) to 5 years (for a new source, treatment facility and connecting infrastructure) to 20 years (for needs that require substantial construction projects). The time frame addressed in LANDSCAPES and *Watersheds* is through 2020.

Each of the basic components of Integrated Water Resources Planning are summarized below. Further guidance and information are available in the *Compendium*. In addition, DRBC has published an Integrated Resources Planning Guidance document that is strongly recommended for use by municipalities undertaking such planning. Data sources, methodology and assumptions for all information provided below are detailed in the *Compendium*.

Figure 6-1:
Potential Integrated Water Resources Planning Partners



Chester County
Adjacent county
Municipality

Areas sharing common resources and/or planning needs

1 Northern Schuylkill
2 Southern Schuylkill
3 Upper East Branch Brandywine/Conestoga
4 Upper West Branch Brandywine/Pequea
5 East Branch Brandywine
6 Delaware
7 Lower Brandywine
8 West Brandywine
9 Octoraro
10 Chesapeake/Lower Octoraro
11 White Clay/Christina
12 Red Clay

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Projecting Future Growth in Population and Employment

The first step in evaluating water supply needs is to obtain best available estimates of current population and projected growth in the planning region. Estimates of future water supply needs can then be easily developed based on those population projections. It is important to include current and projected commercial and industrial growth as well. One method of estimating these needs is to include employment statistics in the estimating process. Table 6-1 (found at the end of Part 6) presents 1998 and 2020 population and 1997 and 2020 employment estimates and projections for each municipality based on data published by CCPC and DVRPC. (The 2000 Census data were not yet available when these analyses were conducted.)

These data indicate that the total Chester County population was estimated to be about 421,700 in 1998, and was projected to grow by about 106,100 persons (or 25%) by 2020. Total projected population for 2020 is about 527,800. The municipalities with the largest projected population increases are Uwchlan, Upper Uwchlan, West Bradford, West Whiteland and West Brandywine Townships. Municipalities with the greatest projected increases in employment are West Whiteland, East Whiteland, Tredyffrin, East Goshen and Uwchlan Townships.

Identifying Planned Public Water/Wastewater Service Areas

The most immediate need for municipalities to address is the delineation of areas planned for future public water and/or wastewater service that are consistent with their municipal comprehensive planning and zoning and *LANDSCAPES*. This delineation can be a relatively easy exercise using the Urban, Suburban, Suburban Centers, and Rural Centers landscapes identified in *LANDSCAPES* (see Figure 1-5). These represent the areas that *LANDSCAPES* encourages utility services to be focused within, thereby protecting the Rural and Natural landscape areas. Municipalities may choose to refine these boundaries based on local planning, and existing service areas that already occur in Rural landscapes. Municipalities should also consider existing service and franchise areas within or near their municipalities.

It is important to understand the terminology applied to different types of utilities with regard to "planning," "service" and "franchise" areas:

- "Franchise" area or territory is that area that has been "certificated" or officially assigned by the PUC to an investor owned utility. This represents an area in which only one PUC-regulated utility can provide future service. (However, in other areas of Pennsylvania, PUC has reportedly granted overlapping franchise areas to more than one utility.) A PUC-regulated utility can serve within any municipality provided the utility obtains PUC certification for that area, and, further provided there are no conflicts with existing infrastructure from another private or public utility.
- Municipal authorities are governed by the Municipal Authorities Act of 1945 and can serve areas where a need for service is established. Municipal authorities are neither required nor have a statutory right to be assigned "franchise" areas and are not governed by the PUC (except for limited regulation where a utility

operating as a department of a municipality serves areas outside of its originating municipality).

- "Service" area is used to refer to areas that are receiving (or planned to receive) utility service connections to customers. These are not "officially" designated by any agency and are merely a delineation of where existing service connections are located for any utility. For PUC-regulated utilities, the service area must lie within their franchise area.
- "Planned service" area is used to refer to areas where a municipality has indicated a need for future water and/or wastewater service to customers by public systems to support planned growth (i.e., planned growth areas).

Municipalities and utilities should work together to ensure that future "franchise" areas do not exceed the bounds of the municipality's "planned service" area. Municipalities should also incorporate their planned service areas within their comprehensive plans and zoning to insure consistent implementation and that both franchise and service areas are consistent with designated growth areas or areas experiencing localized problems.

Another important consideration in determining water and wastewater service areas is to coordinate municipal and utility planning with County planning, such as *LANDSCAPES*. Such coordination should occur prior to finalizing plans for expansion or submitting requests for state approvals.

It is recommended that the areas within the designated *LANDSCAPES* planned growth areas be used as areas designated for water and wastewater utility expansion. To achieve the vision of *LANDSCAPES*, Figure 6-2 shows the "landscapes" where public water infrastructure should be guided to, as well as existing public water service areas and areas where localized ground water problems have been identified that may need to be addressed. Figure 6-2 also presents similar information for wastewater, as well as existing public wastewater service areas, and areas where localized problems have been identified (i.e., failing septic systems, etc.). These maps provide the recommended basis for delineating future water and wastewater planning areas and for developing plans for addressing water and wastewater needs in the Rural landscape areas. Figure 6-3 presents a map showing existing public water supply service and franchise areas, and names of the major water supply utilities. Table 6-2 (found at the end of Part 6) lists the small community systems shown on Figure 6-3.

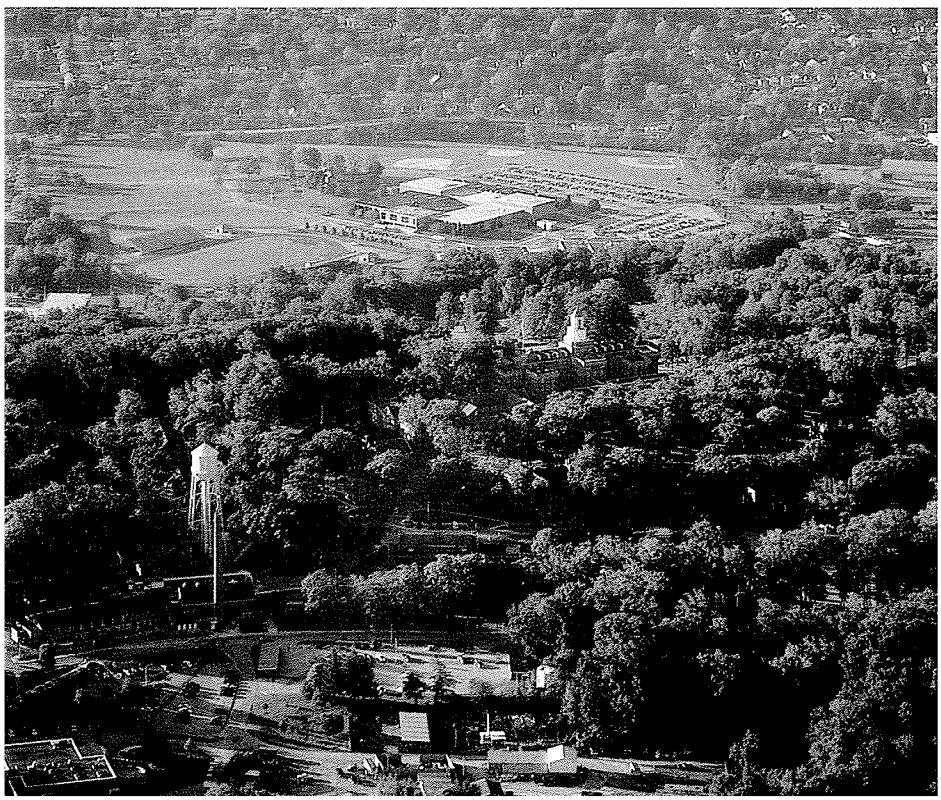
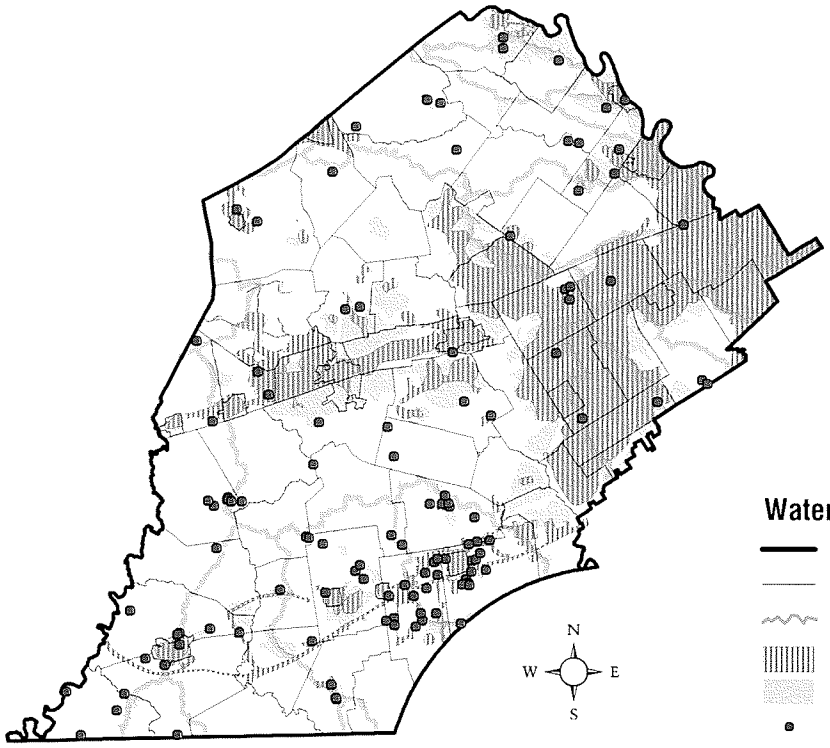
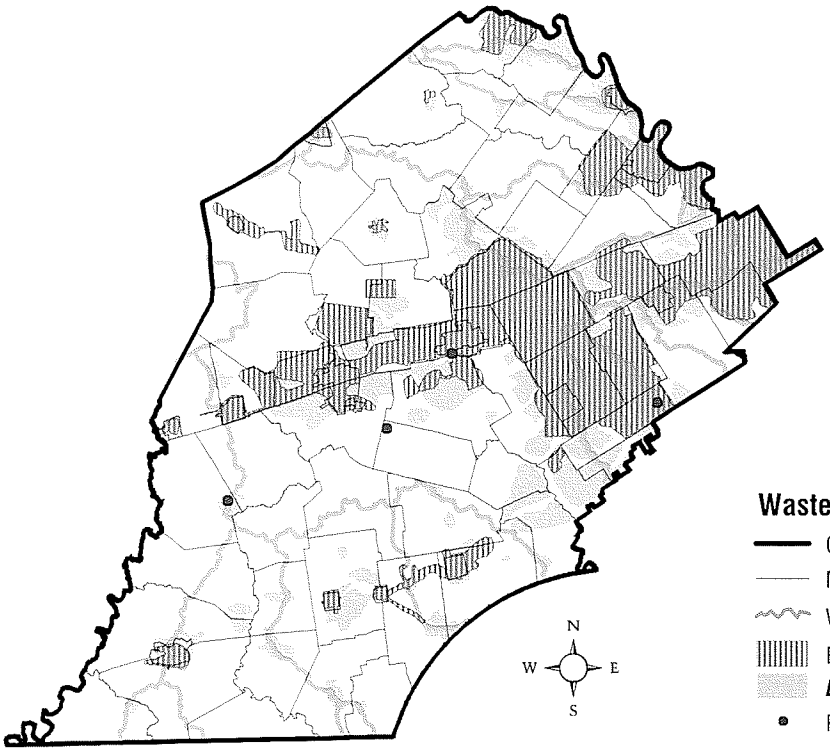


Figure 6-2:
Areas of Future Need and Growth—Water and Wastewater



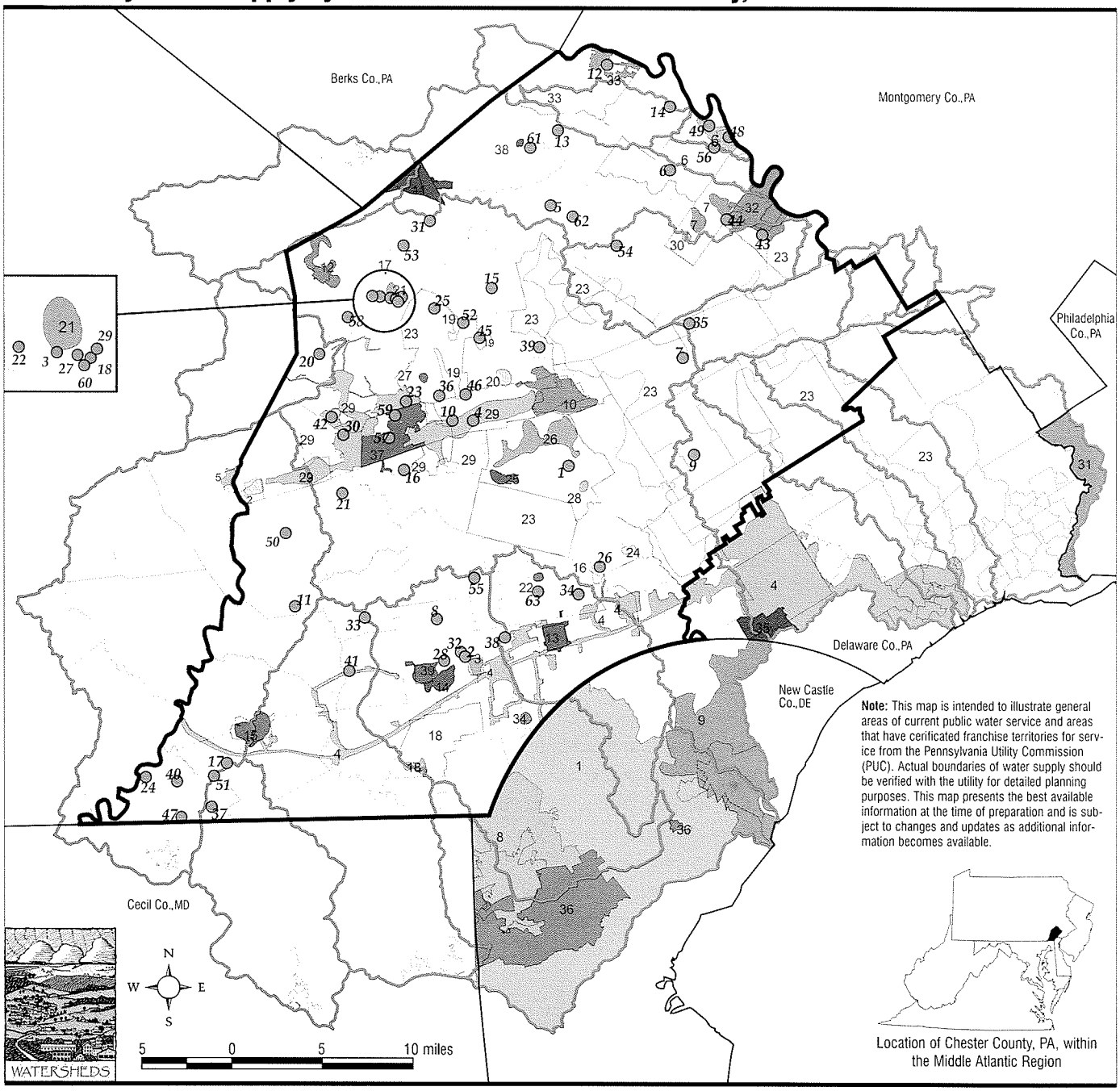
Water
- Chester County
- Municipality
- Watershed
- Existing water service areas
- ***Landscapes*** planned growth area
- Reported location of water problem



Wastewater
- Chester County
- Municipality
- Watershed
- Existing wastewater service areas
- ***Landscapes*** planned growth area
- Reported location of wastewater problem

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Figure 6-3:
Community Water Supply Systems in and Near Chester County, PA



Chester County
Adjacent county
Municipality
Watershed
16 Small community water suppy system
Number associated with each point corresponds to the number in Table 6-2

Areas of existing water service

1 Artesian Water Company
2 Atglen Borough Water Dept.
3 Avondale Borough Water Dept.
4 Chester Water Authority
5 Christiana Borough Water Dept.
6 Citizens Utilities Home Water Co. Main System
7 Citizens Utilities Home Water Co. Merlin Hills System
8 City of Newark
9 City of Wilmington
10 Downingtown Municipal Water Authority
11 Elverson Water Company
12 Honey Brook Borough Water Authority
13 Kennett Square Municipal Waterworks
14 London Grove Township Municipal Authority
15 Oxford Borough Water Department
16 PSWC - Beversrede System
17 PSWC - Cupola Court
18 PSWC - Franklin Water Co.
19 PSWC - Friendship Water Co. Little Washington System
20 PSWC - Friendship Water Co. Locust Knoll System
21 PSWC - Grandstaff Water Co.
22 PSWC - La Reserve Water Co.
23 PSWC - Main System
24 PSWC - Pocopson System
25 PSWC - Spring Run Water Co. B & E Water System
26 PSWC - Spring Run Water Co. Spring Run System
27 PSWC - Woodbrooke Sysstem
28 PSWC. - Spring Run Water Co. Marshallton Manor System
29 Penn American - City of Coatesville Authority
30 Penn American - Fox Knoll Water Co.
31 Philadelphia Water Department
32 Phoenixville Borough Water Dept
33 Pottstown Borough Water Department
34 Shangrala Water Co.
35 United Water Bethel
36 United Water Delaware
37 Valley Twp.
38 Warwick Water Works
39 West Grove Borough Water Department
Franchise area where no water service currenty exists.

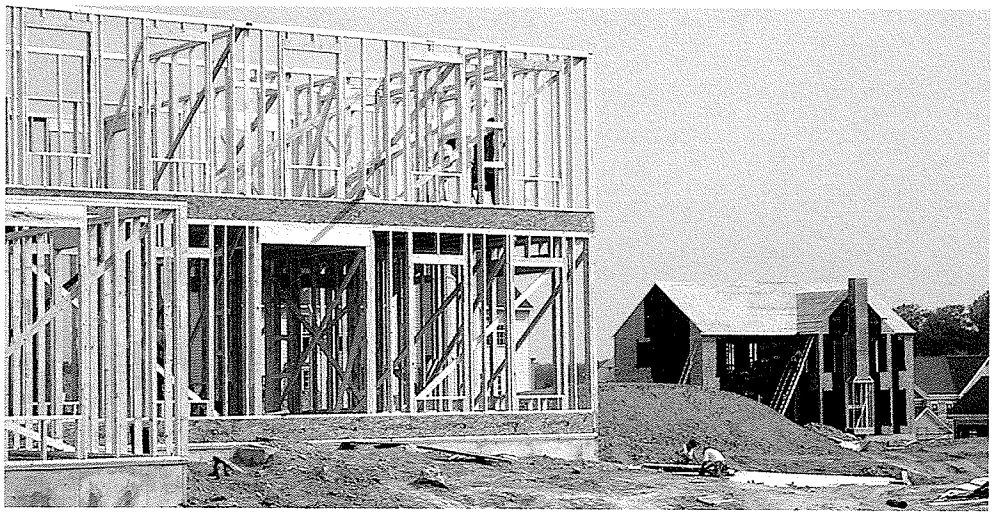
Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Based on the policies of *LANDSCAPES,* the following guidelines are recommended for determining where public water and wastewater infrastructure should and should not occur:

- Restrict the extension of sewer and water facilities in Rural and Natural landscapes.
- Support the use of satellite systems and service areas to meet the needs of Rural Centers, Villages, cluster communities and other isolated developed areas surrounded by Rural landscapes and where:
  a) Ground water quality is unsafe and in-home treatment is not practicable,
  b) The quantity of ground water resources or well yields are no longer sufficient to provide safe and reliable supplies to existing individual well users,
  c) Cluster communities are planned and individual septic systems (on-lot or off-lot) are not a viable alternative,
  d) Septic discharges have significantly impaired ground water quality, and/or
  e) Local conditions create widespread septic system failures or failed percolation tests.
- Encourage expansion of existing water and wastewater facilities to support planned growth within Urban and Suburban landscapes, and Suburban Centers. Where housing densities are greater than 1 dwelling unit per acre, community wastewater service is recommended; where densities are greater than 2 dwelling units per acre, community wastewater service should be required.

Because of the decentralized growth patterns of Chester County, the extension of water and wastewater infrastructure through rural areas should be avoided to the maximum extent practicable. Such extension through Rural and Natural landscape areas may be plausible where it has been determined jointly by the municipality(ies) and utility through an alternatives evaluation process to be the most suitable solution to meet both the identified need and comprehensive planning objectives, and where both the municipality(ies) and utility have jointly committed to implementing measures to avoid undesired connections and growth along the rural pipeline corridor.

Wastewater treatment plant



Estimating Current and Future Water Demand

Based on the delineation of planned or desired public water/wastewater service areas, some assumptions must be made regarding what percentage of projected population and employment growth will occur within those areas, and what percentage will occur within rural areas. These distinctions can then be used to develop estimates of current and projected water demand (and corresponding wastewater capacity needs) for public supplies and rural supplies. These estimates of water demand can then be compared to existing system capacities and available ground water and stream resources within the planning subbasins to determine how best to meet the additional water demand.

Based on the population and employment statistics discussed above, Table 6-3 (found at the end of Part 6) presents an initial set of average daily water demand estimates for current (1998) and future (2020) water supply and wastewater capacity needs for each of the municipalities in Chester County. The estimates include water demand served by individual residential wells and public water systems. To help account for what areas may need more or less water due to anticipated non-residential water uses (i.e., agricultural, commercial, industrial, turf irrigation, etc.), estimates of water used per day per employee were included in the calculations for public water demand. Assumptions were made regarding the portion of new residential growth that would be concentrated within designated growth areas and rural areas to assist in estimating the water demands for public versus individual water systems.

These estimates represent average daily water demand and are based solely on 1998 and 2020 population and employment projections and per capita water usage of 60 gallons per person per day for residential use (whether on individual well supplies or public water supplies), and 75 gallons per employee per day for public supply areas (as an average of commercial, industrial, institutional, non-agricultural irrigation, and agricultural water use). Estimates of additional wastewater capacity needed assumed an average of 10% of water used would be consumed and not returned as wastewater.

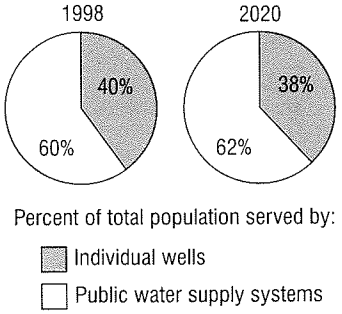
These water and wastewater projections are intended to provide municipalities with a starting point for understanding current and future water demand and

should not be used as absolute planning figures without more detailed local water usage data. For example, per capita water usage by residents and employees will vary from area to area within the County. More importantly, water supply planning and projections should address peak water demand rather than average daily water demand. These estimates and the data on which they are based should be reviewed, updated, and revised to reflect localized water usage conditions in developing detailed projections of increased water and wastewater demand for Integrated Water Resources Plans.

As presented, the total estimate of water used in Chester County in 1998 is 42.1 million gallons per day, of which 76% is provided by public water supplies and 24% is provided by individual residential wells. Total additional water demand for Chester County in 2020 is estimated to be 10.4 million gallons per day, or 3,784 million gallons per year. Of the additional demand, 81% is projected to be provided by public water supply systems and 19% is projected to be provided by individual residential wells. The total estimated water demand in 2020 is 52.5 million gallons per day, with 77% to be provided by public water supplies and 23% to be provided by individual residential wells. These estimates do not include the volume of water used or needed for non-drinking water commercial uses that rely on individual commercial, industrial or agricultural ground water wells (i.e., golf course irrigation, agricultural irrigation, individual industrial wells, etc.).

The calculations estimate that in 1998, 60% (254,500 persons) of the Chester County population relied on public water supplies and 40% (167,000 persons) relied on individual residential wells for domestic water supplies (Figure 6-4). In 2020, the estimates indicate that 62% of the total Chester County population (327,000 persons) will rely on public water supplies and 38% (200,750 persons) will rely on individual residential wells for domestic water supplies.

Figure 6-4: Current and Future Delivery of Water Supply



In 1998, the estimates indicate approximately 16.8 million gallons per day are provided by public water systems for non-domestic purposes (commercial, industrial, institutional, etc.). In 2020, it is estimated that this will increase by 4 million gallons per day, for a total non-domestic public water demand of approximately 21 million gallons per day.

The largest growth in municipal estimates is expected in municipalities where projected population and employment growth are high. East Whiteland, West Whiteland, Tredyffrin, Uwchlan, and Upper Uwchlan Townships are estimated to each need over 500,000 gallons per day (GPD) of additional water by 2020. These townships include the rapidly growing Great Valley and Route 100 north commercial /residential corridors. East Goshen and West Goshen Townships are estimated to increase by 419,000 and 395,000 gpd by 2020, respectively, indicating the expected commercial and residential growth in the greater West Chester area. Additional water demands by 2020 in the Borough of Modena and Newlin Township are estimated to increase the least (800 GPD and 6,000 gpd respectively).

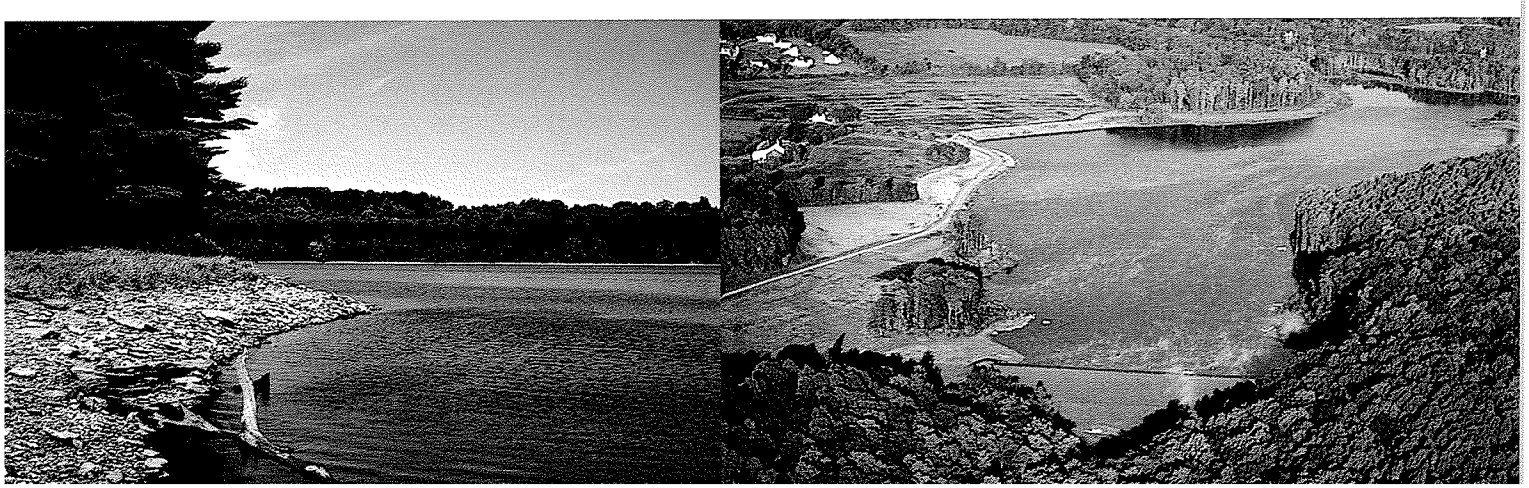
The 2020 projected water needs are intended to assess the ability of the natural resource to provide sufficient water on an average annual basis to meet demand. It is not intended as an estimate of the required 2020 source water design capacity. Water suppliers will have to use peak demand requirements to design systems adequate to meet the expected growth in demand.

Based on estimates of available ground water resources and existing unused surface water allocations and reservoir storage, there exists within Chester County sufficient available resources to meet the additional water demand projected for 2020. From data presented elsewhere in Part 6, the following summarizes the estimated volume of water resources available within Chester County to meet future water supply needs:

- Ground Water Resources: 136 MGD. This is based on the net ground water withdrawal targets presented in Figure 4-2 and Table 6-4 for subbasins within Chester County. For comparison, assuming only 25% of the 1 in 25 year average annual baseflow of Chester County's subbasins is available for future withdrawal, the total available volume of ground water would be still be substantial at 46 MGD.
- Existing But Currently Unused Surface Water Withdrawal Allocations: 36 MGD. This assumes only a small portion (10%) of Chester Water Authority's and Borough of Pottstown Authority's unused allocations are available for future use in Chester County.
- Marsh Creek Reservoir Water Supply Storage, Currently Unallocated for Withdrawal: 4.9 MGD.
- Potential Water Conservation Achieved by 10% Reduction in 1998 Total Water Use: 4.2 MGD.
- Total Available Water Resources: 91.1 MGD (using minimum estimate of available ground water resources) to 181.1 MGD (using net ground water withdrawal targets from Figure 4-2).
- Total Projected Increase in Water Demand from 1998 to 2020: 10.4 MGD.

Thus, a substantial volume of available ground water and surface water resource alternatives exist in Chester County to support growth in and near existing public water supply service areas. In rural areas and growth centers located away from existing public water supply service areas, substantial ground water resources are an available alternative for supporting future growth.

However, because the growth management patterns of the County are de-centralized and include several disconnected urban centers, detailed plans for meeting future needs will need to be developed on a smaller regional basis. Through the IWRP process, all available alternatives can be identified and the most suitable sources can be selected for meeting future needs while supporting the local planning and zoning goals.



Identifying Potential Alternatives for Meeting Future Water Demand

A complete range of alternatives (including the no-action alternative and conservation management practices) for meeting the projected water demand should be developed. For water supply, this may include consideration of use or expansion of existing facilities and/or sources, new satellite systems, local and/or out of basin sources, ground water, surface water, and increased conservation/efficiency management practices, etc. For wastewater, this may include septic systems, small community systems, expanded sewer service, land application, surface discharge, and re-use, etc. In some cases, it may be necessary to implement multiple alternatives.

Because selection of specific sources must consider many variables that cannot be assessed in this study, specific recommendations for additional sources to meet specific needs for each municipality are not addressed here. Such recommendations would require detailed information on potential sources, the exact locations of new demand, existing infrastructure, potential locations for intakes or wells, aquifer yields, unit costs, and utility-specific policies and information, etc. and must be dealt with by the municipality(ies) and utility(ies) involved in that growth.

Each of the available alternatives within Chester County are discussed below:

- The availability of ground water resources within each subbasin of Chester County.
- Existing surface water supply systems.
- Available reservoir capacities.
- Conservation and re-use measures.

This information, combined with the estimates of future municipal water demand, begins to show what options may have promise for meeting future needs and in what areas.

Residential well (wellhead)

Ground Water Use and Availability

Water resource planning requires viewing water use by subbasins, as waters naturally occur within subbasin or watershed boundaries and not municipal borders. Once the total additional water demand is determined, it must be compared against the available water sources. This should consider the amount of water currently being used from nearby ground water and streams and whether the additional need can be supported by those resources (either through existing or new infrastructure).

Considering water withdrawals and availability on a subbasin basis also allows for evaluating what demands are being placed on those resources by others. Most subbasins support water supplies to multiple municipalities. If a single municipality evaluates only its withdrawals of water, the available remaining resource may be significantly over-estimated. By looking at cumulative withdrawals on the entire subbasin, all municipalities supported by those subbasins can use consistent information for planning.

Tables 6-3, 6-4, and 6-5 (found at the end of Part 6) provide the best available information to start the process of comparing the current withdrawals within the subbasin against the projected additional water needed, and to evaluate whether natural resources are available within the subbasin to

support the future demand. Total withdrawals and recharges returned to the subbasin should be considered, particularly for the purpose of maintaining the ground water balance.

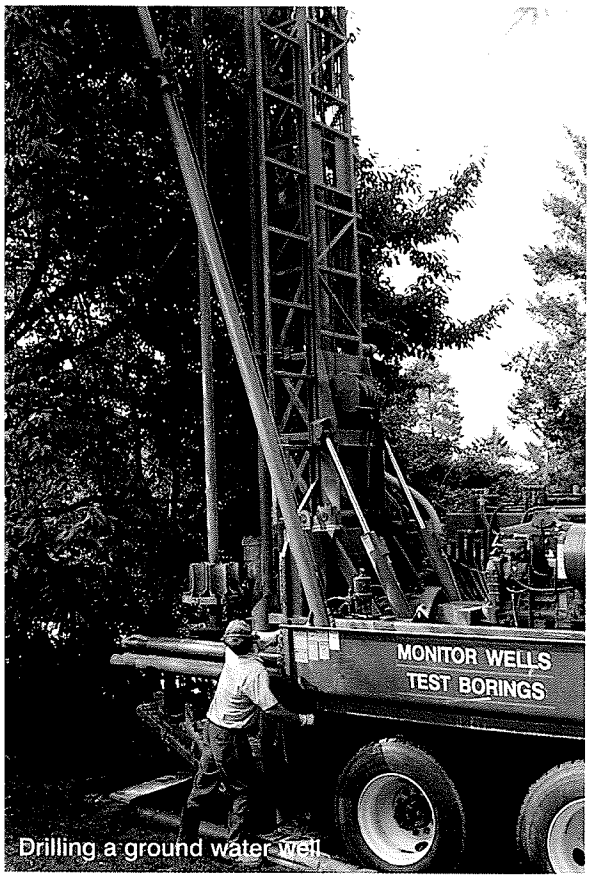
Table 6-4 summarizes the ground water balances for the subbasins in the study watersheds. These data (presented in million gallons per year) show 1998 total ground water withdrawals and recharges (i.e., spray irrigation, etc.), and the net ground water withdrawals as a percentage of each subbasin's withdrawal management target. Table 6-5 summarizes the total volumes of ground and surface waters withdrawn for public and individual water systems, and estimates of future (2020) water demand in each subbasin (also presented in million gallons per year). This information provides a basis for understanding the magnitude of current water withdrawals and the volume of additional ground water resources available for future withdrawals in each subbasin.

Table 6-4 evaluates the sustainability of existing ground water withdrawals for each watershed and subbasin for 1998 based on data gathered from ground water withdrawal and discharge permits, estimates of withdrawals of ground water from individual residential wells, and estimates of discharges via individual residential septic systems. For each subbasin, the net ground water withdrawals (withdrawals minus recharges) are shown. The 1 in 25 year average annual base flow volume is used as the basis of evaluating the relative conditions of stress within each subbasin that may be caused by the total volume of net ground water withdrawals.

Where the net volume of ground water withdrawn (column 6) is very low compared to the net ground water withdrawal target (column 7), ground water resources in the subbasin are not stressed and ground water resources can be considered a viable alternative for meeting future water needs. Where the value in column 6 is approaching the value in column 7, ground water resources are potentially stressed and other sources of water should be considered for use in conjunction with ground water for meeting future needs. When the value in column 6 is at or above the value in column 7, the ground water resources of the subbasin are stressed and efforts should be made to increase recharges and to identify sources other than ground water to meet future water needs.

Table 6-5 presents estimates of total average "annual" water withdrawals (ground water and surface water) and projected future withdrawal needs on a subbasin basis. Available data preclude developing water use and projections by subbasin on an average "daily" use basis (as is presented in Table 6-3 for municipalities). The data in Table 6-5 do not reflect recharges returned to ground water or discharges returned to streams.

Not all water withdrawn from a subbasin is used within that subbasin, and some subbasins use more water than is withdrawn from that subbasin. To most effectively meet water demands, it is necessary to export or import water between subbasins and watersheds. Table 6-5 helps evaluate the relative need for future water within each subbasin relative to the volume of withdrawals currently being taken from the subbasin. This will help municipalities and others developing Integrated Water Resources Plans to better understand that the combined demands for water on a particular subbasin's resources may be greater than or less than the total water demand for human use within the subbasin.



Drilling a ground water well

The ground water balances developed on a watershed and subbasin basis for ***Watersheds*** (Figures 3-13, 3-14 and Table 6-4) generally indicate that the present consumption of ground water is small in comparison to the volume of ground water discharged into the streams, even during low flow periods. The only exceptions are Trout Creek, West Valley Creek, Crow Creek, and Schuylkill River/Mingo Creek subbasins. In these subbasins, future ground water withdrawals should be monitored and compared to the recommended withdrawal management targets to avoid over-withdrawal and impacts to stream baseflows, and to identify opportunities to increase ground water recharge. In all the remaining watersheds and subbasins, ground water appears to be a viable source for future supply.

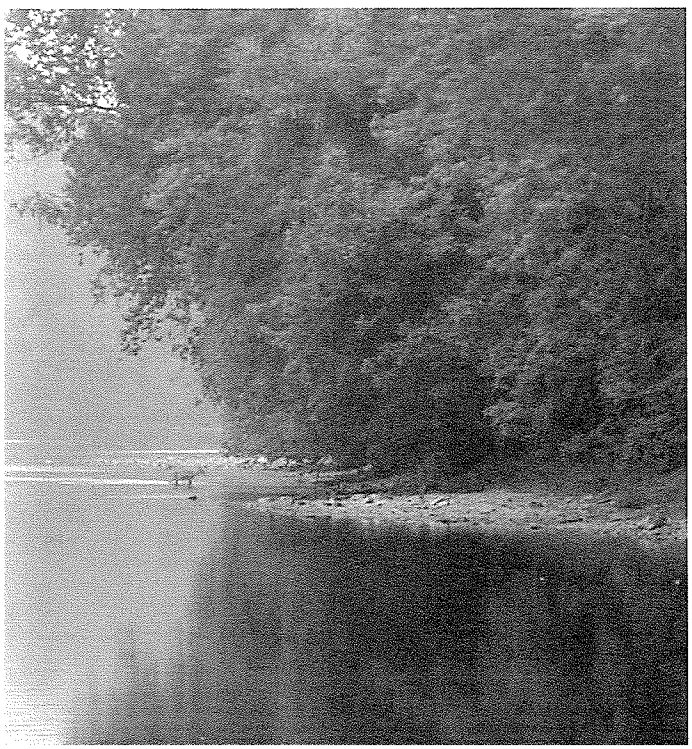
Quality of ground water can also be a concern. Figure 1-2 shows the areas of identified ground water quality problems. These include areas where data or reports indicate high iron, high nitrate, Methyl Tert-Butyl Ether (MTBE) or other volatile organic compounds (VOCs), on-lot septic system problems, elevated pesticide concentrations, or reported gasoline spills or leaking tanks (not included are areas suspected of having high levels of radium and radon in ground water). The map is only a snapshot of available data, and should be used as an initial indication of where ground water contamination problems might be occurring. Further, more detailed assessment of the proposed source area must be carried out if new ground water wells are being planned.

Many existing public water systems across Chester County rely on ground water sources. Nearly all municipal systems rely on ground water sources, with the notable exceptions of Chester Water Authority, Downingtown Municipal Water Authority (DMWA), and Phoenixville Municipal Water Works. Private and investor-owned ground water systems include Superior Water Company in North Coventry Township, former Citizens Water Company (now Pennsylvania-American Water Company) in northeastern Chester County, and the Philadelphia Suburban Water Company's Great Valley, Embryville, Little Washington, Kimberton, and Friendship systems (among others). These systems are typically designed to meet pre-determined planning needs. As new needs arise, these systems should be evaluated to determine if their available capacity can be used, or if there is viable opportunity to expand the system (i.e., adding additional wells).

Existing Surface Water Systems

Several surface water intakes and treatment plant facilities for public water supplies exist in Chester County, among them are: Octoraro Creek at Octoraro Reservoir, Rock Run Reservoir, West Branch Brandywine Creek, East Branch Brandywine Creek/Downingtown, East Branch Brandywine Creek/Ingrams Mill, Chester Creek, Pickering Creek Reservoir, and the Schuylkill River. Figure 1-3 shows the locations of reservoirs and surface water intakes for public water supplies. Such sources may offer opportunities for future supplies both within and adjacent to their corresponding subbasins. Typically, these systems are designed and permitted with specific planning areas and needs in mind. However, as new needs arise, they should be evaluated to determine if they can be used or expanded to help meet those needs. Specific allocations for these intakes are as follows:

- Susquehanna River and Octoraro Creek at Octoraro Reservoir (Chester Water Authority), current allocation for transfer from Susquehanna River transfer is 30 MGD; current allocation from Octoraro Creek is 30 MGD; current combined average daily withdrawal is 33.8, including 29.6 MGD from the Octoraro Creek and 4.2 from the Susquehanna River).
- Rock Run Reservoir (Pennsylvania-American Water Company, PAWC), current allocation is 3 MGD; current average daily withdrawal volume is approximately 2.5 MGD.
- Upper West Branch Octoraro Creek (PAWC), current allocation is 2 MGD; current average daily withdrawal volume is approximately 1.1 MGD. Although this intake is located outside of Chester County, it is inter-connected with other sources in the Coatesville regional water supply system and is used to provide water supply to areas within Chester County.
- West Branch Brandywine Creek (PAWC), current allocation is 4 MGD; current use of this intake is only on an as needed basis, generally during prolonged drought events, to supplement the Rock Run Reservoir. During recent drought events, maximum daily withdrawal volume was approximately 2.4 MGD.
- East Branch Brandywine Creek/Downingtown (DMWA), current maximum allocation is 2.5 MGD. DMWA has additional water supply storage allocation available in Marsh Creek Reservoir to support a total allocation of 3.8 MGD. DMWA's current average daily withdrawal volume is approximately 1.1 MGD.
- East Branch Brandywine Creek/Ingram's Mill (PSWC), current allocation is 6.0 MGD, with a 1-day maximum of 8.5 MGD. PSWC's current average daily withdrawal volume at this intake is approximately 2.8 MGD.
- East Branch Chester Creek (Fern Hill plant/ West Chester Reservoir) (PSWC), current allocation is 1.3 MGD. Current average daily withdrawal volume at this intake is approximately 0.6 MGD.



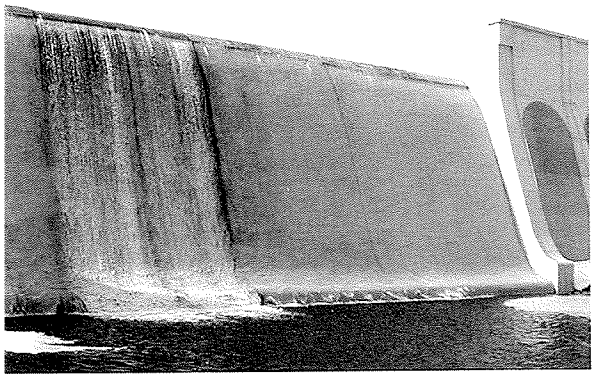
- Schuylkill River and Pickering Creek at Pickering Creek Reservoir (PSWC), current allocation from Schuylkill River is 30 MGD; current allocation from Pickering Creek is 5 MGD. Current combined average daily withdrawal volume is approximately 18.4 MGD.
- Schuylkill River (Borough of Pottstown Authority), current allocation is 12 MGD. Current average daily withdrawal is approximately 5.3 MGD.
- Schuylkill River (formerly Citizens Utility Home Water Co., now PAWC), current allocation is 5 MGD. Current average daily withdrawal volume is approximately 1.5 MGD.
- Schuylkill River (Phoenixville Municipal Water Works), current allocation is 7 MGD. Current average daily withdrawal volume is approximately 3.0 MGD.

These existing surface water intakes represent potential sources of additional water for other subbasins depending on the proximity of connecting infrastructure to the area of need and impact to subbasin water balances. However, owners of these systems typically have planned for and identified areas where they anticipate using their available sources to serve current or future customers.

Several inter-basin and inter-watershed transfers of water already exist in Chester County's watersheds. Examples of the distribution of water from surface water sources include:

- A 48-inch diameter transmission line was built to connect the City of Chester with reliable and potable sources of water supply provided by the Susquehanna River and Octoraro Creek. The Chester Water Authority pipeline extends through southern Chester County (through Lower Oxford, East Nottingham, New London, London Grove, New Garden, Kennett and Pennsbury Townships) and into southern Delaware County. It provides service to several of these municipalities as well as to the City of Chester and northern New Castle County, DE. The Authority includes these and nearby southern Chester County municipalities in the planning area for future water supplies.
- The Pennsylvania American Water Company's Coatesville regional distribution system serves water from 3 sources of surface waters including the Rock Run and West Branch Brandywine intakes listed above, and an intake on upper West Branch Octoraro Creek.
- The Borough of Pottstown Authority withdraws water from the Schuylkill River, provides treatment at its Pottstown plant, and then transports a portion of the water back across the river to serve portions of North Coventry Township.
- Water from the Pickering Creek sources owned and operated by PSWC are distributed to areas west of the reservoir through the PSWC Great Valley System into Uwchlan and East and West Whiteland Townships, among others.
- The Downingtown Municipal Water Authority's intake on East Branch Brandywine provides water for the immediate Downingtown region.
- The Ingram's Mill intake (PSWC) on East Branch Brandywine Creek serves water to much of the greater West Chester region.

Similarly, the collection areas for wastewater treatment plants connect areas from various watersheds and subbasins for transport, treatment and disposal.



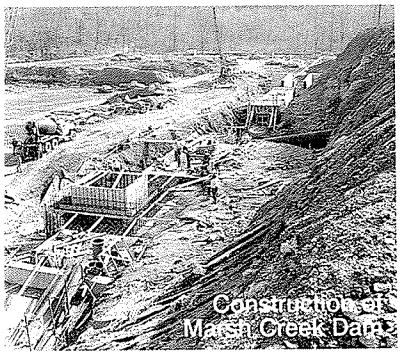
Existing Reservoirs

Current Pennsylvania regulations require that surface water withdrawals be conducted in such a way as to protect the low stream flows at the point of withdrawal. This is generally accomplished by stipulating a "pass-by flow requirement," or a minimum volume of flow that must be allowed to pass by the intake to protect downstream resources under extreme low flow conditions. When the natural stream flow drops to or below this level, the intake must cease or releases from a pre-determined source (i.e. reservoir) must be provided to the stream to replace the amount withdrawn. Wastewater discharges returned to the stream, are sometimes considered as a portion of the replacement water.

For suppliers to insure a reliable and uninterrupted supply of water, surface water intakes are generally supported by large reservoirs of stored water that are designed and used in one of two operating methods:

- The reservoir is used to release water only during extreme low flow periods to provide replacement water to support instream withdrawals located downstream of the reservoir. Marsh Creek Reservoir supports downstream withdrawals at Downingtown and Ingram's Mill on the East Branch Brandywine Creek. Chambers Lake Reservoir supports withdrawals at Wagontown on the West Branch Brandywine Creek.
- The reservoir is used to store water for continuous direct withdrawal to meet daily demand at an immediately adjacent treatment plant (such as Rock Run Reservoir, Octoraro Reservoir, Pickering Creek Reservoir, and West Chester Reservoir).

Surface water intakes that do not have an upstream source of replacement water (i.e., West Branch Octoraro intake in Lancaster County) must cease (or "interrupt") the withdrawal when natural stream flows drop below the required pass-by level. These supplies are reliable during normal rainfall conditions, but have limited reliability under drought conditions.



Construction of Marsh Creek Dam

Present use of the Marsh Creek Reservoir indicates that of the 13.4 MGD of replacement water supply storage available in the reservoir, currently only 9.8 MGD have been allocated for downstream water withdrawals, and of that, about 5.5 MGD are currently being used to support downstream withdrawals. This leaves an additional 7.9 MGD of available replacement water supply storage to support future water needs. This is significantly more than the combined future needs of the downstream municipalities, estimated to be about 2.6 MGD by the year 2020. Additional information regarding the publically owned Marsh Creek and Chambers Lake Reservoirs is contained in the *Compendium*. These two reservoirs were constructed specifically to provide water supply for use in Chester County.

No new water supply reservoirs are anticipated to be planned for construction in the foreseeable future, and estimates of available resources versus projected water demand do not support consideration of such projects. However, abandoned quarries have been considered for adaptive use as water storage facilities, such as Cornog Quarry in Wallace Township. Although water supply storage provides an excellent opportunity for re-use of abandoned quarries, other regional and environmental issues must be considered in planning for this use.

Drought impacts on agriculture

Spray irrigation systems, spray heads and hose

Rain barrel

Water Conservation and Re-use

It is important to recognize that some of the projected water needs can be met with additional water conservation and re-use. In fact, aggressive conservation programs of approximately 5% reductions can, in some subbasins, free up enough water from existing sources to meet 2020 demand. For the purposes of this assessment however, future demand projections did not incorporate any potential reductions from conservation management practices.

Many people think of "water conservation" as referring to reducing use of water for non-essential uses during droughts. However, water conservation management practices include a broad range of strategies that address all types of water users and should be implemented on a widespread and permanent basis, not just during droughts.

Water conservation refers to a holistic approach to water management, rather than an individual act. Water conservation management measures include:

- Minimizing the volume of stormwater runoff generated and maximizing the use of pervious areas to maintain natural infiltration of rain.
- Infiltration of stormwater to recharge ground water and support stream baseflows.
- Detection and repair of leaking water supply infrastructure to reduce the volume and cost of water needed to be withdrawn from the watershed to meet customer demand.
- Use of land application of treated wastewater such as drip or spray irrigation, to provide for re-use of the water (i.e., for pasture, golf course and athletic field irrigation) and to support ground water recharge.
- Storage and re-use of retained stormwater for irrigating athletic fields and turf.
- Reducing residential water use through low-flow fixtures and personal habits.
- Re-use of water within industrial and commercial operations to minimize the need for additional withdrawal.

These and other conservation management measures should be included in Integrated Water Resources Planning to encourage all water users to reduce, re-use and replenish water.

Identifying Constraints

Once a set of alternatives has been selected for consideration, each alternative should be reviewed to identify environmental and other obvious constraints that must be addressed or overcome. These constraints would then become part of the alternatives evaluation process discussed below.

This would include identifying sensitive stream resources such as High Quality or Exceptional Value (HQ or EV) streams, Scenic or Wild and Scenic Rivers, presence of endangered species or sensitive wetlands, first order streams, etc. An initial listing of these constraints can be obtained from Figures 1-3, 3-5, 3-7, 3-11, 3-13, and 3-14. Other existing resource inventories and maps should also be consulted to update these inventories. Many sources of information and GIS mapping are available, much of which is included in the *Compendium*. For Exceptional Value watersheds, the documentation compiled and submitted to support that designation is a useful source of instream aquatic resources and water quality.

The potential environmental impacts of the proposed action on these resources should be considered, and any adverse environmental effects which cannot be avoided should the proposal be implemented should be considered for potential mitigation actions. Environmental impacts should be evaluated for individual and cumulative impacts for instream habitat loss using the PAFBC or similar approach to habitat loss modeling, if available. Potential impacts to stream baseflow and downstream water uses (i.e., habitat, recreation, etc.) should also be considered, as well as potential impacts to nearby ground water users.

In addition to protecting natural and sensitive resources, constraints should be considered that relate to other existing water uses. This can include downstream recreational uses, water supply intakes, wastewater discharges, all of which rely on specific water quantity and quality conditions.

Evaluating Alternatives

Although Pennsylvania does not have a formal Environmental Impact Statement (EIS) or Environmental Impact Assessment (EIA) requirement, it is recommended that the lessons learned from the EIS process in other states and on Federal projects be applied to the utility planning process in Chester County. This approach could be used to improve coordination of utility planning (both wastewater and water), municipal land use planning and watershed-based resource planning. In addition, this approach lends itself to multi-municipal Integrated Water Resources Planning process.

A comprehensive evaluation of the alternatives should be prepared and documented, including environmental, economic/cost, regulatory, and engineering considerations, as well as consistency with local land use planning, public health, and technical considerations. The evaluation of the alternatives should include a similar level of detail for each alternative to ensure an objective evaluation. The results of the full evaluation should be included in the submittal of the appropriate permit application to PADEP, PUC and the river basin commissions. The submittal should also include statements from the affected municipality(ies) and county(ies) that the final selected alternative is most consistent with local comprehensive land use plans and zoning, including *LANDSCAPES* and *Watersheds.*

The evaluation of alternatives should consider the following hierarchy for selecting such options for meeting new demand:

- Existing sources should be considered prior to development of new sources (i.e., connection to and/or expansion of an existing system and/or source within immediate proximity to the area of need).
- Sources located within the same subbasin as the area of demand should be considered prior to sources in another subbasin.
- Sources located within the same watershed as the area of demand should be considered prior to sources outside of the watershed.
- Ground water sources should generally be considered first before surface water sources, particularly in areas where net ground water withdrawals are well below the withdrawal management target.
- Where net ground water withdrawals are approaching the withdrawal management target, a combination of surface water and ground water sources (i.e., conjunctive use) should be considered for meeting future needs.
- Surface water should be considered for meeting all future needs in areas where: net ground water withdrawals are at or exceed the net withdrawal management targets, localized ground water impairments occur, or properly developed surface water sources presently exist with excess capacity.
- Utilize available or expanded capacity in a distant water supply system only when sufficient safeguards can be put in place to avoid unplanned development and connections along the rural pipeline corridor.

If a new source of water is required, it must be decided whether ground water or surface water will provide the additional water needed to meet increased demand. The above listing can assist in those decisions. This will also depend on the availability of high quality ground water, and the relative pumping stress as determined by a comparison of present ground water pumping within the subbasin.

A detailed ground water balance should be developed for the subbasin under consideration and compared against the 1 in 25 year average annual baseflow withdrawal target for the subbasin. If source or discharge is located within a first order stream, a water balance for the first order stream drainage area should be developed. The water balances presented in the *Compendium* can serve as a basis, however, in many situations, more detailed information for the subbasin needs to be collected to develop a more accurate balance. The impact of water withdrawals, and disposal of treated wastewater, on the water balance should be assessed.

Although the ***Watersheds*** strategies strive to discourage additional increases in inter-basin transfers of water, all available sources should be equally considered and the final selection should be based on a thorough evaluation of economic, engineering, environmental, regulatory, and local land use planning implications. If an existing utility system is located in close proximity to the area of need, it should be evaluated as a potential source in this context. Where selected options include inter-basin or inter-watershed transfers, they should include a balancing return of wastewater and other resource management practices to minimize the impacts to the sending watershed.

Based on the results of the alternatives evaluation, a final alternative should be selected, considering in balance, the environmental, economic, engineering, regulatory, and land use planning implications.

Techniques for Protecting Rural Pipeline Corridors

The expansion of infrastructure should be restricted in rural areas to avoid encouraging undesired growth along rural pipeline corridors. However, the growth patterns of Chester County are not centralized around one single growth center. Thus, there may be occasions where extension of a pipeline through a rural area is deemed by the municipality and the utility as the best available alternative for meeting a certain need.

The suggested approach for implementing rural planned service areas and protecting rural pipeline corridors from undesired growth is as follows:

- Each municipality or group of municipalities (where joint planning is occurring) should delineate and adopt planned community water and wastewater service areas (consistent with planned growth areas) within their comprehensive plans and implement zoning consistent with those delineations and with *LANDSCAPES*.
- Each municipality should develop, adopt, and strictly enforce zoning that is consistent with maintaining the planned service areas and restricting other areas from growth patterns that would necessitate infrastructure needs.
- Each municipality should enter into agreements with utilities operating within its borders regarding a process for coordination, planning, approval, and limitations for extension of service or infrastructure. Municipalities with municipal water and/or wastewater departments or authorities should exercise similar agreements.
- Where extension of facilities or infrastructure beyond the planned service area is needed to reach a satellite source or service area, measures should be jointly agreed upon and implemented by the municipality and utility to avoid customer connections in areas not planned for public service.

Agreements between municipalities and PUC-regulated utilities should be filed with the PUC. Examples of some municipalities where such agreements have been used include:

- Charlestown Township has reportedly had an existing agreement with Philadelphia Suburban Water Company for many years restricting access to a water supply pipeline through a rural area.
- Sadsbury Township recently executed an agreement with Pennsylvania-American Water Company to protect a lengthy segment of water supply pipeline through a rural area from future service connections, while allowing water supply to reach a planned growth area.

- Wallace Township recently executed an agreement with Philadelphia Suburban Water Company to (among other points) restrict future public water service in the township without the township's prior approval.
- West Caln Township recently executed an agreement with Pennsylvania-American Water Company to (among other points) restrict future expansion of public water service in the township without the township's prior approval.
- Pocopson Township specified the area of that township where future public water service was desired and reached an agreement with Philadelphia Suburban Water Company to restrict future service to that area.

Protecting Sources of Public Drinking Water Supplies

It is recommended that water and wastewater planning include a strong component for protecting sources of water that contribute to public water supplies. For example, over 500,000 people in Pennsylvania and Delaware rely on the waters of the Brandywine Creek watershed for public and individual water supplies. As growth continues, more people will rely on local sources of water supply and, conversely, more people are conducting more activities that threaten the integrity of the sources of those supplies. Public water supplies rely on the same resources as do natural species and recreational users.

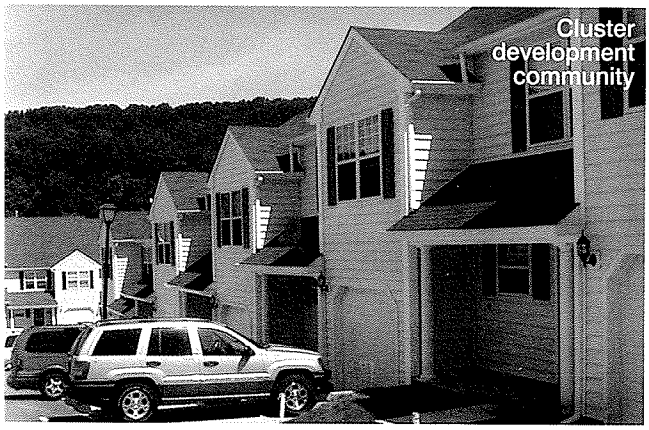
Protection of sources of water supplies provides the following benefits:

- Helps insure that local sources of supply are sustained.
- Helps reduce the cost of public water by reducing treatment requirements.
- Helps minimize or avoid taste and odor problems caused by unregulated contaminants.
- Helps reduce or avoid the need to import public water supplies from other watersheds and distant locations to replace contaminated supplies.

As part of the planning process, sources of public surface and ground water supplies should be included in areas prioritized for maximum protection of water quality and quantity. Both stream intakes and public ground water wells should be identified and provided protection. Strategies that can be implemented to protect source waters are discussed in the *Compendium* and include:

- On-lot septic system management programs.
- Comprehensive stormwater management regulations designed to reduce volume and rate of runoff, reduce erosion and sedimentation within streams, and reduce runoff of nonpoint source pollutants.
- Agricultural and landscape management programs to reduce runoff of nutrients and pesticides to streams and ground water.
- Incentives and requirements for protection and creation of forested riparian buffers.

- Wellhead protection programs.
- Wastewater disposal planning that considers the implications of the water quality of the effluent on the water quality of any downstream raw water intake and reservoir for public water supply.
- Stream stabilization and restoration to repair damaged stream channels and eroding banks that contribute excessive sediment loads to downstream stream segments and reservoirs.
- Spill and Pollution Prevention Plans for facilities storing chemicals.
- Removal of constituents that cause persistent taste and odor problems.
- Public education to encourage land owners and facility operators to be aware of sources of water supplies in their watershed(s) and to exercise good "housekeeping" and stewardship practices to help protect them.



Recommendations for Small Water Systems

Although some existing small systems will be consolidated into larger systems over time, numerous small systems will continue to exist (Figure 6-3 and Table 6-2). In addition, small satellite systems will continue to be needed to support Rural Centers, conservation subdivisions (i.e., cluster communities), Villages or localized areas of impaired ground water. Municipalities are encouraged to consider satellite systems to serve needs in rural areas when and where feasible and where long-term operation and management by qualified operators can be assured.

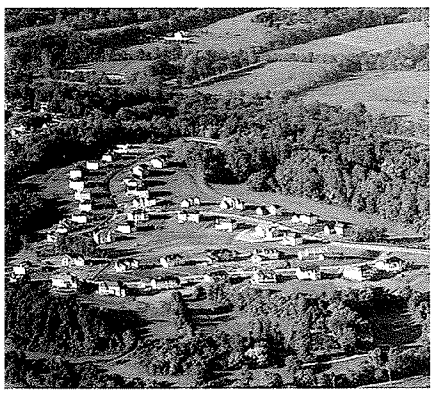
Satellite systems can be installed, operated and maintained in a reliable manner. While problems have occurred where system operators were unable to keep the systems properly functioning, there are now a number of professional system management companies that service small systems. These entities include large utilities as well as independent companies. Municipalities should encourage the use of satellite systems to serve rural water and wastewater needs, but should insist that newly developed systems be owned and/or operated by a qualified professional entity.

Small systems (serving less than 10,000 persons) have special concerns. As such, the following list of recommendations was developed for municipalities that have or contemplate small systems in their communities:

- The community and municipality where the small water system exists should clearly understand whether or not the small water supply system can or can not supply enough water for fire protection. If the system cannot supply enough volume and pressure for fire fighting, the residents and businesses in the service area should be informed and alternative fire fighting water supplies (ponds, streams, swimming pools, tankers, etc.) should be clearly identified.
- Small water supply systems should strive to establish sufficient backup supplies to be able to meet average daily demand when their major well or intake is out of service. They should also have sufficient capacity to meet maximum daily demand with their entire system operational. The total developed ground water

capacity should equal or exceed the design maximum daily demand. For ground water sources, multiple large wells should be considered over a single source to provide backup supplies. A better approach to managing pumping rates is to develop manageable yields based on well performance and drought data rather than the traditional safe yield method. Some small systems may need to consider an interconnection with an adjacent system to provide additional backup protection where practicable and where such inter-connection will not contribute to undesired growth in rural areas.

- Municipalities should initiate and implement wellhead protection or other source water protection programs to reduce or eliminate potential sources of contamination and to protect ground water recharge. These programs should be in place and be consistent with Pennsylvania's approved state Source Water Assessment and Protection program. Delineation of public water supply wellhead protection areas will allow municipal governments to take active measures towards protecting public water supplies, including adoption of regulations preserving and protecting wellhead and recharge areas.
- Leak detection programs, metering, and illicit connections detection programs should be instituted. The target for small water systems should be to reduce unaccounted for water to less than 15%.
- A conservation program with a target of 5% reduction in total per capita water use by 2020 below current use should be instituted using leak detection, public education, and other conservation management measures.
- Small water systems should have adequate facility plans, management plans, and financial/business plans in place to ensure the system can operate on a sound business basis and provide high quality and sustainable quantity of water in the face of changing regulations and needs. Guidance for preparing these plans is available from PADEP.
- Small water systems should have and implement adequate operation and maintenance plans for pumping, treatment, and distribution systems.



In addition to the above recommendations, small water systems (as well as larger systems) should develop drought contingency plans to meet demand under drought conditions. Within the Delaware River Basin, the PADEP has developed draft standards for the preparation and implementation of contingency plans by public water supply agencies and major commercial and industrial water users to reduce water use within specified areas of Pennsylvania's portion of the Delaware River Basin. The objective is to conserve water, to balance demand with limited available supplies, and to assure that sufficient water is available to serve essential health, safety and economic needs. The proposed standards are intended to implement the state's Drought Contingency Plan. More information about the content of such plans can be found in the *Compendium.*

In addition, the *Compendium* contains information on several water quality treatment rule changes being implemented or discussed by the USEPA that may significantly impact small water systems.

Considerations for Wastewater Planning

Several general recommendations apply to all public wastewater utilities (regardless of ownership by municipal authorities, municipalities, private company, or investor owned utility) with wastewater collection and treatment responsibilities when planning for new developments. These are particularly important when planning developments with average densities of more than 1 dwelling unit per acre:

- In Rural or outlying Suburban landscapes, consideration should be given to individual off-lot septic systems as a potential alternative where appropriate site conditions exist. Where this is not an option, then:

  a) Community sewer systems are encouraged for all developments with an average density of greater than 1 dwelling unit per acre.

  b) Community sewer systems should be required for all developments with an average density of greater than two dwelling units per acre.

- Land application or other recharge based systems are encouraged for all community systems.

- In planning new or expansion of community wastewater facilities or service area, the impacts to loss of ground water recharge, either through spray irrigation or through stream discharge should be calculated. Where the expansion is likely to cause net ground water consumption to exceed the withdrawal management target of the subbasins, other alternatives should be pursued. If a community wastewater system is necessary, ground water recharge should be increased in some other manner for the development, such as through the use of stormwater recharge BMPs, etc.

- The impact of stream discharges to the stream water quality, or of land application to the ground water quality must be assessed, and particularly when discharged or recharged upstream/upgradient from public water supply sources.

In essence, there are two main disposal alternatives: land application and stream discharge. Where feasible, municipalities and utilities are encouraged to give preference to land application options. However, stream discharges also provide potential environmental benefits and should not be ruled out without consideration to the overall low-flow management regime of the watershed.

Installation of drip irrigation system

Stream discharge is regulated by PADEP which sets quality and disinfection standards for effluent. Applicants are required to obtain an NPDES permit to discharge treated effluent (aimed at protecting water quality during periods of low flow). The primary environmental impact of stream discharge is degraded surface water quality due to the release of nutrients or other components that are not completely removed during the treatment process. It is because of these discharges that Congress acted to "eliminate" stream discharges in the Clean Water Act Amendments of the early 1980s. Subsequent improvements in treatment technology have partially addressed this concern, but surface water quality degradation remains a concern.

The most widely used techniques for applying treated effluent to the land are spray irrigation, subsurface disposal, rapid infiltration, and drip irrigation. With spray irrigation, treated effluent is sprinkled or sprayed on fields, lawns, or woodlands. Vegetation and soil microbes assist with effluent "polishing" and nutrients found in wastewater nourish vegetation. Water not absorbed by growing plants percolates through the soil and contributes to ground water.

"Subsurface disposal" is similar in methodology to that used for individual septic systems. Larger systems use pumps and a series of subsurface pipes to evenly distribute effluent to absorption beds. As with other land application systems, effluent percolates through the soil beneath the absorption beds and eventually recharges ground water. These systems generally require better and more permeable soils than spray irrigation systems. Some subdivision designs utilize off-lot open space areas for individual septic systems and subsurface wastewater disposal.

"Rapid infiltration" is similar to subsurface disposal except that the absorption beds are not covered and planted. Instead, land is formed into a holding area or basin to which sand is applied on top of the soil layers. After treatment, effluent flows into the basin where it permeates the sand and soil layers and eventually makes its way

to the ground water aquifer. These systems also require better and more permeable soils than spray irrigation systems.

Concern over the amount of evaporation that can result from spray irrigation systems led to the development of drip irrigation technology. A drip irrigation system is comprised of a series of small diameter polyethylene tubing. The tubing contains specially designed valves or emitters two feet apart that are bonded to the inside of the tubing. When water fills the tubing and creates pressure, the valves compensate by releasing or "emitting" a small amount of water through the valve holes. The tubing is placed between six and eight inches below the soil surface. Benefits of drip irrigation are reported to include:

- A reduction in the amount of land needed to disperse treated effluent (over other land treatment technologies such as spray irrigation).
- A reduction in required setbacks or buffer zones.
- The ability to apply treated effluent year-round.
- A higher percentage of ground water recharge.
- The elimination of storage facilities (typically used during winter months when ground is frozen and surface application is not permitted).
- Reduced maintenance and land costs, and greater application rates (due in part to less interruptions from inclement weather).
- Potential use of the drip fields for recreational fields.

Of the disposal alternatives, variations of spray or drip irrigation are encouraged wherever practicable because both provide effluent polishing, contribute nutrients to surface plants (such as a growing crop), and recharge ground water.

It is also important that other emerging technologies for improved treatment and disposal be monitored and utilized when appropriate, including evolving on-lot septic system technologies that more effectively remove nutrients.

Installation of residential septic system

Table 6-1: 1998 and 2020 Population and Employment Estimates and Projections*

Municipality	Population			Employment		
	1998	2020	Total Growth	1997	2020	Total Growth
Atglen	1,005	1,250	245	526	600	74
Avondale	949	1,200	251	1,534	1,850	316
Birmingham	4,025	6,300	2,275	218	300	82
Caln	12,250	15,050	2,800	8,925	10,000	1,075
Charlestown	3,501	3,851	350	1,343	1,450	107
Coatesville	10,687	11,550	863	4,634	4,900	266
Downingtown	7,767	8,500	733	6,942	7,000	58
East Bradford	8,286	12,000	3,714	1,429	2,250	821
East Brandywine	5,947	7,900	1,953	419	1,300	881
East Caln	2,807	3,450	643	1,162	1,550	388
East Coventry	4,609	5,300	691	419	450	31
East Fallowfield	4,837	6,000	1,163	411	500	89
East Goshen	16,577	18,550	1,973	5,839	9,850	4,011
East Marlborough	5,503	7,600	2,097	1,338	1,400	62
East Nantmeal	1,643	1,800	157	244	350	106
East Nottingham	4,838	5,900	1,062	2,041	2,850	809
East Pikeland	7,107	9,350	2,243	986	950	-36
East Vincent	4,784	5,900	1,116	1,539	1,700	161
East Whiteland	9,103	9,800	697	19,693	26,150	6,457
Easttown	10,055	10,205	150	6,190	5,750	-440
Elk	1,472	1,750	278	81	150	69
Elverson	822	1,350	528	981	1,100	119
Franklin	3,483	4,550	1,067	393	1,000	607
Highland	1,262	1,262	0	961	1,150	189
Honey Brook	1,334	1,500	166	553	650	97
Honey Brook Twp.	5,930	7,250	1,320	1,657	2,150	493
Kennett	5,886	7,250	239	2,415	2,650	235
Kennett Square	5,161	5,400	1,364	5,161	5,900	739
London Britain	2,927	4,050	1,123	143	350	207
London Grove	4,727	6,600	1,873	856	1,000	144
Londonderry	1,443	2,000	557	201	350	149
Lower Oxford	3,649	4,000	351	679	800	121
Malvern	3,114	3,450	336	6,012	7,750	1,738
Modena	564	600	36	168	150	-18
New Garden	7,593	10,050	2,457	2,952	3,800	848
New London	3,928	5,950	2,022	339	600	261
Newlin	1,150	1,200	50	166	200	34

*NOTE: Data were prepared prior to availability of 2000 Census data.
Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

(Table 6-1 continued*)

Municipality	Population			Employment		
	1998	2020	Total Growth	1997	2020	Total Growth
North Coventry	7,896	9,350	1,454	1,303	1,550	247
Oxford	3,821	4,000	179	2,525	2,700	175
Parkesburg	3,028	3,300	272	1,247	1,400	153
Penn	2,590	3,900	1,310	293	400	107
Pennsbury	3,701	5,300	1,599	280	300	20
Phoenixville	15,207	17,100	1,893	5,746	6,450	704
Pocopson	3,423	5,200	1,777	687	750	63
Sadsbury	2,608	3,100	492	395	450	55
Schuylkill	6,251	7,400	1,149	2,894	2,800	-94
South Coatesville	1,016	1,050	34	1,106	1,600	494
South Coventry	1,893	2,500	607	86	200	114
Spring City	3,351	3,650	299	1,421	1,400	-21
Thornbury	1,530	2,250	720	290	550	260
Tredyffrin	29,263	32,650	3,387	28,625	34,000	5,375
Upper Oxford	2,048	2,700	652	138	200	62
Upper Uwchlan	6,568	12,500	5,932	2,708	4,700	1,992
Uwchlan	15,394	22,400	7,006	6,683	10,500	3,817
Valley	5,187	8,250	3,063	1,284	1,550	266
Wallace	3,168	4,550	1,382	719	900	181
Warwick	2,674	3,500	826	235	250	15
West Bradford	10,848	15,900	5,052	2,467	3,550	1,083
West Brandywine	7,523	11,550	4,027	2,273	2,850	577
West Caln	7,087	10,100	3,013	762	1,100	338
West Chester	17,988	19,100	1,112	14,984	15,150	166
West Fallowfield	2,578	3,650	1,072	592	650	58
West Goshen	19,693	22,550	2,857	17,525	20,500	2,975
West Grove	2,444	3,300	856	1,792	1,950	158
West Marlborough	885	900	15	169	300	131
West Nantmeal	2,165	3,050	85	234	300	66
West Nottingham	2,402	3,250	848	750	800	50
West Pikeland	3,143	4,100	957	969	1,300	331
West Sadsbury	2,466	3,800	1,334	878	1,950	1,072
West Vincent	2,758	4,150	1,392	280	450	170
West Whiteland	15,936	20,150	4,214	20,787	29,950	9,163
Westtown	12,183	15,800	3,617	2,963	3,800	837
Willistown	10,245	12,150	1,905	8,538	9,350	812
Total	**421,686**	**527,818**	**106,132**	**224,178**	**277,500**	**53,322**

*NOTE: Data were prepared prior to availability of 2000 Census data.
Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Table 6-2: Small Community Water Systems within Chester County (as shown in Figure 6-3)

Number	System Name	Number	System Name
1	Appleville Mobile Home Park	33	Londonderry Court
2	Avon Wheel Estate Mobile Home Park	34	Longwood Gardens
3	Brandywine Terrace Mobile Home Park	35	Malvern Courts Inc.
4	Caln Mobile Home Park	36	Maplewood Mobile Home Park
5	Camp Hill Special School	37	Martin's Mobile Home Village
6	Camphill Village USA Inc.	38	Modern Mushroom Farms
7	CFS — School at Church Farm	39	Mount Idy Mobile Home Park
8	Chatham Acres Nursing Home	40	Nottingham Manor Mobile Home Court
9	Chatwood Water Company	41	Oxford Village Mobile Home Park
10	Coatesville Veterans Administration Hospital	42	Perry Phillips Mobile Homes
11	Cochranville Mobile Home Park	43	Phoenix Mobile Homes
12	Coventry Garden Apartments	44	Phoenixville Mobile Homes Inc.
13	Coventry Manor Nursing Home	45	Philadelphia Suburban Water Co.— Culbertson Run
14	Coventry Terrace	46	Philadelphia Suburban Water Co.— Brandywine Hospital
15	Devereux Foundation	47	Ridgeview Mobile Homes
16	East Fallowfield Utilities, Inc	48	Riveredge
17	Echo Valley	49	S. E. PA Veterans Center
18	Gregory Courts Inc.	50	Shady Grove Mobile Home Park
19	Heatherwood Retirement	51	Shady Side Mobile Home Park
20	Hideaway Mobile Home Park	52	Springton Court Mobile Homes
21	Highland Court	53	St. Mary's of Providence
22	Icedale Mobile Home Courts	54	St. Stephens Green
23	Imperial Mobile Home Park	55	Stone Barn
24	Independence Park	56	Stony Run Mobile Home Park
25	Indian Run Village	57	Taylor's Mobile Home Park
26	Kendal Crosslands/Consiston	58	Tel Hai Rest Home
27	Keystone Court	59	Valley Springs Water Co.
28	Lake Road Mobile Home Park	60	Valley View Mobile Home Park
29	Lazy Acres Mobile Home Park	61	Warwick Mobile Home Park
30	Lincoln Crest Mobile Home Park	62	Wetherhill Estates
31	Loags Corner Mobile Home Park	63	Willowdale Water Company
32	London Grove Mobile Home Park		

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Table 6-3: Estimated 1998 and 2020 Average Daily Water Demand by Municipality (GPD)*

Municipality	1998 Water Demand			Additional Water Needed by 2020			2020 Wastewater	Total Estimated Water Demand 2020		
	From Individual Residential Wells	From Public Systems	Total Water Served	From Individual Residential Wells	From Public Systems	Total Water Needed	Additional Capacity Needed	From Individual Residential Wells	From Public Systems	Total Water Demand
Atglen	11,119	88,631	99,750	-	20,250	20,250	18,225	11,119	108,881	120,000
Avondale	7,805	164,185	171,990	-	38,760	38,760	34,884	7,805	202,945	210,750
Birmingham	81,724	176,126	257,850	13,620	129,000	142,620	128,358	95,344	305,126	400,470
Caln	380,352	1,024,023	1,404,375	37,800	210,825	248,625	223,763	418,152	1,234,848	1,653,000
Charlestown	190,588	120,197	310,785	14,910	14,115	29,025	26,123	205,498	134,312	339,810
Coatesville	36,667	952,103	988,770	-	71,730	71,730	64,557	36,667	1,023,833	1,060,500
Downingtown	69,164	917,506	986,670	-	48,330	48,330	43,497	69,164	965,836	1,035,000
E. Bradford	386,899	217,436	604,335	48,495	235,920	284,415	255,974	435,394	453,356	888,750
E. Brandywine	322,288	65,957	388,245	58,560	124,665	183,225	164,903	380,848	190,622	571,470
E. Caln	80,409	175,161	255,570	3,120	64,560	67,680	60,912	83,529	239,721	323,250
E. Coventry	275,678	32,287	307,965	26,100	17,655	43,755	39,380	301,778	49,942	351,720
E. Fallowfield	194,832	126,213	321,045	20,352	56,103	76,455	68,810	215,184	182,316	397,500
E. Goshen	223,707	1,208,838	1,432,545	5,919	413,286	419,205	377,285	229,626	1,622,124	1,851,750
E. Marlborough	316,568	113,962	430,530	75,480	54,990	130,470	117,423	392,048	168,952	561,000
E. Nantmeal	96,805	20,075	116,880	8,556	8,814	17,370	15,633	105,361	28,889	134,250
E. Nottingham	261,382	181,973	443,355	38,220	86,175	124,395	111,956	299,602	268,148	567,750
E. Pikeland	353,180	147,190	500,370	29,622	102,258	131,880	118,692	382,802	249,448	632,250
E. Vincent	235,743	166,722	402,465	25,440	53,595	79,035	71,132	261,183	220,317	481,500
E. Whiteland	33,838	1,989,317	2,023,155	4,182	521,913	526,095	473,486	38,020	2,511,230	2,549,250
Easttown	88,286	979,264	1,067,550	1,200	(25,200)	(24,000)	(21,600)	89,486	954,064	1,043,550
Elk	88,320	6,075	94,395	16,680	5,175	21,855	19,670	105,000	11,250	116,250
Elverson	986	121,909	122,895	-	40,605	40,605	36,545	986	162,514	163,500
Franklin	201,521	36,934	238,455	27,540	82,005	109,545	98,591	229,061	118,939	348,000
Highland	75,720	72,075	147,795	-	14,175	14,175	12,758	75,720	86,250	161,970
Honey Brook	-	121,515	121,515	-	17,235	17,235	15,512	-	138,750	138,750
Honey Brook Twp.	286,460	193,615	480,075	55,440	60,735	116,175	104,558	341,900	254,350	596,250
Kennett	286,345	247,940	534,285	-	31,965	31,965	28,769	286,345	279,905	566,250
Kennett Square	24,840	671,895	696,735	27,840	109,425	137,265	123,539	52,680	781,320	834,000
London Britain	175,570	10,775	186,345	40,440	42,465	82,905	74,615	216,010	53,240	269,250
London Grove	230,035	117,785	347,820	47,172	76,008	123,180	110,862	277,207	193,793	471,000
Londonderry	86,580	15,075	101,655	33,420	11,175	44,595	40,136	120,000	26,250	146,250
Lower Oxford	176,131	93,734	269,865	12,660	17,475	30,135	27,122	188,791	111,209	300,000
Malvern	3,737	634,003	637,740	-	150,510	150,510	135,459	3,737	784,513	788,250
Modena	27,517	18,923	46,440	-	810	810	729	27,517	19,733	47,250
New Garden	349,234	327,746	676,980	61,920	149,100	211,020	189,918	411,154	476,846	888,000
New London	208,196	52,909	261,105	46,080	94,815	140,895	126,806	254,276	147,724	402,000
Newlin	69,000	12,450	81,450	3,000	2,550	5,550	4,995	72,000	15,000	87,000

*NOTE: The data presented in this table are estimates intended only to provide planners with a starting point for determining the future water and wastewater demand and should not be used as absolute planning figures without more detailed local water usage and projection data.

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

(Table 6-3 continued*)

Municipality	1998 Water Demand			Additional Water Needed by 2020			2020 Wastewater	Total Estimated Water Demand 2020		
	From Individual Residential Wells	From Public Systems	Total Water Served	From Individual Residential Wells	From Public Systems	Total Water Needed	Additional Capacity Needed	From Individual Residential Wells	From Public Systems	Total Water Demand
N. Coventry	371,274	200,211	571,485	45,348	60,417	105,765	95,189	416,622	260,628	677,250
Oxford	29,753	388,882	418,635	-	23,865	23,865	21,479	29,753	412,747	442,500
Parkesburg	28,330	246,875	275,205	-	27,795	27,795	25,016	28,330	274,670	303,000
Penn	155,400	21,975	177,375	47,160	39,465	86,625	77,963	202,560	61,440	264,000
Pennsbury	186,403	56,657	243,060	57,564	39,876	97,440	87,696	243,967	96,533	340,500
Phoenixville	22,277	1,321,093	1,343,370	-	166,380	166,380	149,742	22,277	1,487,473	1,509,750
Pocopson	197,166	59,739	256,905	71,430	39,885	111,315	100,184	268,596	99,624	368,220
Sadsbury	62,700	123,405	186,105	13,260	20,385	33,645	30,281	75,960	143,790	219,750
Schuylkill	62,876	529,234	592,110	17,391	44,499	61,890	55,701	80,267	573,733	654,000
S. Coatesville	31,936	111,974	143,910	-	39,090	39,090	35,181	31,936	151,064	183,000
S. Coventry	113,580	6,450	120,030	21,840	23,130	44,970	40,473	135,420	29,580	165,000
Spring City	21,947	285,688	307,635	-	16,365	16,365	14,729	21,947	302,053	324,000
Thornbury	45,360	68,190	113,550	8,640	54,060	62,700	56,430	54,000	122,250	176,250
Tredyffrin	46,191	3,856,464	3,902,655	9,144	597,201	606,345	545,711	55,335	4,453,665	4,509,000
Upper Oxford	122,880	10,350	133,230	23,460	20,310	43,770	39,393	146,340	30,660	177,000
Upper Uwchlan	280,476	316,704	597,180	54,444	450,876	505,320	454,788	334,920	767,580	1,102,500
Uwchlan	77,144	1,347,721	1,424,865	-	706,635	706,635	635,972	77,144	2,054,356	2,131,500
Valley	27,926	379,594	407,520	40,416	163,314	203,730	183,357	68,342	542,908	611,250
Wallace	190,080	53,925	244,005	49,740	46,755	96,495	86,846	239,820	100,680	340,500
Warwick	159,137	18,928	178,065	42,120	8,565	50,685	45,617	201,257	27,493	228,750
W. Bradford	483,526	352,379	835,905	112,152	272,193	384,345	345,911	595,678	624,572	1,220,250
W. Brandywine	399,090	222,765	621,855	89,418	195,477	284,895	256,406	488,508	418,242	906,750
W. Caln	333,665	148,705	482,370	162,720	43,410	206,130	185,517	496,385	192,115	688,500
W. Chester	21,586	2,181,494	2,203,080	-	79,170	79,170	71,253	21,586	2,260,664	2,282,250
W. Fallowfield	154,680	44,400	199,080	38,580	30,090	68,670	61,803	193,260	74,490	267,750
W. Goshen	29,532	2,466,423	2,495,955	12,516	382,029	394,545	355,091	42,048	2,848,452	2,890,500
W. Grove	8,054	272,986	281,040	-	63,210	63,210	56,889	8,054	336,196	344,250
W. Marlborough	53,100	12,675	65,775	900	9,825	10,725	9,653	54,000	22,500	76,500
W. Nantmeal	117,749	29,701	147,450	45,120	12,930	58,050	52,245	162,869	42,631	205,500
W. Nottingham	144,120	56,250	200,370	30,540	24,090	54,630	49,167	174,660	80,340	255,000
W. Pikeland	176,272	84,983	261,255	24,702	57,543	82,245	74,021	200,974	142,526	343,500
W. Sadsbury	132,355	81,455	213,810	48,000	112,440	160,440	144,396	180,355	193,895	374,250
W. Vincent	165,480	21,000	186,480	51,768	44,502	96,270	86,643	217,248	65,502	282,750
W. Whiteland	197,560	2,317,625	2,515,185	21,996	918,069	940,065	846,059	219,556	3,235,694	3,455,250
Westtown	83,435	869,770	953,205	43,404	236,391	279,795	251,816	126,839	1,106,161	1,233,000
Willistown	275,994	979,056	1,255,050	48,024	127,176	175,200	157,680	324,018	1,106,232	1,430,250
Total	**10,946,260**	**31,168,250**	**42,114,510**	**2,015,565**	**8,351,385**	**10,366,950**	**9,330,255**	**12,961,825**	**39,519,635**	**52,481,460**

*NOTE: The data presented in this table are estimates intended only to provide planners with a starting point for determining the future water and wastewater demand and should not be used as absolute planning figures without more detailed local water usage and projection data.

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

Table 6-4: Estimated 1998 Net Ground Water Balances by Subbasin (in MGY)*

Subbasin Code and Name	1 in 25 Year Average Annual Baseflow	1998 Ground Water Withdrawals			Net Withdrawal as % of 1 in 25 Year Baseflow	Subbasin Withdrawal Target as % of 1 in 25 Year Baseflow
		Volume Withdrawn	Volume Recharged	Net Volume Withdrawn		
Brandywine Creek						
B1 Brandywine Creek above Chadds Ford	1,098	65	133	-68	-6%	50%
B2 Brandywine Creek at Wilmington	661	17	14	3	<1%	100%
B3 Brandywine Creek below Chadds Ford	3,313	112	31	81	2%	100%
B4 Brandywine Creek/ Pocopson Creek	2,154	283	173	110	5%	100%
B5 Buck Run	2,925	121	82	38	1%	100%
B6 Doe Run	2,358	46	39	7	<1%	100%
B7 East Branch Brandywine Creek/Shamona Creek	1,938	216	104	112	6%	50%
B8 East Branch Brandywine Creek/Taylor Run	1,407	174	67	108	8%	50%
B9 East Branch Brandywine/ Beaver Creek	2,825	627	172	455	16%	50%
B10 Marsh Creek	2,217	274	149	126	6%	50%
B11 Upper East Branch Brandywine Creek	2,800	166	104	63	2%	50%
B12 Upper West Branch Brandywine Creek	3,300	302	120	182	6%	50%
B13 West Branch Brandywine Creek/Broad Run	3,175	310	230	80	3%	50%
B14 West Branch Brandywine/ Rock Run/Sucker Run	2,945	290	106	184	6%	50%
B15 West Valley Creek	2,233	1,046	45	1,000	45%	50%
Total for Watershed		**4,049**	**1,568**	**2,480**		
Chester Creek						
Ch1 Lower Chester Creek	4,745	154	29	126	3%	50%
Ch2 Upper East Branch Chester Creek	2,488	228	252	-24	-1%	100%
Total for Watershed		**382**	**281**	**102**		
Christina River						
Cr1 Belltown Run	702	3	3	0.6	<1%	100%
Cr2 East Branch Christina River	1,166	12	10	2	<1%	50%
Cr3 Little Mill Creek	1,008	17	13	4	<1%	100%
Cr4 Lower Tidal Christina River	2,397	30	23	7	<1%	100%
Cr5 Muddy Run	946	6	6	-0.2	0%	100%
Cr6 Upper Christina River	2,295	117	104	13	1%	100%
Total for Watershed		**184**	**157**	**26**		

*NOTE: MGY = Million gallons per year
Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

(Table 6-4 continued*)

Subbasin Code and Name	1 in 25 Year Average Annual Baseflow	1998 Ground Water Withdrawals			Net Withdrawal as % of 1 in 25 Year Baseflow	Subbasin Withdrawal Target as % of 1 in 25 Year Baseflow
		Volume Withdrawn	Volume Recharged	Net Volume Withdrawn		
Conestoga Creek						
Con Conestoga Creek	4,543	316	183	134	3%	100%
Total for Watershed		**316**	**183**	**134**		
Crum Creek						
Cm1 Lower Crum Creek	2,456	32	21	11	<1%	100%
Cm2 Upper Crum Creek	1,728	116	91	25	1%	50%
Total for Watershed		**148**	**112**	**36**		
Darby Creek						
D1 Cobbs Creek	1,162	31	27	4	<1%	100%
D2 Lower Darby Creek	5,094	155	136	19	<1%	100%
D3 Upper Darby Creek	2,169	36	27	8	<1%	100%
Total for Watershed		**221**	**191**	**31**		
Elk Creek						
E1 East Branch Big Elk Creek	1,734	85	63	22	1%	50
E2 Lower Big Elk Creek	1,761	133	115	18	1%	100%
E3 Lower Little Elk Creek	2,504	120	102	18	1%	50%
E4 Upper Big Elk Creek	1,931	94	81	13	1%	50%
E5 Upper Little Elk Creek	1,437	51	44	7	<1%	50%
E6 West Branch Big Elk Creek	1,126	128	57	71	6%	50%
Total for Watershed		**612**	**462**	**150**		
French Creek						
F1 Lower French Creek	850	168	30	137	16%	50%
F2 Middle French Creek	2,146	208	83	126	6%	50%
F3 South Branch French Creek	1,404	47	36	11	1%	50%
F4 Upper French Creek	1,736	98	61	36	2%	50%
Total for Watershed		**521**	**210**	**311**		
Gulph Creek						
Gul Gulph Creek	650	5	4	0.77	<1%	100%
Total for Watershed		**5**	**4**	**1**		
Northeast Creek						
N1 Lower Northeast Creek	4,913	287	239	48	1%	100%
N2 Upper Northeast Creek	1,186	88	44	44	4%	100%
Total for Watershed		**375**	**284**	**92**		

*NOTE: MGY = Million gallons per year
Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

(Table 6-4 continued*)

Subbasin Code and Name	1 in 25 Year Average Annual Baseflow	1998 Ground Water Withdrawals			Net Withdrawal as % of 1 in 25 Year Baseflow	Subbasin Withdrawal Target as % of 1 in 25 Year Baseflow
		Volume Withdrawn	Volume Recharged	Net Volume Withdrawn		
Octoraro Creek						
Oc1 Lower East Branch Octoraro Creek	5,769	152	120	32	1%	50%
Oc2 Lower Octoraro Creek	5,278	225	165	60	1%	50%
Oc3 Octoraro Reservoir	1,931	69	259	-190	-10%	50%
Oc4 Upper East Branch Octoraro Creek	3,112	131	93	38	1%	100%
Oc5 Upper West Branch Octoraro Creek	4,303	132	110	23	1%	50%
Total for Watershed		**710**	**746**	**-36**		
Pequea Creek						
Peq Pequea Creek	3,602	189	146	43	1%	50%
Total for Watershed		**189**	**146**	**43**		
Pickering Creek						
Pc1 Lower Pickering Creek	2,281	133	97	37	2%	50%
Pc2 Upper Pickering Creek	1,812	93	76	16	1%	50%
Total for Watershed		**226**	**173**	**53**		
Pigeon Creek						
Pgn Pigeon Creek	816	129	97	32	4%	50%
Total for Watershed		**129**	**97**	**32**		
Red Clay Creek						
RC1 Burrows Run	779	38	31	7	1%	100%
RC2 East Branch Red Clay Creek	1,096	257	63	193	18%	100%
RC3 Lower Red Clay Creek	776	9	7	1	<1%	100%
RC4 Upper Red Clay Creek	1,360	40	9	31	2%	100%
RC5 West Branch Red Clay Creek	1,917	293	284	9	<1%	100%
Total for Watershed		**636**	**394**	**242**		
Ridley Creek						
Rd1 Lower Ridley Creek	1,856	32	16	16	1%	50%
Rd2 Upper Ridley Creek	2,278	370	154	215	9%	50%
Total for Watershed		**401**	**171**	**231**		
Schuylkill River						
S1 Crow Creek	452	377	5	372	82%	100%
S2 Schuylkill-Mingo Creek	236	236	19	216	92%	50%
S3 Schuylkill-Sixpenny Creek	752	84	60	23	3%	50%
S4 Schuylkill-Sprogels Run	302	62	28	34	11%	50%
S5 Schuylkill-Stony Run	158	7	2	5	3%	100%
S6 Schuylkill-Trout Creek a	188	3	13	-10	-5%	50%
S7 Schuylkill-Trout Creek b	143	0.28	0.23	0.05	<1%	100%
Total for Watershed		**769**	**128**	**641**		

*NOTE: MGY = Million gallons per year
Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

(Table 6-4 continued*)

Subbasin Code and Name	1 in 25 Year Average Annual Baseflow	1998 Ground Water Withdrawals			Net Withdrawal as % of 1 in 25 Year Baseflow	Subbasin Withdrawal Target as % of 1 in 25 Year Baseflow
		Volume Withdrawn	Volume Recharged	Net Volume Withdrawn		
Stony Run						
Stn Stony Run	340	71	48	23	7%	50%
Total for Watershed		**71**	**48**	**23**		
Trout Creek						
Trt Trout Creek	870	802	4	798	92%	100%
Total for Watershed		**802**	**4**	**798**		
Valley Creek						
Val East Valley Creek	2,489	681	794	-113	-5%	50%
Total for Watershed		**681**	**794**	**-113**		
White Clay Creek						
WC1 Lower East Branch White Clay Creek	1,563	163	170	-7	<1%	100%
WC2 Lower White Clay Creek	601	3	3	0.54	<1%	50%
WC3 Middle Branch White Clay Creek	1,748	177	77	99.9	6%	100%
WC4 Middle Run	425	2	2	0.31	<1%	100%
WC5 Middle White Clay Creek	988	13	11	2.2	<1%	100%
WC6 Mill Creek	1,409	14	12	1.8	<1%	100%
WC7 Pike Creek	723	6	5	1.0	<1%	100%
WC8 Upper East Branch White Clay Creek	2,064	149	78	70.2	3%	50%
WC9 Upper White Clay Creek	1,106	21	17	3.5	<1%	50%
WC10 West Branch White Clay Creek	1,115	69	54	15.3	1%	100%
Total for Watershed		**617**	**430**	**187**		
Total for Study Area		**12,046**	**6,583**	**5,463**		

*NOTE: MGY = Million gallons per year
Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

- **Column 1**—Subbasin code and name (see Figure 5-1 for a map showing subbasin location and codes).
- **Column 2**—Volume of the 1 in 25 year average annual baseflow for each subbasin (as calculated using USGS data as presented in the *Compendium*).
- **Column 3**—Volume of total ground water withdrawals (total volume of permitted withdrawals and estimated individual residential well withdrawals) within each subbasin.
- **Column 4**—Volume of total recharges to the ground water system from permitted land application and community septic systems, and individual residential septic systems. Recharges from land application systems assume 50% of total application by spray irrigation is lost to evaporation or transpiration.
- **Column 5**—Volume of net ground water withdrawals (total withdrawals minus total recharges).
- **Column 6**—Net volume of ground water withdrawals as a percentage of the volume of the subbasin's 1 in 25 year average annual baseflow.
- **Column 7**—Recommended withdrawal management target for each subbasin (50% of the 1 in 25 year annual average baseflow where the subbasin contains sensitive resources or 100% of the 1 in 25 year average annual baseflow for all other subbasins).

Table 6-5: Estimated Average Annual Water Withdrawals & Future Needs by Subbasin ('98/'20) (MGY)

Subbasin Code and Name	1998 Withdrawals				2020 Projected Needs	
	Ground Water Withdrawals	Surface Water Withdrawals	Total Water Withdrawals	Total Water Used	Additional Water Demand	Additional Wastewater Capacity Needs
Brandywine Creek						
B1 Brandywine Creek above Chadds Ford	65	0	65	159	74	67
B2 Brandywine Creek at Wilmington	17	9,905	9,921	1,726	185	167
B3 Brandywine Creek below Chadds Ford	112	74	186	613	119	107
B4 Brandywine Creek/Pocopson Creek	283	22	305	601	166	149
B5 Buck Run	121	0	121	266	43	39
B6 Doe Run	46	0	46	46	11	10
B7 East Branch Brandywine Creek/Shamona Creek	216	379	596	439	157	142
B8 East Branch Brandywine Creek/Taylor Run	174	1,480	1,654	628	96	87
B9 East Branch Brandywine/ Beaver Creek	627	648	1,275	929	237	213
B10 Marsh Creek	274	0	274	188	145	131
B11 Upper East Branch Brandywine Creek	166	2	168	143	54	48
B12 Upper West Branch Brandywine Creek	302	0	302	212	71	64
B13 West Branch Brandywine 310 Creek/Broad Run	0	310	255	100	90	
B14 West Branch Brandywine/ Rock Run/Sucker Run	290	1,777	2,067	988	261	235
B15 West Valley Creek	1,046	1,128	2,174	966	303	273
Total for Watershed	**4,049**	**15,415**	**19,463**	**8,159**	**2,023**	**1,820**
Chester Creek						
Ch1 Lower Chester Creek	154	844	998	2,669	441	397
Ch2 Upper East Branch Chester Creek	228	238	466	1,768	318	286
Total for Watershed	**382**	**1,082**	**1,464**	**4,437**	**759**	**683**
Christina River						
Cr1 Belltown Run	3	0	3	355	38	34
Cr2 East Branch Christina River	12	262	273	1,201	129	116
Cr3 Little Mill Creek	17	0	17	1,599	172	155
Cr4 Lower Tidal Christina River	30	16	46	2,810	302	272
Cr5 Muddy Run	6	0	6	321	35	32
Cr6 Upper Christina River	117	0	117	1,269	152	137
Total for Watershed	**184**	**278**	**462**	**7,555**	**828**	**745**

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

(Table 6-5 continued)

Subbasin Code and Name	1998 Withdrawals				2020 Projected Needs	
	Ground Water Withdrawals	Surface Water Withdrawals	Total Water Withdrawals	Total Water Used	Additional Water Demand	Additional Wastewater Capacity Needs
Conestoga Creek						
Con Conestoga Creek	316	15	332	216	90	81
Total for Watershed	**316**	**15**	**332**	**216**	**90**	**81**
Crum Creek						
Cm1 Lower Crum Creek	32	6,996	7,028	2,446	78	70
Cm2 Upper Crum Creek	116	4	120	515	73	66
Total for Watershed	**148**	**7,000**	**7,148**	**2,962**	**151**	**136**
Darby Creek						
D1 Cobbs Creek	31	12	43	3,213	29	26
D2 Lower Darby Creek	155	16	171	16,148	31	28
D3 Upper Darby Creek	36	24	59	1,651	62	56
Total for Watershed	**221**	**52**	**273**	**21,012**	**122**	**110**
Elk Creek						
E1 East Branch Big Elk Creek	85	0	85	77	29	26
E2 Lower Big Elk Creek	133	0	133	138	34	30
E3 Lower Little Elk Creek	120	0	120	120	30	27
E4 Upper Big Elk Creek	94	0	94	106	42	38
E5 Upper Little Elk Creek	51	0	51	94	14	13
E6 West Branch Big Elk Creek	128	0	128	148	13	12
Total for Watershed	**612**	**0**	**612**	**683**	**162**	**146**
French Creek						
F1 Lower French Creek	168	15	183	587	104	93
F2 Middle French Creek	208	1	210	92	32	28
F3 South Branch French Creek	47	0	47	60	24	21
F4 Upper French Creek	98	0	98	75	20	18
Total for Watershed	**521**	**17**	**537**	**814**	**179**	**161**
Gulph Creek						
Gul Gulph Creek	5	0	5	525	44	40
Total for Watershed	**5**	**0**	**5**	**525**	**44**	**40**
Northeast Creek						
N1 Lower Northeast Creek	287	0	287	287	71	64
N2 Upper Northeast Creek	88	0	88	48	12	11
Total for Watershed	**375**	**0**	**375**	**335**	**83**	**75**

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

(Table 6-5 continued)

Subbasin Code and Name	1998 Withdrawals				2020 Projected Needs	
	Ground Water Withdrawals	Surface Water Withdrawals	Total Water Withdrawals	Total Water Used	Additional Water Demand	Additional Wastewater Capacity Needs
Octoraro Creek						
Oc1 Lower East Branch Octoraro Creek	152	0	152	142	54	49
Oc2 Lower Octoraro Creek	225	9,552	9,777	249	50	45
Oc3 Octoraro Reservoir	69	0	69	49	7	7
Oc4 Upper East Branch Octoraro Creek	131	47	178	174	80	72
Oc5 Upper West Branch Octoraro Creek	132	376	508	131	34	31
Total for Watershed	**710**	**9,975**	**10,685**	**745**	**226**	**203**
Pequea Creek						
Peq Pequea Creek	189	0	189	177	52	47
Total for Watershed	**189**	**0**	**189**	**177**	**52**	**47**
Pickering Creek						
Pc1 Lower Pickering Creek	133	1,235	1,368	294	55	49
Pc2 Upper Pickering Creek	93	0	93	316	148	133
Total for Watershed	**226**	**1,235**	**1,461**	**611**	**203**	**182**
Pigeon Creek						
Pgn Pigeon Creek	129	0	129	121	22	20
Total for Watershed	**129**	**0**	**129**	**121**	**22**	**20**
Red Clay Creek						
RC1 Burrows Run	38	0	38	48	11	10
RC2 East Branch Red Clay Creek	257	4	260	201	33	30
RC3 Lower Red Clay Creek	9	7	16	916	98	89
RC4 Upper Red Clay Creek	40	943	983	210	23	21
RC5 West Branch Red Clay Creek	293	0	293	294	61	55
Total for Watershed	**636**	**954**	**1,590**	**1,668**	**227**	**204**
Ridley Creek						
Rd1 Lower Ridley Creek	32	991	1,023	1,764	105	95
Rd2 Upper Ridley Creek	370	9	379	624	107	96
Total for Watershed:	**401**	**1,000**	**1,401**	**2,388**	**212**	**191**
Schuylkill River						
S1 Crow Creek	377	0	377	558	105	94
S2 Schuylkill-Mingo Creek	236	0	236	199	26	23
S3 Schuylkill-Sixpenny Creek	84	4	88	115	20	18
S4 Schuylkill-Sprogels Run	62	0	62	103	18	16
S5 Schuylkill-Stony Run	7	1,572	1,579	279	36	32
S6 Schuylkill-Trout Creek a	3	0	3	60	11	10
S7 Schuylkill-Trout Creek b	0	0	0	29	6	5
Total for Watershed	**769**	**1,576**	**2,345**	**1,342**	**221**	**199**

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

(Table 6-5 continued)

Subbasin Code and Name	1998 Withdrawals				2020 Projected Needs	
	Ground Water Withdrawals	Surface Water Withdrawals	Total Water Withdrawals	Total Water Used	Additional Water Demand	Additional Wastewater Capacity Needs
Stony Run						
Stn Stony Run	71	0	71	62	16	14
Total for Watershed	**71**	**0**	**71**	**62**	**16**	**14**
Trout Creek						
Trt Trout Creek	802	0	802	536	68	61
Total for Watershed	**802**	**0**	**802**	**536**	**68**	**61**
Valley Creek						
Val East Valley Creek	681	2,556	3,238	1,002	108	97
Total for Watershed	**681**	**2,556**	**3,238**	**1,002**	**108**	**97**
White Clay Creek						
WC1 Lower East Branch White Clay Creek	163	17	180	177	47	43
WC2 Lower White Clay Creek	3	6,863	6,867	338	36	33
WC3 Middle Branch White Clay Creek	177	0	177	146	57	51
WC4 Middle Run	2	0	2	194	21	19
WC5 Middle White Clay Creek	13	0	13	1,367	147	132
WC6 Mill Creek	14	11	25	1,204	130	117
WC7 Pike Creek	6	17	23	634	68	61
WC8 Upper East Branch White Clay Creek	149	11	159	219	73	65
WC9 Upper White Clay Creek	21	644	665	325	40	36
WC10 West Branch White Clay Creek	69	0	69	69	29	26
Total for Watershed	**617**	**7,563**	**8,180**	**4,672**	**647**	**582**
Total for Study Area	**12,046**	**48,718**	**60,764**	**60,022**	**6,441**	**5,797**

Source: *Chester County, Pennsylvania Water Resources Compendium* (CCWRA 2001)

- **Column 1**—Subbasin code and name.
- **Column 2**—Volume of total annual ground water withdrawals for 1998 from each subbasin as determined from withdrawal permits and estimates of individual residential well withdrawals.
- **Column 3**—Volume of total annual surface water withdrawals for 1998 from each subbasin as determined from withdrawal permits.
- **Column 4**—Volume of total annual water withdrawals from each subbasin for 1998 (column 2 plus column 3).
- **Column 5**—Estimates of total water used within each subbasin, based on population distribution across the portion of each municipality within each subbasin.
- **Column 6**—Projections of total additional water needed to meet usage demands within each subbasin in 2020 based on distribution of projected growth in population by 2020 across the portion of each municipality located within each subbasin.
- **Column 7**—Projections of total additional wastewater capacity needed (in public systems and/or on-lot septic systems) by 2020 for each subbasin, based on the assumption that 10% of all water used is completely consumed and not returned as wastewater.

Stakeholder Roles

Opportunities for Stewardship

One of the purposes of ***Watersheds*** is to provide recommendations and guidance to the stakeholders of the watersheds — county and other government agencies, municipalities, utilities, industry, watershed and land conservation organizations, land owners and operators, and individuals — on ways to better manage the County's water resources that are consistent with **LANDSCAPES.** The most critical components of ***Watersheds*** are the integrated goals and objectives, and their associated strategies that collectively strive to balance human activities with the preservation of watershed resources. Striking this balance requires the direct involvement of all of us. Only by addressing our own fair share of responsibility can we hope to find a collective approach that achieves a balance between society and nature.

Everyone in our watershed communities can contribute in numerous ways to the protection of water resources and the better integration of land use and water resources. This section briefly outlines the roles each of us can undertake. Some involve the use of municipal ordinances. Some address roles for regulatory and resource management agencies. Others address voluntary roles for various stakeholders, such as residential property owners, utilities, and county agencies, among others. Several key roles are recommended below for all stakeholders of Chester County's watersheds.

Municipal Role

Watersheds, as with *LANDSCAPES,* recognizes the key role municipalities must play by incorporating water resources strategies into their land use planning and governance functions. Because of the directives in the Pennsylvania Municipalities Planning Code (MPC), municipalities are the focus of implementation efforts for ***Watersheds.*** Enabled by the MPC, municipalities are the focal point to address runoff from new and existing developed lands, to improve the coordination of land use, water use, and infrastructure planning, to enhance recreational opportunities, and to protect natural resources from land disturbance.

All lands, whether undergoing development or not, should be evaluated and encouraged to use land management practices that reduce impacts to water resources. The most effective opportunities to improve land management practices and to better integrate land and water resources management occur when new land development is being planned. Many BMPs can be incorporated into new development plans to improve the recharge and runoff characteristics of the land. More effective alternatives for water supply and wastewater disposal options can also be evaluated for new development. Lands that serve important hydrologic functions can be protected from disturbance or have their functions restored.

The most fundamental role recommended for consideration by municipalities is to undertake a comprehensive review of their existing land use regulations, policies and requirements to identify where they may be unnecessarily causing impacts to water resources. Examples include: requirements for minimum setbacks that inadvertently impact sensitive resources, street widths that can be reduced, curbs that can be replaced with grassed swales, double sidewalks where single sidewalks can suffice, large radius cul-de-sacs where "hammerheads" or cul-de-sacs with vegetated islands can be used, and expansive paved (impervious) parking lot requirements where porous parking surfaces can be used, among others. Such requirements can unnecessarily generate additional stormwater runoff and reduce ground water recharge. While existing standards may be perceived as necessary for public health, safety and welfare purposes, often such purposes can be achieved while also reducing other unintentional impacts such as increased flooding, loss of ground water recharge, and pollutant runoff.

The recommendations for municipal implementation of ***Watersheds*** are listed below. These encourage municipalities to identify the collective set of water resources related priorities for the municipality and the watershed(s) within which the municipality is located, and to implement appropriate ***Watersheds*** strategies to address those priorities through municipal planning, ordinances, decision-making, and facilities management.

Recommendations for Implementation by Municipalities

- Consider the implications of watershed resources within municipal decision-making (e.g., stormwater runoff, ground water recharge, flooding, water quality, aquatic living resources, water-based recreational and cultural resources and opportunities, etc.).
- Review municipal ordinances and, where appropriate, eliminate requirements that unnecessarily create stormwater or other impacts to watershed resources.
- Revise municipal comprehensive plans and municipal ordinances to incorporate ***Watersheds*** strategies.
- Encourage land owners, operators and developers to implement conservation development designs, best management practices, and other relevant ***Watersheds*** strategies in land use and land management activities.
- Apply relevant ***Watersheds*** strategies to management of lands and facilities owned, leased or operated by the municipality and in projects funded by the municipality.
- Participate in multi-municipal stormwater and Integrated Water Resources Planning efforts to address regional needs and problems.
- Utilize available opportunities to expand public education and awareness regarding watershed stewardship.

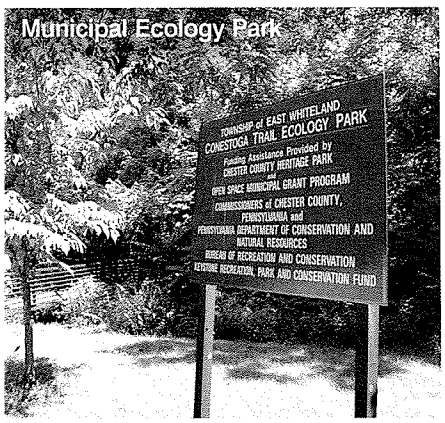
Watersheds recommends 227 different strategies for implementing the goals and objectives (see Part 8). To simplify the selection of strategies to be undertaken by a municipality, the *Compendium* re-organized these strategies into twelve categories (listed below). These categories will help guide municipalities to identify the specific types or options of strategies that can best address their particular interests, needs or problems. The *Compendium* presents detailed guidance for implementing these strategies, explains why each technique is recommended, suggests how they can be implemented at the municipal level, and provides information on related reference materials (this information is presented in Section 13 of the *Compendium*). Where appropriate, the *Watersheds* goals and strategies will be incorporated within Chester County's technical assistance and grants programs related to LANDSCAPES implementation to assist and encourage municipal implementation.

Twelve Categories of *Watersheds* Strategies for Municipal Implementation

1. Involving the Public in Watershed Stewardship.
2. Providing Water-Based Recreation and Cultural Resources.
3. Establishing Networks of Forested Riparian Buffers.
4. Conservation (Low Impact) Development Designs.
5. Land Preservation for Protecting Natural Resources.
6. Protecting Ground Water Quality.
7. Protecting Sources of Public Drinking Water Supplies.
8. Agricultural and Landscape Management.
9. Reducing Stormwater and Flooding Impacts.
10. Natural Stream Restoration and Stabilization.
11. Protecting Ground Water Balances and Stream Baseflow.
12. Integrated Water Resources Planning.

Watersheds presents recommended management priorities for each of Chester County's watersheds (Parts 5 and 10). These priorities are meant to assist municipalities and others in selecting strategies for implementation.

For example, if the municipality is in a watershed that experiences frequent regional flooding, then stormwater reduction strategies may be a priority for their watershed(s). If several stream segments in their subbasin(s) have been designated by PADEP as "impaired streams", then reducing the runoff of nonpoint source pollutants may be a priority for their watershed(s) and subbasin(s). If their subbasin(s) includes points where public drinking water supplies are withdrawn from streams, then protection of source waters may be a priority. Generally, there will be multiple priorities identified for any watershed or subbasin. These priorities should be considered along with other planning and environmental priorities within their municipality. As a default, municipalities are encouraged to consider the four categories listed below as priorities for implementation.

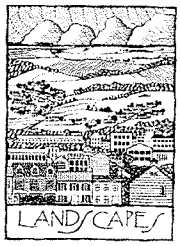


Four Priorities for Municipalities

1. Providing and enhancing water-based recreation and cultural resources.
2. Reducing stormwater and flooding impacts.
3. Establishing networks of forested riparian buffers.
4. Preparing Integrated Water Resources Plans (e.g., planning for future water supply and wastewater needs in an integrated, coordinated effort).

Chester County Role

The *Compendium* lists specific recommendations for a number of Chester County agencies, including the Planning Commission, Water Resources Authority, Parks and Recreation Department, Health Department, Department of Community Development, Department of Emergency Services, and the County Conservation District. Overall, the County's role is to provide guidance, incentives, assistance, and recommendations to municipalities and others in implementing LANDSCAPES and ***Watersheds.*** The following discussion presents the key roles for Chester County agencies for ***Watersheds*** implementation, as staff and funding resources allow.



Chester County Planning Commission (CCPC)

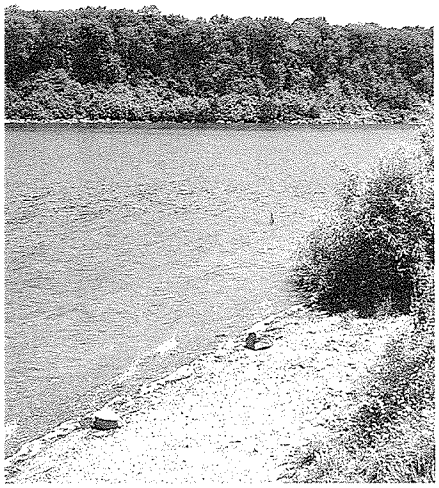
CCPC undertakes county-wide planning pursuant to the Municipalities Planning Code (MPC), as amended, and provides guidance, technical and financial assistance to municipalities on planning issues. CCPC also implements LANDSCAPES and its supporting programs in cooperation with the municipalities of the County. The implementation of ***Watersheds*** will be integrated within appropriate existing CCPC programs.

CCPC Role for Implementation

- Continue implementation of ***LANDSCAPES*** and Vision Partnership Program (VPP).
- Integrate ***Watersheds*** objectives and strategies into the policies of CCPC for planning, municipal guidance, grants criteria and eligibility, regulatory reviews, Acts 247 and 537 reviews, and other relevant activities of the Commission.
- Consider relevant municipal planning activities to implement the ***Watersheds*** goals and strategies as eligible projects for funding under VPP and other Chester County planning grant programs.
- Continue to encourage the implementation of conservation subdivision development design practices.
- Incorporate appropriate water resources "tools" within CCPC's "Community Planning Handbook."
- Continue providing information and publications to municipalities and the public on relevant topics regarding land use and water resources such as the benefits of conservation development design and related planning information and guidance.
- Encourage implementation of the objectives and strategies of the ***Watersheds*** Plan by municipalities and other entities.
- Update GIS mapping for water supply and wastewater pipelines and service areas within Chester County.
- Work with CCWRA in providing technical guidance, coordination, and support for multi-municipal Integrated Water Resources Planning (IWRP) efforts.
- Work with CCWRA and CCCD in conducting comprehensive stormwater management studies and fulfilling the requirements of Act 167 mandates, consistent with the priorities and strategies of ***Watersheds.***

Chester County Water Resources Authority (CCWRA)

CCWRA serves as the County's water resource management agency and its current programs address the interaction of land use, growth and water resources. All of CCWRA's programs and activities have been designed to support the implementation of *LANDSCAPES* and *Watersheds,* and to provide the understanding and information to support sound land and water use decision-making. CCWRA provides flood protection for Brandywine Creek communities, regional water management, streamflow and riparian lands management, stormwater management planning, field science and investigations to address priority concerns, and technical assistance, guidance and education to municipalities and the public. CCWRA will be the lead agency responsible for coordinating the implementation of *Watersheds* and its strategies.



CCWRA Role for Implementation

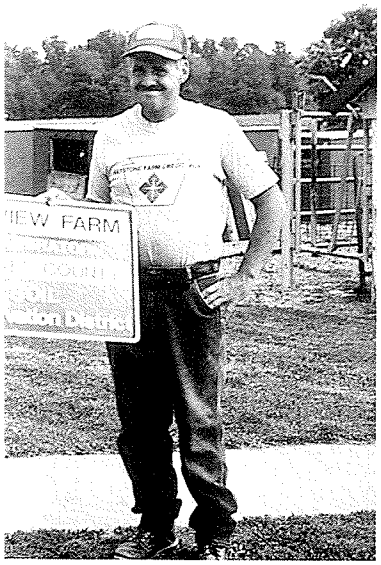
- Coordinate the implementation of the ***Watersheds*** goals and strategies among County agencies and watershed stakeholders.
- In cooperation with the watershed associations, petition PADCNR to include all remaining streams and tributaries within Chester County on the PA Rivers Conservation Registry.
- Work with CCPC to identify and track water resources "indicators" for ***LANDSCAPES*** and ***Watersheds.***
- Support implementation of individual watershed action plans developed as part of the *Chester County, PA Water Resources Compendium.*
- Provide technical guidance, coordination, and information to support multi-municipal Integrated Water Resources Planning efforts in cooperation with CCPC and CCHD.
- Represent Chester County in regional water management and planning coordination activities regarding water use, water quality, and resources protection.
- Operate and maintain CCWRA's 4 water control structures to provide flood protection for Brandywine Creek communities and water supply for the Coatesville region.
- Continue to assist and support implementation of nonpoint source and point source management practices and strategies throughout the County's watersheds.
- Work with CCPC, CCHD and other appropriate entities to conduct comprehensive stormwater management plans, consistent with the ***Watersheds*** priorities and strategies and PA Act 167.
- Provide basic science, information and data to support sound land and water use decisions and multi-municipal Integrated Water Resources Plans.
- Monitor the County's hydrologic conditions and provide results to municipalities, other agencies, utilities, and the public to support drought and flood preparedness and response decision-making.
- In cooperation with other entities, identify training opportunities for municipal officials, representatives and staff, as well as utilities and developers, to facilitate their implementation of the goals and strategies of ***Watersheds.***
- Review ***Watersheds*** and update as necessary.

Chester County Conservation District (CCCD)

CCCD reviews, issues permit approvals, and inspects conservation practices associated with new development and farming activities, promotes conservation practices and administers grant programs to install best management practices and conserve natural resources. CCCD is the lead agency responsible for providing incentives, technical assistance and grant funding to land operators to address soil and water conservation, nonpoint source pollutant management, and stormwater management systems and BMPs. Because of their mission of soil and water conservation, CCCD will be a key agency in the implementation of *Watersheds.*

CCCD Role for Implementation

- Integrate ***Watersheds*** goals and strategies as appropriate into the policies of CCCD planning, programs, regulatory reviews (i.e., sediment and erosion control, stormwater management, stream protection, biosolids, and nonpoint source pollution control), grants, technical assistance, public outreach and education, and other activities.
- Accelerate the implementation of agricultural and other nonpoint source BMPs, whenever possible.
- Encourage and actively promote use of recommended stormwater management goals and strategies by land developers and municipalities.
- Prioritize nonpoint source reduction BMPs in subbasins given high priority for water quality restoration in watersheds.
- Accelerate implementation of riparian buffer protection/restoration through technical assistance, CCCD and other County and federal grants, and educational programs.
- Continue to provide public education workshops, materials, and technical assistance regarding protection of watershed resources and watershed stewardship to municipalities, agricultural operators, watershed/conservation organizations, land developers, and the public.
- Continue role of "watershed coordinator" to provide assistance and coordination for watershed restoration, protection and education activities conducted by stakeholders in the County's watersheds.
- Work with CCWRA and CCCD in conducting comprehensive stormwater management studies, consistent with the priorities and strategies of ***Watersheds,*** and fulfilling the requirements of Act 167 mandates.



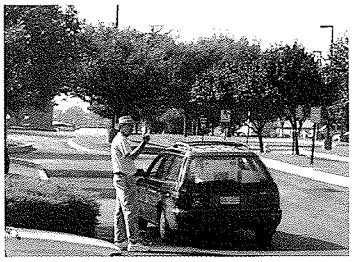
Chester County stormwater BMP tour

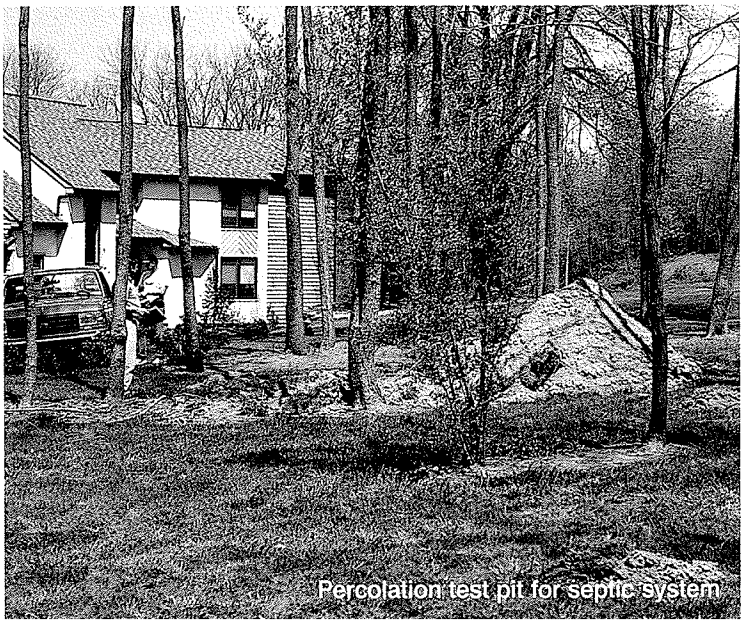
Chester County Health Department (CCHD)

CCHD administers the County's various health regulations, inspects site activities, and issues permits associated with ground water wells, on-lot wastewater disposal, public drinking water supply systems, and other aspects of environmental health. Because of their numerous programs and responsibilities related to water resources issues, CCHD will be a key agency in the implementation of the *Watersheds* Plan.

CCHD Role for Implementation

- Implement ***Watersheds*** goals and strategies as appropriate within relevant ongoing regulatory and public health programs.
- Continue public environmental protection, waste management and education programs that contribute to watershed stewardship (i.e., household hazardous waste disposal, composting, recycling programs, etc.).
- Continue to provide public education and materials regarding protection of watershed resources and watershed stewardship.
- Provide technical information, guidance, and assistance to municipalities to develop local on-lot septic system management programs.
- Work with CCWRA to coordinate and maintain data management for water supply and wastewater facilities and permits in support of multi-municipal Integrated Water Resources Planning.
- Continue programs to provide field science, data and information to evaluate conditions for water supply, wastewater, instream uses, and other public health related concerns.
- Continue participation on Chester County Drought Emergency Task Force with CCDES, CCWRA and other entities, on an as needed basis.
- Coordinate with CCDES, PADEP, and CCWRA to maintain an effective emergency notification system to immediately alert water suppliers and reservoir owners and operators of releases of hazardous materials into their source waters.
- Work with CCWRA and CCPC to assist municipalities in developing multi-municipal Integrated Water Resources Plans.
- Encourage implementation of water supply reservoir monitoring programs by owners.
- Support municipal and water supplier efforts to develop and implement source water protection programs, including the Brandywine Valley Association effort in Brandywine Creek watershed.





Percolation test pit for septic system

Chester County Department of Community Development (CCDCD)

CCDCD administers federal, state and County funding for affordable housing, homelessness assistance, community and economic development, and job training. The funding is awarded through application processes to local organizations and governmental entities. Funding programs administered by CCDCD include the Community Development Block Grant Program and the Chester County community revitalization grant program (for boroughs and the City of Coatesville). Certain water, wastewater, and/or stormwater management projects may be eligible for grant funding under these programs. The implementation of *Watersheds* will be integrated within appropriate existing CCDCD programs.

CCDCD Role for Implementation

- Integrate the goals and strategies of ***Watersheds*** within appropriate CCDCD policies and grant programs, and particularly Chester County community revitalization grants.
- Encourage and consider relevant water, wastewater and/or stormwater management projects that implement the goals and strategies of ***Watersheds*** for funding under appropriate CCDCD grant programs.

Chester County Parks and Recreation Department (CCPRD)

CCPRD maintains the lands, facilities and natural resources of the County's parks and administers its recreation programs. In addition, it is the lead agency for numerous County grant programs that address protecting natural resources and open space and providing recreational lands for public use, which will be key in the implementation of *Watersheds.*

CCPRD Role for Implementation

- Integrate the goals and strategies of ***Watersheds*** within the manuals, criteria, incentives, and eligible projects for CCPRD grants to municipalities and other qualifying non-profit organizations.
- Continue efforts in riparian land preservation, buffer vegetation enhancement, and recreation on County-owned lands, public education, and grant funding programs, consistent with ***Watersheds*** priorities.
- Integrate the goals and strategies of ***Watersheds*** into Natural Resources Management Plans for each park site, and continue implementation of those plans for natural resources conservation, restoration, and management at each park.
- Implement the goals and strategies of ***Watersheds*** on other lands owned and managed by CCPRD.
- Consider land and resources preservation priorities presented in ***Watersheds*** when acquiring additional lands.
- Provide public education opportunities and demonstration projects for composting, rain barrels, correcting erosion problems, riparian buffer protection/restoration, and other watershed stewardship techniques through the Chester County parks system.

Chester County Department of Emergency Services (CCDES)

CCDES coordinates the County's emergency services, and provides emergency warnings and contingency planning services. CCDES provides emergency preparedness and response programs and training for municipal emergency management staff. CCDES involvement with water resources management includes: flooding, droughts, releases of hazardous materials and contaminants to streams and sources of water supplies, and assistance in implementation of Emergency Action Plans for dams located within Chester County. Water-related emergency coordination functions of CCDES will be key in the implementation of *Watersheds.*

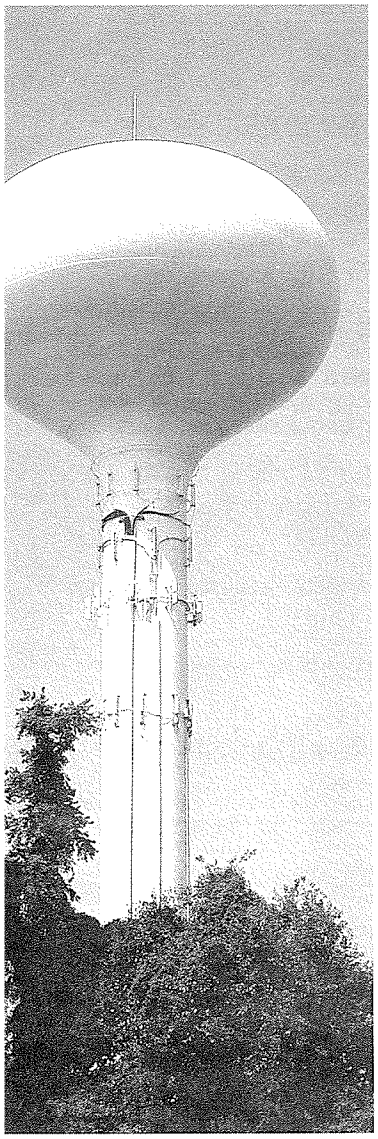
CCDES Role for Implementation

- Continue to lead and coordinate the Chester County Drought Emergency Task Force with CCHD, CCWRA, and other entities, on an as needed basis.
- Coordinate with CCHD, PADEP, and CCWRA to maintain an effective emergency notification system to provide immediate alert to water suppliers of releases of hazardous materials into their source waters.
- Provide early alert of potential major flood conditions to municipalities and dam owners when possible.
- Serve as central point of communication and coordination for preparation and implementation of flood alert and response procedures for lower Brandywine Creek municipalities and work with CCWRA to explore opportunities to develop similar procedures for other areas of Chester County.
- Participate in preparation and implementation of Emergency Action Plans for dams located within and upstream of Chester County.
- Provide public education and materials regarding emergency preparedness and response for water related emergency events (i.e., flooding, dam emergencies, hazardous materials releases, etc.)

Roles for Water and Wastewater Utilities

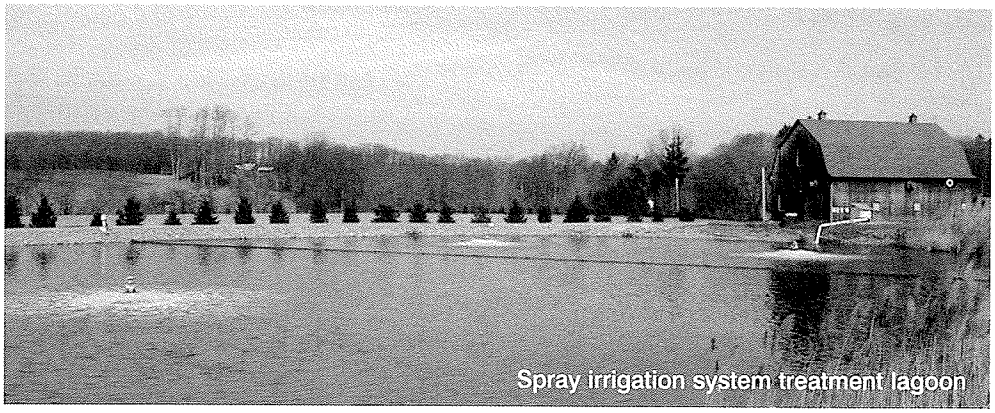
Public water and wastewater purveyors (utilities) rely on sustainable water resources for their livelihood and undertake extensive planning and investigation in making decisions regarding the expansion or modification of their systems. Several recommendations were presented in the *Compendium* for consideration by the water and wastewater utilities to bring together their knowledge and planning processes with those of the municipalities and County, and for making decisions regarding new water sources, new disposal options, and new system expansions. Key among those are the recommendations listed below. Chester County will be available to work with the utilities to clarify the recommendations made, and provide input and support for their consideration and/or implementation. These recommendations are intended to apply to all utilities—whether municipal and privately owned.

Water Supply Utilities



Recommendations for Implementation

- Support and participate in multi-municipal Integrated Water Resources Planning efforts in subbasins in which the utility is or intends to operate.
- Work with municipalities and Chester County to identify areas planned for future public supply service and areas to be protected from service connections consistent with ***Landscapes*** and municipal planning and zoning.
- Work with municipalities and Chester County when planning for system expansions and new sources.
- Restrict franchise and service areas to only those areas designated by municipalities as planned for or in need of public water service.
- Provide or participate in mechanisms (i.e., installation of independent "satellite" water supply systems and agreements with municipalities) to protect rural areas and pipeline corridors through rural areas from undesired service connections.
- Work within subbasin and watershed water balances when planning new sources of withdrawals.
- Thoroughly evaluate viable options for new source alternatives, new systems, and expansions based on cost/economics, environmental, engineering/technical, regulatory, and local land use planning implications and provide those evaluations as part of the permit application package.
- Consider protection of instream flows and instream flow-sensitive habitats to protect sensitive resources when planning new withdrawals.
- Develop source water protection programs consistent with state guidelines and share information with County agencies and municipalities to facilitate local source water protection efforts.
- Increase water conservation and re-use throughout the utility system by incentives and education programs.
- Reduce unaccounted-for water to help reduce demand for unnecessary withdrawals.
- Provide in annual water supplier reports, the system's annual, monthly, and municipal water use data to indicate the amount distributed for domestic, commercial, industrial, institutional uses, and unaccounted-for water, estimated population served by municipality, and annual and monthly total raw water used by source to assist in water supply planning and maintaining subbasin water balances.
- Prepare emergency management plans for meeting water supply needs during drought conditions (as required by the state), and provide plans to and coordinate with affected municipalities and county(ies).


Spray irrigation system treatment lagoon

Wastewater Utilities

Recommendations for Implementation

- Support and participate in multi-municipal Integrated Water Resources Planning efforts in subbasins in which the utility is or intends to operate.
- Work with municipalities and Chester County to identify areas planned for future public service and areas to be protected from service connections, consistent with ***Landscapes*** and municipal planning and zoning.
- Work with municipalities and Chester County when planning for system expansions, new disposal alternatives, and sewered areas.
- Restrict franchise and service areas to only those areas designated by municipalities as planned for or in need of public wastewater service.
- Provide or participate in mechanisms (i.e., installation of smaller, independent "satellite" systems and agreements with municipalities) to protect rural areas and pipeline corridors through rural areas from undesired service connections, consistent with ***Landscapes*** and municipal planning.
- Thoroughly evaluate viable options for new disposal alternatives, new systems, and expansions based on cost/economics, environmental, engineering/technical, regulatory, and local land use planning implications and provide those evaluations as part of the permit application package.
- Work toward maintaining or enhancing subbasin and watershed water balances when planning new disposal alternatives.
- Consider source water protection needs when selecting treatment techniques and technologies to protect raw water sources of public water supplies to the maximum extent possible.
- Work with water suppliers to address non-regulated constituents that are directly linked to taste and odor problems.
- Increase water conservation and re-use throughout the utility system and its customers through incentives and education programs.
- Aggressively work to locate and repair leaking wastewater collection mains to reduce inflow/infiltration and/or raw sewage discharges to the environment.
- Consider land application alternatives along with instream discharge alternatives for new facilities.
- Consider innovative small systems technologies for their consistency with local land use planning and their environmental benefits where appropriate.
- Consistent with Clean Water Act Amendments, consider eliminating stream discharges where feasible and incorporating innovative land application approaches.
- To assist in improved understanding and water supply/wastewater planning by local governments, provide in the discharge report to state regulators, the system's annual and monthly flow data, by municipality, to indicate the amount collected from domestic, commercial, industrial, and institutional customers, and annual and monthly total wastewater treated and released by each discharge or land application facility.

Roles for Watershed, Conservation, and Land Conservancy Organizations

Recommended roles were also identified for watershed and conservation organizations and land conservancies active in Chester County. Many of these are already working with Chester County under various programs to jointly conduct watershed protection, restoration, recreation and/or land preservation activities. Key recommendations for how these entities can support the implementation of *Watersheds* are listed below.

Recommendations for Implementation

- Continue to provide programs, activities and materials to educate and involve the public in watershed stewardship.
- Consider or continue community and citizen monitoring programs to help identify and bring assistance to locations where runoff or activities are directly impairing streams or ground water and where improved management practices are needed.
- Assist in and support implementation of strategies and priorities of ***Watersheds.***
- Work with CCWRA to petition PADCNR to include all remaining streams and tributaries of Chester County on the PA Rivers Conservation Registry.
- Prioritize lands in riparian corridors, first order drainage areas, wellhead protection areas, and 100-year floodplains for land preservation and protection and implementation of strategies for protection of natural resources.
- Participate with and assist municipalities to develop Integrated Water Resources Plans in conjunction with CCPC and CCWRA.
- Pursue, when feasible, grants and funding to implement activities consistent with ***Watersheds*** goals and strategies and with priorities identified within individual watershed action plans.
- Coordinate with CCWRA to expand upon and implement planning efforts completed by watershed associations and adopted by the municipalities in the watershed, and to implement the individual watershed action plans prepared as part of the *Compendium*.

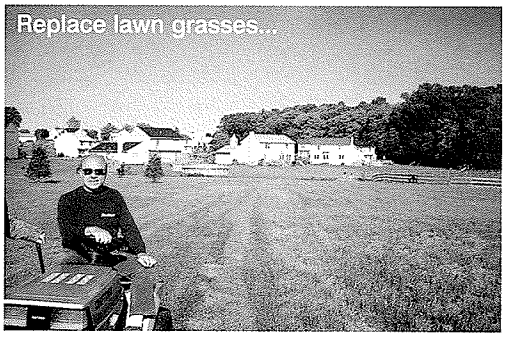
Roles for Land Owners and Operators

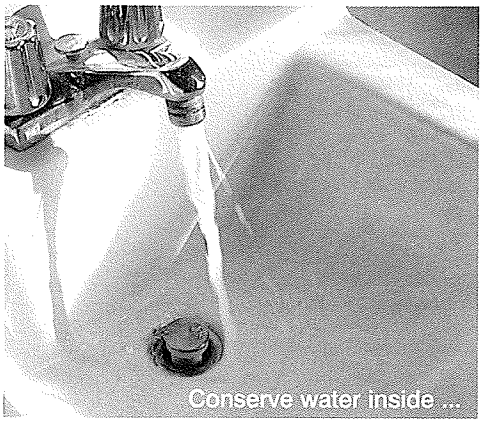
Land owners and operators are the most important stakeholders in implementing the *Watersheds* goals and strategies. Other agencies and entities can provide incentives, assistance, and mandates; however, voluntary watershed stewardship by all land owners and operators is essential to protect and restore the County's watersheds while simultaneously minimizing the need for additional regulatory controls. Key recommendations for implementation by residential, agricultural and turf land owners and operators, industrial and commercial facility operators, and land developers are listed below.

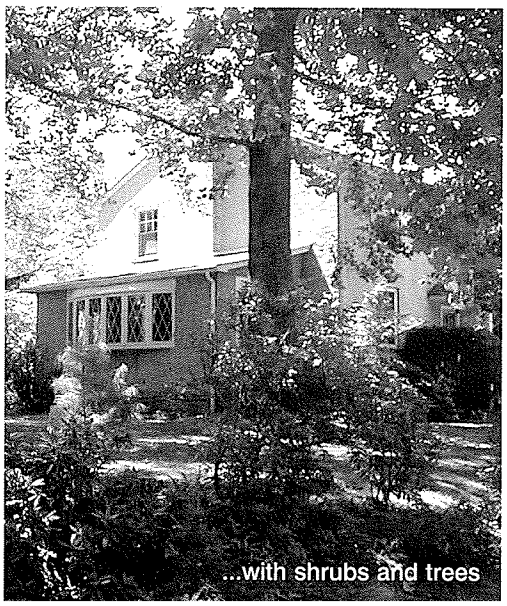
Residential Land Owners and Home Owners Associations

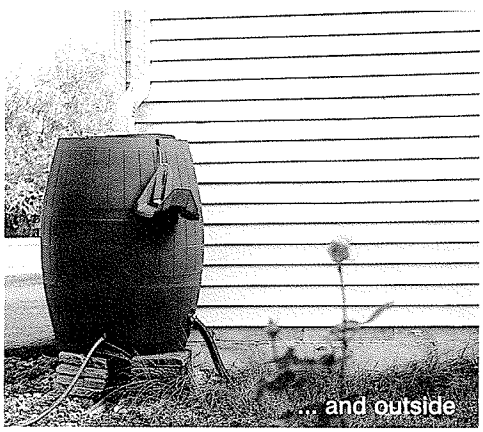
Recommendations for Implementation

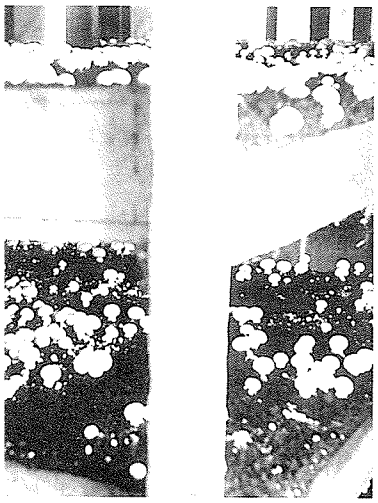
- Improve their understanding and awareness of the impacts of human activities on stormwater runoff and the water quality of ground water and streams in their watershed.
- Implement "watershed stewardship" practices in their landscape and outdoor housekeeping practices.
- Join and support the activities of their local watershed association.
- Reduce water use.
- Minimize the release of unnecessary chemicals into the environment.
- Encourage healthy riparian habitats.







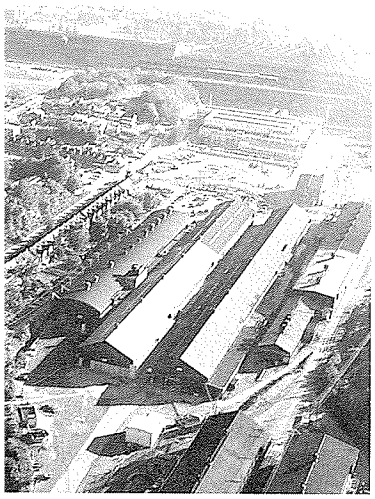




Agricultural and Turf Land Owners and Operators

Recommendations for Implementation

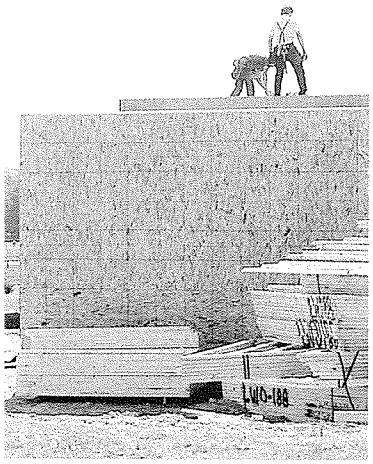
- Implement best management practices to provide soil and water conservation, and reduce nonpoint source pollutant runoff from agricultural lands and operations.
- Reduce the application of fertilizers, pesticides, herbicides, and water to the minimum amount necessary to support healthy plant growth.
- Implement water conservation and re-use techniques wherever possible.
- Establish and protect forested riparian buffers.
- Assist with, expand and provide education and training for other agricultural and turf land owners and operators regarding reducing runoff and nonpoint source pollutants, watershed stewardship, etc.



Industrial and Commercial Facility Operators

Recommendations for Implementation

- Implement landscape management practices that reduce the runoff of nonpoint source pollutants.
- Implement water conservation and re-use techniques whenever possible.
- Implement safe chemical storage, handling and transportation practices to minimize the likelihood of a contaminant release to streams or waterways.
- Evaluate industrial processes to reduce the level of contaminants in effluent discharged from the facility.
- Assist with, expand and provide education and training for other operators regarding facility management, water conservation and re-use, reducing stormwater and pollutant runoff, etc.



Land Developers

Recommendations for Implementation

- Incorporate conservation subdivision development design practices into new land development projects.
- Implement best management practices and comprehensive stormwater management principles to protect ground water recharge, remove nonpoint source pollutants, protect riparian buffers and stream channels and reduce downstream flooding, consistent with the ***Watersheds*** goals and strategies.
- Assist in educating new home owners regarding the need to maintain installed BMPs, riparian buffers and other watershed protection features within their development.
- Work with municipalities and utilities to design new land developments consistent with Integrated Water Resources Planning objectives regarding water and wastewater planning.
- Assist with, expand and provide education and training for land developers regarding conservation development design practices, comprehensive stormwater management, and other watershed stewardship practices.

Roles for State Agencies

In preparation of the *Compendium,* CCWRA recommended several roles for consideration by relevant state agencies to improve water resources management and assist local government and stakeholders in implementing their roles as well. Key among the recommendations are those listed below. Chester County will approach the agencies and listed organizations, clarify the recommendations made, and provide input and support for their consideration and/or implementation.

Several agencies of the Commonwealth of Pennsylvania are involved in the state's many water resources related regulatory and management programs, in particular PA Department of Environmental Protection (PADEP), PA Public Utilities Commission (PUC), and PA Department of Conservation and Natural Resources (PADCNR). The ability to fully achieve the benefits of the ***Watersheds*** goals and strategies through local implementation will be augmented by the State's addressing the following recommendations.

Recommendations for Implementation

- Prepare a state water plan embracing the concepts and principles of integrated water resources management and planning, and that recognizes, encourages, and supports adopted local land use planning, Integrated Water Resources Plans, and other adopted plans.
- Pursue a state-wide comprehensive water resources management law that provides a fair and equitable framework for integrated and consistent management of ground water and surface water resources, protects ground water recharge and stream baseflows, reflects the finite nature of natural water resources, calls for the evaluation of proposed project alternatives and their mitigation needs, incorporates "comprehensive stormwater management" principles, supports and balances the needs of all water users in nature and society, and designates and authorizes an appropriate government entity to implement and enforce the law.
- Provide information and incentives for protecting and enhancing ground water recharge and utilizing effective innovative wastewater treatment alternatives, particularly those capable of recharging ground water.
- In conjunction with DRBC, Chester County and affected municipalities, explore expansion of Southeastern PA GWPA throughout the Delaware River Basin within Chester County.
- In conjunction with SRBC, consider initiating a pilot project similar to DRBC's Southeastern PA GWPA in an appropriate area of the Susquehanna River Basin.
- Consider modifying the PUC regulations to further encourage if not require consistency and coordination of water and wastewater infrastructure expansion with adopted municipal and county land use plans, ordinances, zoning, and Integrated Water Resources Plans.
- Provide information and dialog to improve the municipalities' understanding of the PUC review process and regulatory requirements to facilitate better coordination of municipal and PUC decisions.
- Integrate the various existing state level stormwater management and runoff related programs into a single "comprehensive stormwater management" program that addresses all aspects of stormwater runoff quality and quantity management and geomorphology conditions, provides streamlined and consistent technical guidance, assistance and financial support to conservation designs, counties and municipalities to conduct and implement effective stormwater management plans and local regulations.
- Through PADEP and PUC, provide technical guidance and funding assistance for development and adoption of county and multi-municipal Integrated Water Resources Plans and rely on adopted and approved IWRPs as guidance for regulatory decisions.
- Continue Growing Greener and other watershed conservation and restoration grant funding programs to empower all appropriate entities to be involved in protection and restoration of watershed resources.
- In conjunction with DRBC, improve the basis of regulatory decisions regarding water use of Brandywine Creek and Marsh Creek Reservoir by conducting instream flow analyses of Brandywine Creek and other warm water streams to evaluate the impacts of proposed withdrawals and discharges.
- Re-analyzing the safe yield of Marsh Creek Reservoir based on the current state approach to instream passby requirements and to evaluate alternative operating schemes to best utilize the Reservoir to support planned growth in Chester County.
- Improve permit and other relevant data collection, management, and access (i.e. water supply, wastewater, NPDES, Section 303(d) stream assessments data, etc.) in a consistent electronic format to allow their ready use by local governments and the public to support Integrated Water Resources Planning and water use management.
- Prepare and provide watershed stewardship and water resources educational materials suitable for distribution by local entities.
- Provide for the development and expanded use of watershed science curriculum in schools.
- Provide training opportunities and guidance for municipalities, land developers and water/wastewater utilities regarding watershed resources protection and integrated water resources management strategies.

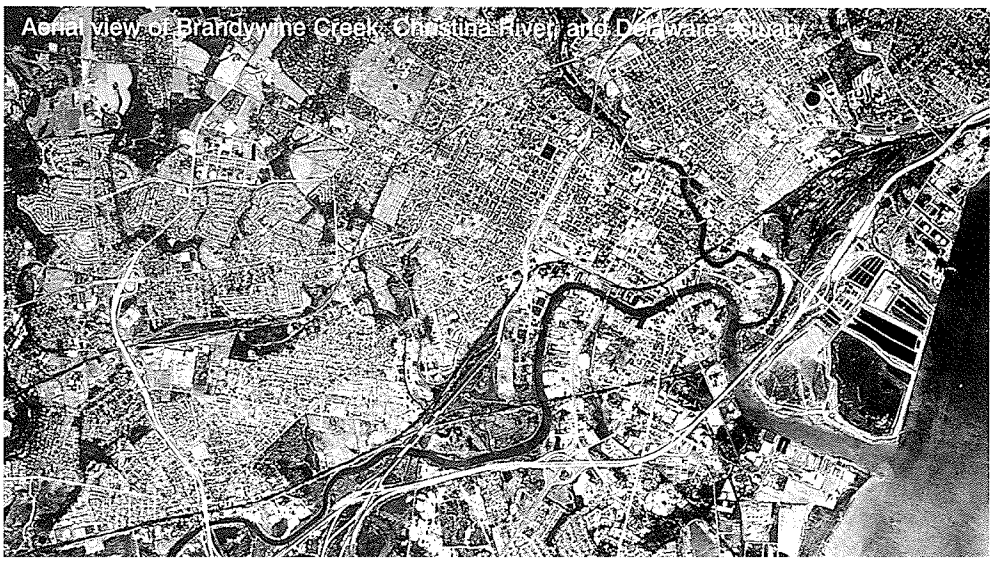
Roles for Inter-State and Federal Agencies

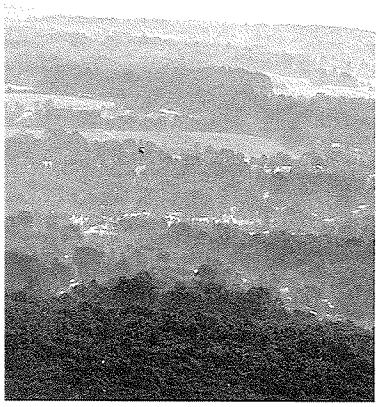
The *Compendium* also identified recommendations for inter-state (i.e. river basin commissions) and federal agencies. Key among those recommendations are those listed below. Chester County will approach the agencies to clarify the recommendations made, and provide input and support for their consideration and/or implementation. Recommendations are included for the following agencies: Delaware River Basin Commission, Susquehanna River Basin Commission, Natural Resources Conservation Service (NRCS) (U.S. Department of Agriculture), U.S. Environmental Protection Agency, U.S. Geological Survey (U.S. Department of Interior), and the National Park Service (U.S. Department of Interior).

Delaware River Basin Commission (DRBC)

Recommendations for Implementation

- Prepare a basin-wide comprehensive plan, embracing the principles and concepts of Integrated Water Resources Planning and management to manage ground water and surface water in a coordinated and consistent manner.
- Provide technical guidance, funding assistance, and incentives for multi-municipal Integrated Resources Planning.
- In conjunction with PADEP, provide instream flow analysis of Brandywine Creek as pilot for warm water streams and to provide scientifically sound basis for future decision-making regarding water withdrawals/discharges in the Brandywine Creek.
- Conduct ground water—instream flow study of French Creek to investigate the inter-relationship of ground water withdrawal and instream flow in the Triassic geologic units of the DRBC Southeastern PA GWPA.
- In the absence of new state legislation that provides comprehensive water management and state oversight of ground water withdrawals, work with PADEP, Chester County and the affected municipalities to explore expansion of the GWPA throughout the Delaware River Basin of Chester County.
- Continue efforts to improve permit data collection and management toward a process consistent with needs to address Integrated Water Resources Planning.
- Provide public educational materials suitable for distribution by counties, municipalities and conservation organizations.





Susquehanna River Basin Commission (SRBC)

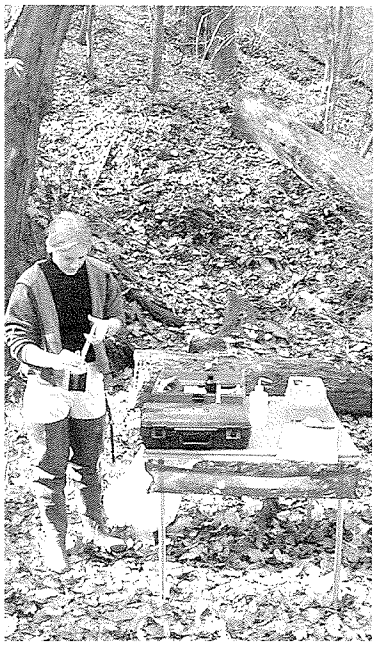
Recommendations for Implementation

- Embrace principles and concepts of integrated water resources management and planning within the SRBC's Comprehensive Plan, regulations, decisions, and planning.
- Provide technical guidance, funding assistance, and incentives for multi-municipal Integrated Water Resources Planning.
- Improve permit data collection and management toward a process consistent with needs to address local Integrated Water Resources Planning.
- In conjunction with PADEP, consider initiating a pilot project similar to DRBC's Southeastern PA GWPA in an appropriate area of the Susquehanna River Basin.
- Provide public educational materials suitable for distribution by counties, municipalities and conservation organizations.

Natural Resources Conservation Service (NRCS)

Recommendations for Implementation

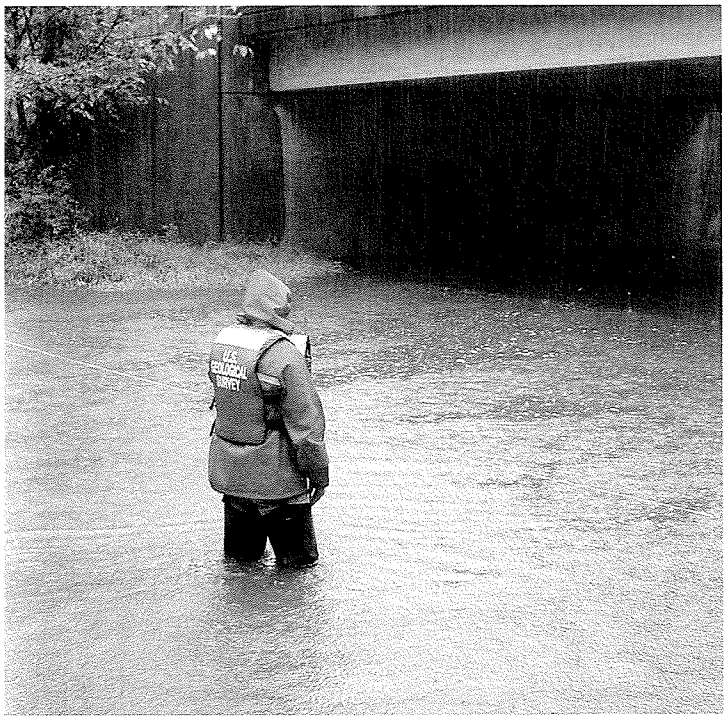
- Provide funding, incentives and technical assistance to accelerate the implementation of agricultural BMPs throughout the study watersheds consistent with the priorities and strategies outlined in the *Compendium*.
- Encourage and promote the implementation of ***Watersheds*** goals and strategies in the agricultural and land management community through NRCS technical assistance, funding, and education programs and materials.
- Continue to provide partnership and technical and financial assistance in support of the implementation of the Brandywine Watershed Workplan and operation and management of the 4 CCWRA dams and related water and wetland resources in the Brandywine Creek watershed.
- Provide public educational materials suitable for distribution by counties, municipalities and conservation organizations.



U.S. Environmental Protection Agency (USEPA)

Recommendations for Implementation

- Continue to closely involve Chester County and other local entities in the development and implementation of TMDL regulations for point and nonpoint source pollutants in the Christina River Basin under the Christina River Basin Water Quality Management Strategy programs, and within other watersheds of Chester County.
- Consider ***Landscapes*** and ***Watersheds*** in decision-making regarding actions of USEPA in Chester County.
- Assist Chester County in implementing ***Landscapes*** and ***Watersheds*** through EPA activities.
- Provide public educational materials suitable for distribution by counties, municipalities and conservation organizations.



U.S. Geological Survey (USGS)

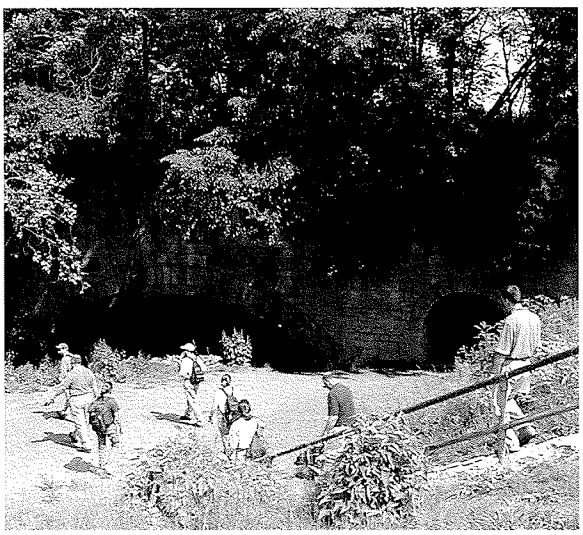
Recommendations for Implementation

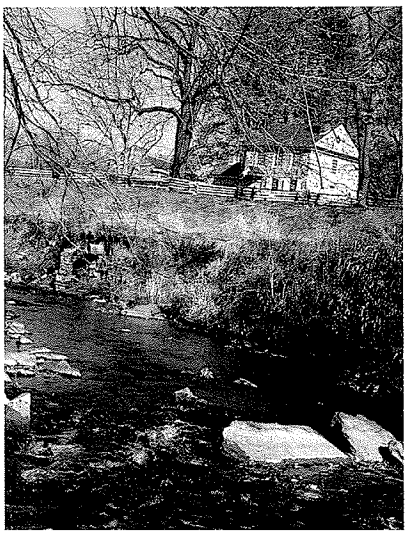
- Maintain cooperative funding programs with Chester County for continuation of monitoring and gaging programs and special investigations necessary to address priorities and needs of Chester County and its constituents.
- Maintain continuous stream gaging program, in cooperation with local and state partners, to provide real-time data necessary for flood alerts, drought management, water supply planning and management, reservoir operation, natural resources protection, and water quality monitoring of the Chester County and southeastern PA watersheds.
- Provide results and conclusions of monitoring and measurement programs and special investigations in a manner easily understandable by the general public.
- Provide public educational materials suitable for distribution by counties, municipalities and conservation organizations.
- Continue investigation of inter-relationships of ground water flow and withdrawals on stream baseflows for French Creek in conjunction with DRBC.

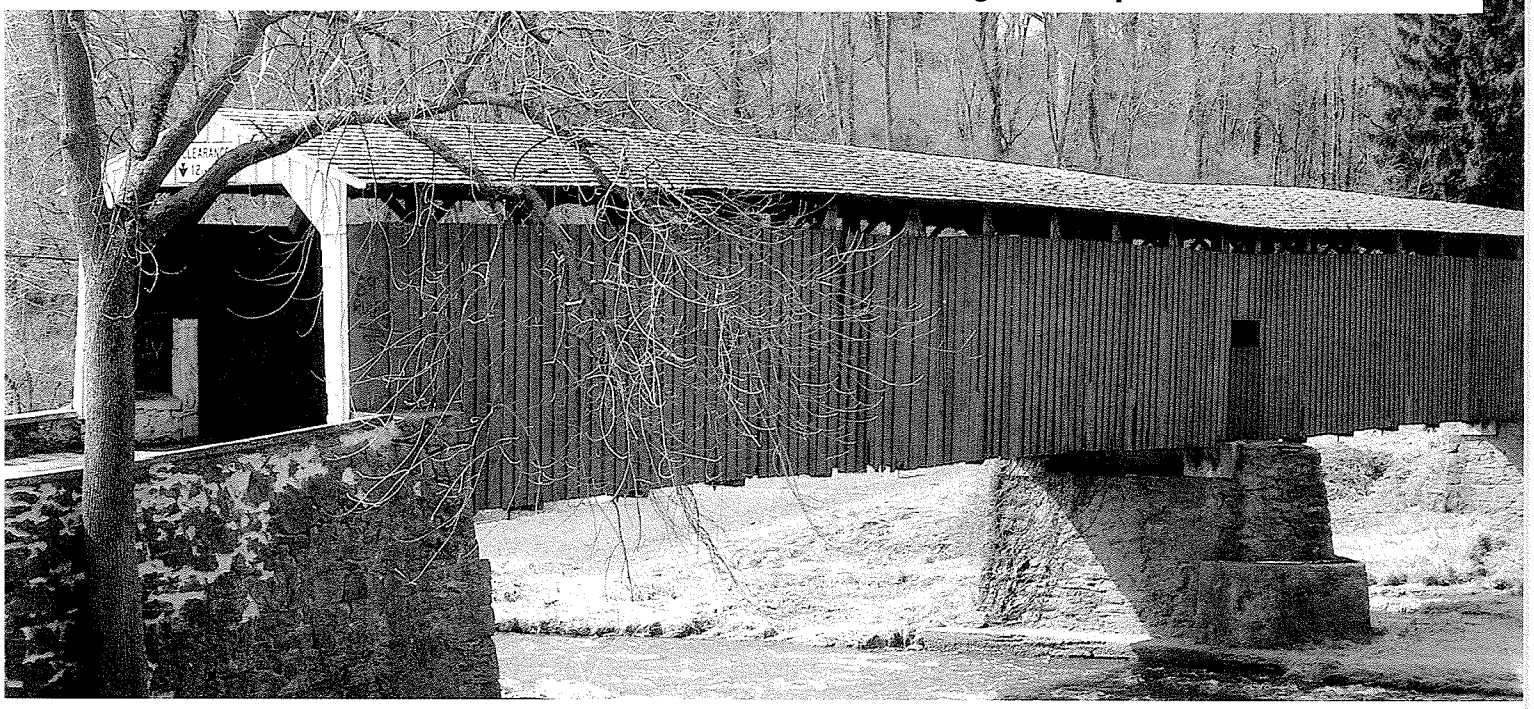
National Park Service

Recommendations for Implementation

- Provide funding and staff for implementation of White Clay Creek Federal Wild and Scenic Rivers Designation Program and Plan.
- Provide direct participation in developing and implementing the results of the East Valley Creek Comprehensive Stormwater Management Study.
- Implement ***Watersheds*** goals and strategies for watershed resources protection on lands owned and/or operated by the National Park Service in the study watersheds.
- Provide public educational materials suitable for distribution by counties, municipalities and conservation organizations.







Strategies for Implementation

Previous parts of ***Watersheds*** present the goals and objectives (Part 4), implementation priorities (Part 5), guidance and information for Integrated Water Resources Planning (Part 6), and roles for stakeholders (Part 7). Presented here are the key strategies that are recommended for implementation to achieve the goals and objectives of ***Watersheds.*** It is essential that all sectors of the watershed communities work cooperatively together to implement these strategies in order to manage and preserve our water resources to sustain both the resources and planned growth in a manner consistent with the land use policies contained in *LANDSCAPES.*

The strategies chosen are those best suited to accommodate existing land uses and planned growth in a manner that is consistent with the natural characteristics of the receiving watershed systems and that sustains:

- Ground water recharge,
- Stream baseflows,
- Stable stream channel processes,
- Flood carrying capacity of the streams and their floodplains,
- Water quality of the streams and ground water, and
- Riparian and aquatic living resources.

It is intended and recommended that these strategies be implemented to the maximum extent practicable throughout Chester County's watersheds, provided their implementation will not do more harm than good. Immediate and widespread implementation of these 227 strategies is unrealistic. However, many of these strategies can be implemented individually or in groups (such as the ten principles

of stormwater management). The broad array of strategies provides numerous options for implementation that will help achieve the purpose and goals of *Watersheds.*

The selection of strategies to be implemented should be based on the priority needs of the individual watershed(s) and municipality(ies). Priority management needs for each watershed are listed in Part 10. Strategies that address the following are strongly recommended for implementation across Chester County and its watersheds:

- Provide and enhance water-based recreational and cultural resources.
- Reduce stormwater runoff and flooding.
- Establish networks of forested riparian buffers.
- Develop Integrated Water Resources Plans to meet future water and wastewater needs.

Detailed guidance for implementation of the strategies by municipalities and other stakeholders is provided in the *Compendium.*

Goal 1: Engage and Educate Individuals, Communities and Governments in Watershed Stewardship

Objective 1-1

Engage the public at all levels to accept individual responsibility for implementing watershed stewardship and good housekeeping practices on private, commercial, industrial, institutional, and public lands and roads.

Public education event

Key Strategies

- Support public education and training programs describing the benefits of land maintenance practices that protect watershed resources.
- Provide demonstration projects as examples of implementation of watershed stewardship techniques.
- Provide information regarding easily accessible and easily implementable watershed stewardship practices.
- Continue to provide support to organizations undertaking watershed monitoring and outreach programs.

Objective 1-2

Expand and sustain public education at all levels to achieve widespread public understanding of the inter-relationship of human activities and natural resources, and the economic, public health, environmental, and community benefits of preserving the integrity of the natural watershed ecosystems.

Key Strategies

- Provide municipal training and ordinance tools to assist in effective implementation of the *Watersheds* goals and strategies.
- Provide watershed stewardship educational materials for the public and educational curriculum for schools.
- Provide "stream schools" and other education and public involvement programs.
- Prioritize educational opportunities for residential riparian property owners.

Objective 1-3

Engage governments at all levels to implement appropriate *Watersheds* goals and strategies in their regulations, programs and activities.

Key Strategies

- Adopt governance tools that implement the *Watersheds* goals and strategies.
- Review and revise municipal ordinances to reduce, where possible and appropriate, the area of impervious cover required for proposed land development projects, (such as cartway and roadway widths, curbs, double sidewalks, impervious parking areas, building setbacks, etc.).
- Adopt governance tools that: implement conservation design practices; minimize the amount of stormwater runoff generated; reduce and disconnect impervious land cover; utilize pervious areas to infiltrate or reuse stormwater on-site; minimize site disturbance; concentrate development; preserve ground water recharge and ground water balances; protect floodplains, riparian corridors, wetlands, woodlands, steep slopes, and other natural areas; eliminate pollutant loads released to streams and ground water; and concentrate growth in the most appropriate areas to reduce the need for infrastructure expansion while providing for reliable water supply and wastewater disposal.
- Develop and manage all properties owned, managed or leased by government entities in a manner consistent with the *Watersheds* goals and strategies.
- Design and construct projects funded for development and re-development by government entities consistent with the *Watersheds* goals and strategies.
- Provide public education opportunities in conjunction with relevant programs and activities.
- Implement strategies within government decisions and actions from adopted Rivers Conservation Plans, Wild and Scenic Rivers Management Plans, Stormwater Management Plans, and other adopted watershed management plans.

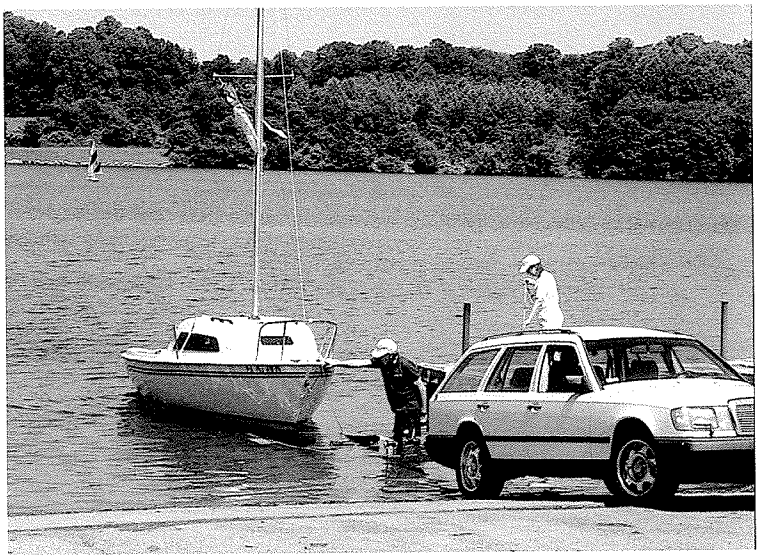
Goal 2: Enhance Water-Based Recreational and Cultural Resources

Objective 2-1

Provide and maintain access to streams at multiple locations in all watersheds.

Key Strategies

- Link residential, institutional and commercial areas to streams with trails, where appropriate.
- Encourage use of trails and trail set-asides within new developments to provide access to stream corridors.
- Create a network of water trails where sufficient water depth, flow and access are available.
- Link trails, greenways and other natural corridors to provide regional systems consistent with *Linking Landscapes* and other open space plans.
- Consider options to acquire and/or obtain necessary rights-of-way to provide trails, water access, and linking of corridors.
- Include trails, parks, access, and other linkages to water features within municipal Open Space, Recreation, and Environmental Resources Plans.

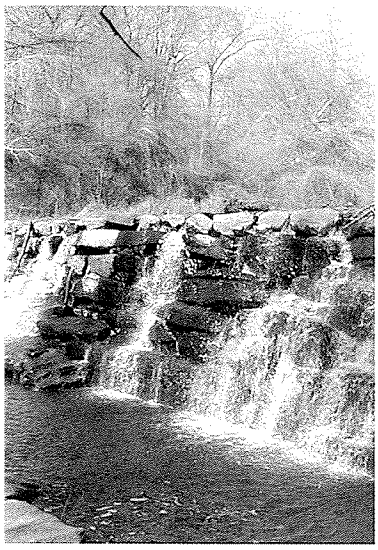


Objective 2-2

Maintain stream, pond and lake conditions necessary to support water-based recreational uses including canoeing, kayaking, fishing, swimming, tubing, and sailing.

Key Strategies

- Protect instream baseflows by implementing objectives and strategies of Goal 3: Preserve Natural Resources.
- Protect and enhance water quality by implementing objectives and strategies of Goal 4: Improve Water Quality.



Objective 2-3

Preserve and/or support re-use of water-based historic features where increased flooding and impacts to aquatic systems can be mitigated or avoided.

Key Strategies

- Update municipal historic resources inventories to identify water-based historic features.
- Prepare historic preservation ordinances or provisions for existing ordinances that address water-based resources.
- Sponsor municipal and county-wide events to encourage appreciation of the historic and cultural amenities of/or near streams.
- Promote land development that is sensitive to the historic and cultural "aesthetics" of the surrounding area.
- Pursue funding and opportunities to preserve and rehabilitate historic resources, and to identify and protect heritage corridors.

Objective 2-4

Pursue opportunities to restore abandoned waterfront development.

Key Strategies

- Inventory existing or under-utilized waterfront areas and determine desired restoration and/or re-use objectives (i.e., natural riparian corridor and floodplain, recreational use, economic re-development, and/or mixed use, etc.).
- Identify riparian corridors and other watershed resources within under-utilized waterfront areas to be protected or restored.
- Identify appropriate economic development programs and incentives for rehabilitation and re-use.
- Explore opportunities within "Brownfields" and "Industrial Sites Restoration" programs to rehabilitate abandoned or unused industrial sites.

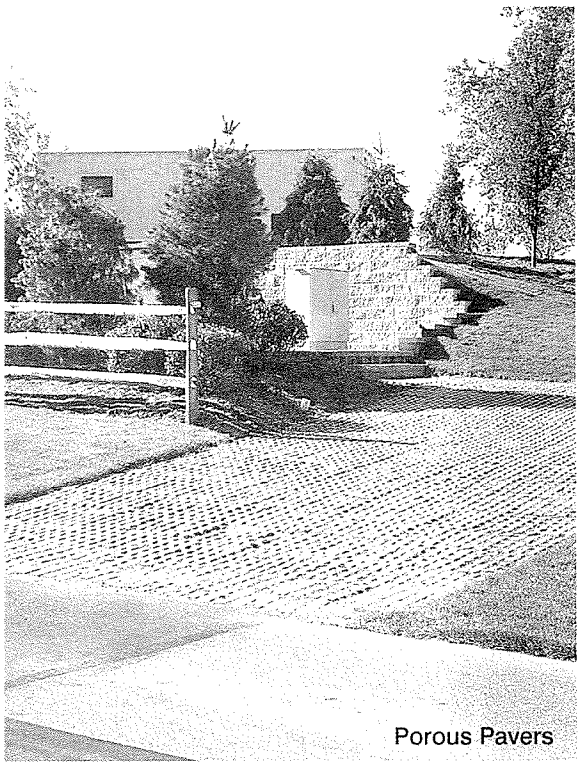
Goal 3: Preserve Natural Resources

Objective 3-1

Protect and enhance ground water recharge and quality.

Key Strategies

- Review and revise municipal ordinances to reduce, where possible, any unnecessary requirements for impervious cover for proposed land development projects (such as by reducing cartway and roadway widths, eliminating double sidewalks, requiring porous parking areas, reducing building setbacks for shorter driveways, requiring grassed swales in place of curbs, incorporating alternative "cul-de-sac" designs to allow sufficient room for emergency vehicle turn-around while reducing the total paved area, etc.).
- Adopt governance tools that: implement conservation development design practices; maximize the amount of pervious area available for infiltration of rainfall and stormwater; minimize the amount of stormwater runoff generated; reduce and disconnect impervious land cover; infiltrate rainfall or re-use stormwater on-site; minimize site disturbance and concentrate development; preserve infiltration, ground water recharge and ground water balances; protect floodplains, riparian buffers, wetlands, woodlands, steep slopes, and other natural areas; eliminate pollutant loads released to streams; and concentrate growth in the most appropriate areas to reduce the need for infrastructure expansion while providing for reliable water supply and wastewater disposal.
- Maintain at least the "open meadow condition" volume of annual average ground water recharge by infiltrating the net increase in volume (from "open meadow condition" to post-development condition) of runoff of the 1-inch storm, and where site conditions permit, infiltrate the net increase in volume (from "open meadow condition" to post-development condition) of runoff of the 2-year storm.



Porous Pavers

- Maximize the use of pervious areas for on-site rainfall infiltration and incorporate stormwater BMPs that first manage stormwater by dispersing runoff as sheet flow over pervious areas or into infiltration BMPs (i.e., routing runoff as sheetflow to rain gardens, through forested riparian buffers, into wetlands, to level spreaders, etc.).
- Encourage the "disconnection" of impervious cover created during development.
- Define "pre-development condition" as "open meadow condition" for all stormwater and development design calculations.
- For "brownfields" sites or other sites where soils contamination is present, avoid infiltration of stormwater recharge if adverse impacts to ground water quality will occur.
- Infiltrate or discharge stormwater within the same subbasin in which it originates.
- Implement infiltration BMPs and conservation design practices to eliminate the need for, or reduce the size of, stormwater basins for flood peak attenuation. Where such structures are necessary, first consider wet retention ponds, then extended retention basins over dry detention basins to provide additional pollutant removal and infiltration of stormwater prior to its release to streams.

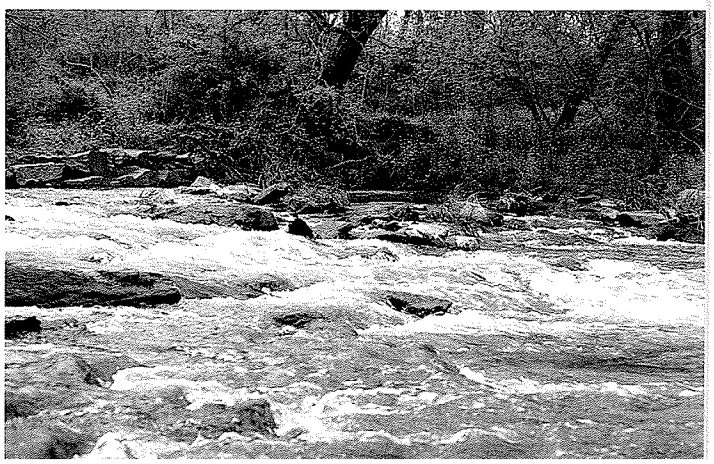
- Consider land application of treated wastewater over stream discharge whenever practicable.
- Implement conservation development design practices and "comprehensive stormwater management" for new development to maximize infiltration of rainfall and stormwater.
- Develop and implement well and wellhead protection programs.

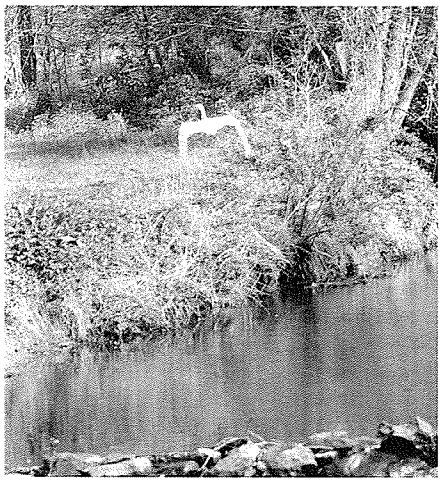
Objective 3-2

Protect and enhance the natural instream resources of streams, including stable stream channel processes and geomorphology conditions, aquatic living resources, stream baseflows, and water quality.

Key Strategies

- Avoid instream discharges whenever possible, through infiltration and land application.
- Infiltrate stormwater and utilize land application of treated wastewater over stream discharge everywhere practicable and as near to source of withdrawal or stormwater generation as possible.
- Design stream discharges to achieve and maintain stable stream channel processes and geomorphology conditions within the receiving stream.
- Remove sediments and pollutants from all discharges, including stormwater, to the maximum extent practicable prior to release to waterways.
- Implement *Watersheds* goals and strategies to maximize infiltration of rainfall and stormwater to protect ground water recharge.
- Implement *Watersheds* goals and strategies to reduce impacts of withdrawals on stream baseflows.
- Design bridges and other structural stream crossings to intersect as closely as practicable to perpendicular with the stream (preferably within 15 degrees), to avoid channel scour, to maintain or enhance the natural channel geometry and habitat of the stream segment, and minimize disturbance in the riparian corridor.
- Design instream culverts to ensure fish and water passage at low flow, to avoid channel scour, and to maintain or enhance the natural channel geometry and habitat of the stream segment.
- Design and implement stream channel restoration efforts based on natural stream system geomorphology to restore stable stream conditions.
- Prioritize impaired streams in "sensitive resources" drainage areas for restoration efforts.
- Design restoration plans based on field assessment of natural geomorphology and instream conditions.
- Remove abandoned dams that present a risk to public safety or impede migratory fish passage.





Objective 3-3

Protect and enhance first order perennial streams to recognize their vulnerability to low streamflows and water quality impairments.

Key Strategies

- Define first order streams as USGS mapped first order perennial streams.
- Protect drainage areas of first order streams from over-withdrawal of ground water.
- Prioritize first order streams for establishing forested riparian buffer networks.
- Prioritize first order streams for water quality protection.
- Include first order streams and their drainage areas among priorities for land and woodland preservation efforts.

Objective 3-4

Protect and enhance streams supporting "sensitive resources" to recognize their vulnerability to low stream flows and water quality impairments. "Sensitive resources" as used in *Watersheds* include:

- Exceptional Value watersheds and High Quality streams as designated by Pennsylvania.
- Instream sources of community water supplies and reservoirs.
- State-designated water-based habitats — including State Verified Naturally Reproducing Trout Waters, Class A Wild Trout Waters, "cold water fishes" waters, and sites identified in Pennsylvania Natural Diversity Index (PNDI).

Key Strategies

- Protect subbasins with "sensitive resources" from over-withdrawal of ground water.
- Prioritize subbasins with "sensitive resources" for establishing forested riparian buffer networks.
- Prioritize subbasins with "sensitive resources" for water quality protection.

Objective 3-5

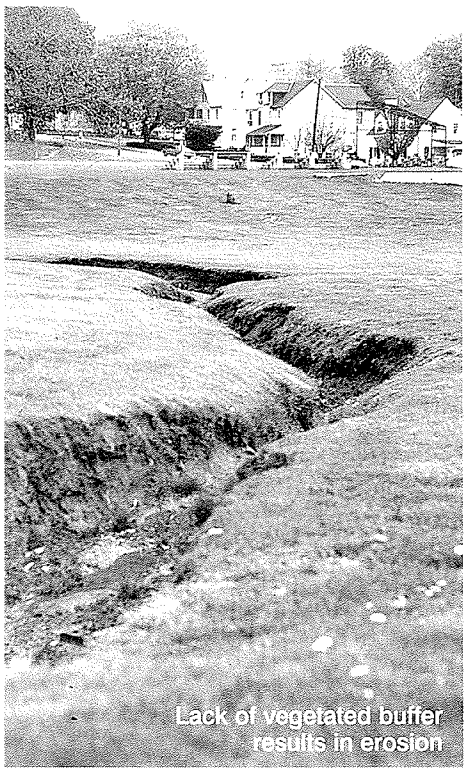
Protect wetlands for their hydrologic and ecological functions, and pursue opportunities to mitigate, restore or create wetlands.

Key Strategies

- Implement existing wetlands protection and regulatory programs.
- Identify and pursue opportunities to mitigate, restore or create beneficial wetlands where appropriate conditions exist for their survival.

Objective 3-6

Create and enhance a network of protected forested riparian buffers along ponds, lakes, wetlands, and baseflow-fed perennial and intermittent streams to protect water bodies from erosion and pollutants, to provide infiltration, to stabilize stream channel processes, and to provide shading, food and habitat for aquatic species.



Lack of vegetated buffer results in erosion

Key Strategies

- Protect and enhance existing riparian buffers or, where they do not exist, create or restore forested riparian buffers to include each of the following:

  a) 100 feet from water's edge of lakes and baseflow-fed perennial and intermittent streams (on each side of water body) to include: 35 feet width of undisturbed forested buffer adjacent to the water feature (to provide shade canopy, streambank stabilization, stream movement and meander growth); a minimum of 40 feet width of managed forested buffer (to provide infiltration of rainfall, removal of nutrients, sediments and other pollutants from ground and surface water); and the remainder as a filter strip of dense grass and forbs or other features (to provide sediment filtering, nutrient uptake, and convert concentrated flow to uniform, shallow, sheet flow).

  b) 50 feet of undisturbed vegetated land surrounding wetlands of greater than 20,000 square feet, from where all three wetland criteria are met (hydrology, vegetation, and hydric soils).

  c) Forested riparian buffers should also be considered for open sink holes, and other significant hydrologic features (i.e., carbonate aquifer outcrops, etc.).

- Where new development is occurring, through ordinance provisions and/or incentives, utilize conservation development design techniques to delineate and integrate the protected riparian buffer within the subdivision design while accommodating development objectives consistent with municipal zoning and *LANDSCAPES,* such as:

  a) Apply conservation development design practices and natural resource protection measures to delineate the resources to be protected (including undisturbed riparian buffer) and, separate the building envelope and disturbance areas from the protected resources.

  b) Setback all structures and constructed features from the water body to provide for the undisturbed buffer, and reduce setback requirements from the street.

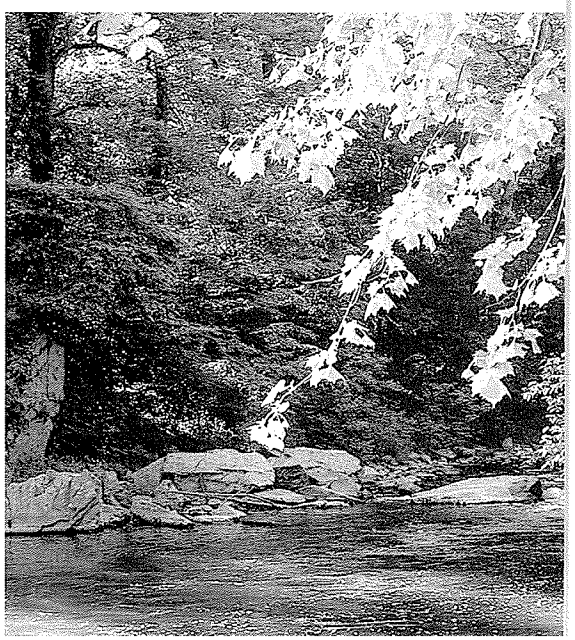
  c) Where necessary, apply minimum developable area requirements or minimum disturbance/minimum maintenance standards that allow the undisturbed buffer to be included as part of the individual lot area(s) but excluded from the area of disturbance or construction. When the protected buffer is included as part of an individual lot area(s), implement measures to insure the long-term protection and management of the forested riparian buffer (see below).

d) When, after applying these or similar techniques, the land area is insufficient to accommodate the 100 foot protected riparian buffer and be consistent with a municipality's comprehensive planning objectives as expressed in its development codes, consider allowing the reduction of the managed forest and grass filter widths to achieve a total average riparian buffer width of 75 feet from edge of water (on each side of water body) throughout the development, with a minimum width of not less than 50 feet at any location, ONLY when each of the following have also been implemented:

   - Conservation development design techniques that minimize the amount of stormwater generated and maximize the use of pervious areas for infiltration of rainfall and stormwater, and achieve other open space and environmental resources protection objectives appropriate for the site and zoning.
   - "Comprehensive stormwater management" practices to ensure that post-development conditions are consistent with the natural characteristics of the receiving stream (as described in Goal 5: Reduce Stormwater Runoff and Flooding), including stormwater quality BMPs.
   - Other BMPs such as level spreaders, meadow grass filter strips, or similar techniques to disperse overland flow prior to entering the protected buffer area where the width of the buffer is less than 75 feet.

e) Implement measures to insure the long-term protection and maintenance of the forested riparian buffer, including:

   - Establish permanent restrictions of use and maintenance of the buffer area through deed restrictions and/or through conservation easements.
   - Designate an entity responsible for maintenance and protection of the protected buffer, such as a homeowners' association, municipality, easement holder, etc.
   - Where the protected buffer is included on individual lot(s), require property owners to sign a document that they understand the restrictions and maintenance requirements.
   - Install a visible linear feature (and/or signage) to demarcate the outer edge of the protected area (i.e., level spreader, tree line, etc.).
   - Provide a management and maintenance plan for the forested riparian buffer.
   - Delineate protected forested riparian buffers on final subdivision plans consistent with municipal plan submission requirements.



- On agricultural lands, and lands undergoing development or re-development in urban areas, protect and enhance existing riparian buffers or where none exist establish forested riparian buffers to achieve the maximum width practicable given the site conditions, and including each of the following:

  a) The maximum width achievable for the site conditions. Where achievable, a minimum of 35 feet of undisturbed forested buffer (from edge of water, on each side of water body) is recommended, and a 100 foot width of forested riparian buffer (from water's edge on each side and as described above) is preferred.

  b) On agricultural lands where protected buffer widths are less than 100 feet, implement additional agricultural conservation management plans and nonpoint source water quality BMPs approved by the Chester County Conservation District (CCCD) to provide equivalent reduction of runoff and nonpoint source pollutants.

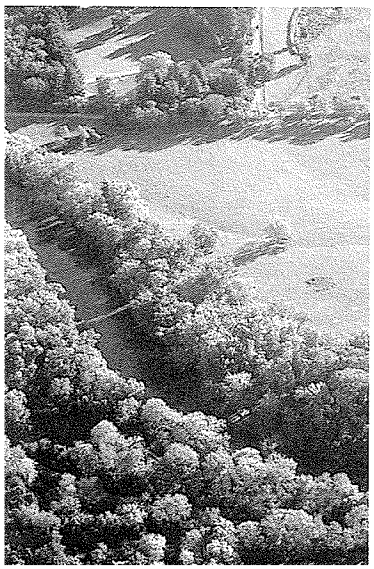
  c) On lands in urban areas, implement conservation design practices and comprehensive stormwater management practices to achieve, to the extent possible, post-development hydrologic conditions consistent with the natural characteristics of the receiving stream, including stormwater quality BMPs.

  d) Consider incentives for the creation or extension of riparian buffers on lands in urban and industrial areas, such as flexible street setbacks or square footage bonuses where overall lot average is reduced.

- Promote establishment of 5 to 15 feet no-mow zones along streams, wetlands and open flow channels on existing small residential lots (1 acre or less).
- For all riparian buffers, the following apply:

  a) "Forested riparian buffer" includes at least 2 species of trees and/or a combination of trees and shrubs, with preference given to native plant species suitable for riparian conditions and managed to minimize invasive species.

  b) Implement forested riparian buffers throughout the study watersheds, but with particular priority given to first order streams, and streams supporting "sensitive resources" (including Exceptional Value streams, sources of drinking water supplies, state-designated trout waters and cold water fishes waters, and PNDI sites).



  c) The priority is to establish a network of forested riparian buffers protected from disturbance. Existing vegetation within the buffer width should not be disturbed by construction activities. Where needed, forested and unforested vegetation should be established through natural succession. Selective planting should be encouraged on sites devoid of vegetation to stimulate native species and discourage invasive species. Plant selection and planting should be done consistent with CCCD, PADEP or U.S. Department of Agriculture (USDA) riparian forested buffer guidance. It is encouraged that local volunteer groups be involved in the buffer planting.

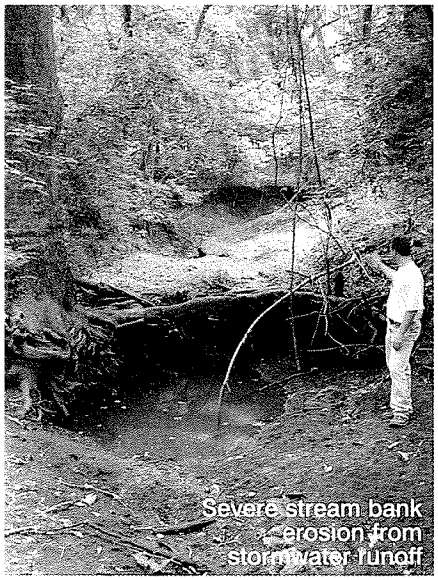
  d) Forested riparian buffers can be included as unmaintained (unmowed) yard areas, passive recreation areas or natural areas, but should not include any use that is considered a source of pollutants.

e) Forested riparian buffers should be undisturbed except for designated forest management practices, with the exceptions of regulated activities permitted by the Commonwealth (i.e., stream or wetland crossing), unpaved trail access, or soil or stream conservation projects approved by CCCD.

f) Extend and inter-connect riparian buffers to the maximum extent practicable.

g) Link riparian corridors with other habitats, wildlife corridors, and established greenways.

- Municipalities should select their final implementation strategies and ordinance provisions for forested riparian buffers based on an overall evaluation of the properties within their municipality that would be affected by the buffer requirements to insure overall consistency with the municipality's other planning and zoning objectives.
- Emphasize efforts to educate residential and other riparian land owners regarding benefits, restricted uses and management requirements of forested riparian buffers by developers, municipalities, watershed and conservation organizations and government agencies.


Severe stream bank erosion from stormwater runoff

Objective 3-7

Consider the cumulative impacts on and benefits of proposed land development to natural resources and identify alternatives to avoid or mitigate impacts.

Key Strategies

- Consider municipal ordinances to require that proposed land development projects inventory site-based natural resources, assess the cumulative impacts and benefits to natural resources, protect such resources to the maximum extent possible, and mitigate unavoidable impacts and/or restore resource functions, and submit the findings to the municipality for review during the subdivision approval process.
- Establish water resources protection ordinance requirements and programs.
- Develop and implement environmental protection ordinances to comprehensively address resource protection issues.

Objective 3-8

Prioritize riparian buffers, 100-year floodplains, first order streams and their drainage areas, and wellhead protection areas for land and/or woodland preservation efforts to protect ground water recharge and water quality of ground water and streams, and to provide for safe conveyance of flood flows and natural migration of stream channels.

Key Strategies

- Establish requirements for conservation easements to protect forested riparian buffers and floodplains.
- Pursue opportunities for transfer of development rights.
- Cooperate in efforts with private land trusts or establish a municipal land trust.
- Pursue opportunities and funding sources for public purchase of land resources and/or development rights.

Goal 4: Improve Water Quality

Improving Surface Water Quality

Objective 4-1

Achieve state designated use water quality standards in all streams.

Key Strategies

- Support implementation of the Total Maximum Daily Load (TMDL) process for point and nonpoint sources in a fair and equitable manner.
- Give highest priority for water quality protection and improvement to first order streams and streams supporting "sensitive resources."

Objective 4-2

Where supported by stream conditions and uses, petition for upgrades in state stream designations.

Key Strategies

- Strive to achieve Exceptional Value (EV) water quality standards in first order streams and streams with state-designated habitats (cold water fishes, PNDI sites, Class A Wild Trout Waters, and verified trout reproducing waters).
- Strive to achieve at least High Quality (HQ) water quality standards in source waters of public drinking water supplies, designated scenic and wild and scenic streams, and Rivers Conservation Registry streams/watersheds.

Objective 4-3

Reduce or eliminate the introduction of unnecessary chemicals and nutrients into the environment.

Key Strategies

- Reduce the application of chemicals and nutrients to the land surface for agriculture, lawn, turf management, and landscaping to the minimum amount and location necessary to support healthy plant production.
- Implement spill and pollution prevention practices at any facility storing or handling bulk quantities of chemicals.
- Continue and expand household hazardous waste collection, used oil disposal, and public education programs.
- Reduce automobile use when practicable to reduce pollutants to air and roadways that are ultimately carried into streams and ground water.

Objective 4-4

Reduce or eliminate movement of sediment from lands into streams to conserve the soil resources and reduce instream siltation and pollutants.

Key Strategies

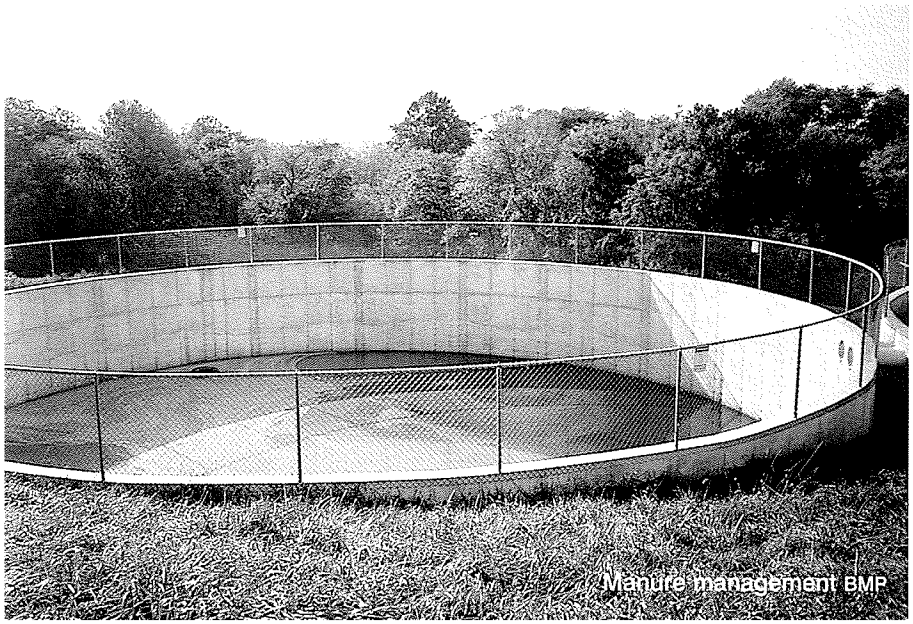
- Stabilize sediment on all land surfaces, slopes and channel banks with vegetation or other measures and management practices.
- Improve effectiveness of erosion and sediment control practices on construction sites.
- Stabilize and re-vegetate streambanks using inter-connected forested riparian buffers.
- Utilize minimum disturbance/minimum maintenance practices in site design and construction to integrate site topography with design and reduce earth moving.

Objective 4-5

Accelerate implementation of agricultural nonpoint source management training, planning and BMPs.

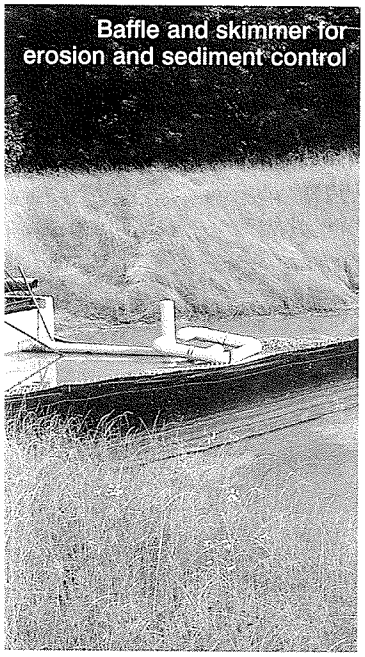
Key Strategies

- Develop or update and implement approved agricultural conservation plans for soil and water conservation by all agricultural operations.
- Develop or update and implement nutrient management plans for all agricultural operations to reduce the application of unnecessary chemicals to the minimum amount and location necessary to support healthy plant growth.
- Implement Integrated Pest Management programs on all agricultural operations.
- Promote Individual Farmer Certification training and nutrient management training workshops and encourage farmers to obtain an individual certification.
- Conduct manure and compost management and handling in accordance with PADEP and conservation district guidance.
- Implement stream bank fencing and stream crossing projects to restrict access of livestock to streams.



Manure management BMP

- Implement forested riparian buffer networks along streams and water bodies.
- Implement buffer strips, low or no-till farming practices, and other farmland runoff management practices.
- Implement crop rotation or other methods to reduce the build-up of phosphorus in soils.
- Support broader implementation of chemical free organic farming practices.


Baffle and skimmer for erosion and sediment control

Objective 4-6

Remove pollutants from stormwater discharges prior to release to waterways.

Key Strategies

- Infiltrate at least the net increase in runoff from the 1-inch storm event, and where site conditions allow, the net increase of the 2-year storm event, to protect ground water recharge and allow removal of pollutants through the soils and vegetation uptake.
- Where not infiltrated, implement on-site stormwater BMPs specifically designed to reduce sediment, nutrient and other pollutant loads for runoff from events up to a 1-inch storm.
- Install and maintain water quality inlets to collect stormwater from commercial and industrial parking areas.
- Install and maintain oil/water separators and water quality inlets in storm drains of automobile service, maintenance, and salvage areas.
- Where stormwater basins are necessary, implement wet retention or extended detention ponds over dry detention basins to improve pollutant removal and allow infiltration of stormwater.

Objective 4-7

Reduce pollutant loadings from point source discharges.

Key Strategies

- Implement TMDLs in a fair and equitable manner utilizing combinations of point source and nonpoint source reductions where practicable and support achievable trading scenarios.
- Identify and address non-regulated pollutants that may impair the quality of drinking water and establish cooperative and voluntary programs to control their release to source waters of instream water supply intakes.
- Reduce the number of individual (residential) wastewater systems discharging to streams by use of effective alternative technologies.

Improving Ground Water Quality

Objective 4-8

Protect ground water from contamination from all sources.

Key Strategies

- Construct all wells and promptly plug and seal unused wells in accordance with Chester County Health Department regulations.
- Pursue remediation of ground water contamination and contain or eliminate the sources of contamination.
- Where ground water contamination exists, coordinate new land development planning to avoid impacts from the contamination to the water supplies of the new development, and to avoid further expansion of the contaminant plume that may be caused by pumping of wells for the new development.

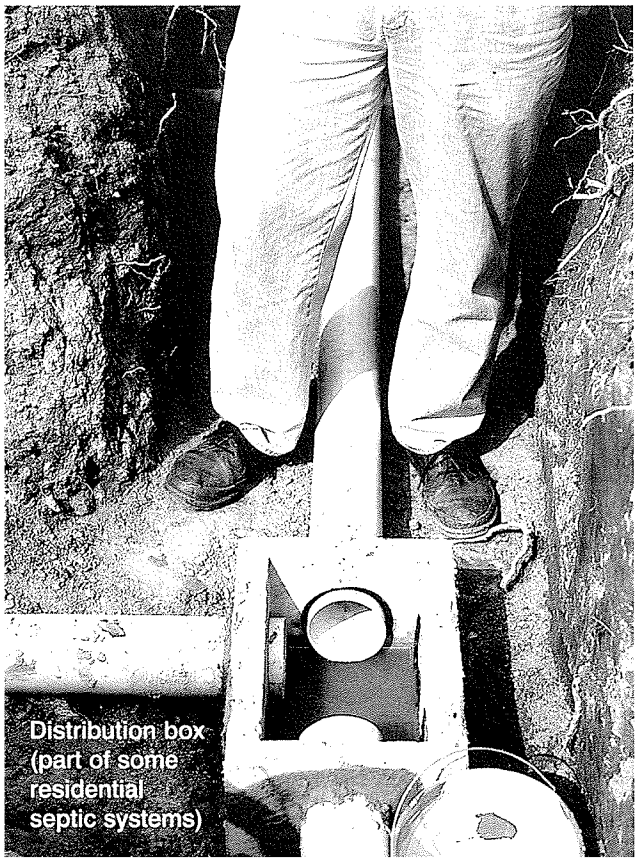
- Implement water quality stormwater BMPs to remove pollutants from stormwater discharges originating from land uses with potential for very high pollutant loadings ("hotspots") prior to infiltration.
- Implement nutrient and pesticide management practices for turf management, lawns, landscaping, farming and manure handling operations to eliminate over-application of chemicals and nutrients.
- Support broader implementation of chemical free organic farming practices.

Objective 4-9

Protect recharge areas of public water supply wells from sources of pollution.

Key Strategies

- Identify public water supply wells and include in municipal comprehensive planning maps.
- Develop and implement wellhead protection programs to protect recharge and eliminate or contain potential sources of contaminants in wellhead areas of public water supply wells.
- Consider wellhead protection areas for voluntary land preservation strategies.
- Complete source water protection assessments and implement source water protection plans.



Objective 4-10

Reduce pollutant loadings from treated effluent of land applied wastewater disposal systems, including on-lot septic systems.

Key Strategies

- Implement municipal programs for individual on-lot septic system maintenance to achieve cleanouts and inspections every 2 to 3 years and the immediate repair or replacement of failing systems.
- Identify and address non-regulated pollutant loadings in land application systems that may impair the quality of drinking water supplies and establish cooperative and voluntary programs to control their release to ground water.
- Explore and pursue innovative individual and land application wastewater treatment systems with improved treatment capabilities.

Goal 5: Reduce Stormwater Runoff and Flooding

Objective 5-1

Achieve post-development hydrologic conditions that are consistent with the natural hydrologic characteristics of the receiving stream system and that sustain and enhance:

- Ground water recharge and subbasin ground water balances,
- Stream baseflows,
- Stable stream channel processes,
- Flood carrying capacity of the receiving streams and their floodplains, and
- Water quality conditions necessary to meet state water quality standards, support natural aquatic species and their habitats, and protect sources of public drinking water supplies.

Key Strategies

- Implement "comprehensive stormwater management" throughout the study watersheds (see Objective 5-2).

Objective 5-2

Implement comprehensive stormwater management requirements in all municipalities that incorporate each of the following ten principles:

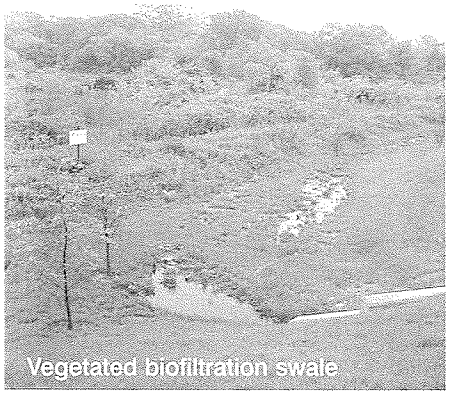
- Reduce the volume of stormwater generated by:
  a) Maximizing the use of pervious areas for infiltration of rainfall and stormwater.
  b) Utilizing conservation development design (conservation subdivision design) techniques and low impact development designs.
  c) Eliminating unnecessary requirements for impervious land cover and incorporating conservation development design techniques within municipal subdivision and land development ordinances.
- Design new developments and their stormwater management systems so that net post-development conditions achieve "open meadow condition" hydrologic characteristics.
- Protect ground water recharge through infiltration of rainfall and stormwater.
- Remove pollutants from stormwater runoff prior to release to protect water quality of streams and ground water.
- Protect stable stream channel processes and geomorphology conditions.

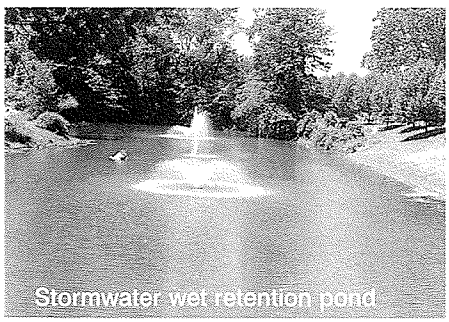
- Reduce flood peak runoff rates to reflect "open meadow condition," and further reduce flood peak runoff rates for areas contributing to frequently floodprone urban/developed areas.
- Insure that stormwater management facility operation and maintenance occur on a permanent basis.
- Protect adjacent lands that are receiving stormwater runoff from developed sites.
- Establish forested riparian corridor networks.
- Protect wetlands and floodplains to reduce runoff and flooding.

Key Strategies

- Review and revise municipal ordinances to reduce, where possible, any unnecessary requirements for impervious land cover for proposed land development projects (such as by reducing cartway and roadway widths, eliminating double sidewalks, requiring porous parking areas, reducing building setbacks for shorter driveways, requiring grassed swales in place of curbs, incorporating alternative "cul-de-sac" designs to allow sufficient room for emergency vehicle turn-around while reducing the total paved area, etc.).

- Adopt governance tools that: implement conservation development design practices; maximize the amount of pervious area available for infiltration of rainfall and stormwater; minimize the amount of stormwater runoff generated; reduce and disconnect impervious land cover; infiltrate rainfall or re-use stormwater on-site; minimize site disturbance and concentrate development; preserve infiltration, ground water recharge and ground water balances; protect floodplains, riparian buffers, wetlands, woodlands, steep slopes, and other natural areas; eliminate pollutant loads released to streams; and concentrate growth in the most appropriate areas to reduce the need for infrastructure expansion while providing for reliable water supply and wastewater disposal.


Vegetated biofiltration swale


Stormwater wet retention pond

- Collectively achieve the following through conservation development design techniques and integrated stormwater system design:

  a) Maintain at least the "open meadow condition" volume of annual average ground water recharge by infiltrating the net increase in volume (from "open meadow condition" to post-development condition) of the runoff of the 1-inch storm, and where site conditions permit, infiltrate the net increase in volume (from "open meadow condition" to post-development condition) of runoff of the 2-year storm.

  b) Implement "recommended" water quality BMPs to remove pollutants (particularly sediments and nutrients as well as other pollutants such as organics and metals depending upon the intended use of the site) from the runoff of the first 1-inch of rainfall prior to release of stormwater to water bodies.

  c) Attenuate through on-site vegetated swales, wetlands, ponds or detention/retention, the 1-year 24-hour rainfall runoff for 12 to 24-hours to protect the stream channel stability and maintain the natural dynamic equilibrium of instream flows and channel erosion of receiving streams.

  d) Reduce post-development peak runoff rates of the 2-year through 100-year events to the corresponding "open meadow condition" peak runoff rates.

  e) Where runoff contributes to flooding in downstream urban/developed areas, reduce the post-development peak runoff rates of the 2-year through 10-year events to the "open meadow condition" 2-year peak runoff rate; and reduce the post-development peak runoff rates of events greater than the 10-year event through the 100-year event to 90% of the "open meadow condition" peak runoff rate.

  f) Where Act 167 Stormwater Management Plans have been adopted, implement the net flood peak release rates and other ordinance provisions stipulated in that plan.

- Maximize the use of pervious areas for on-site rainfall infiltration and incorporate stormwater bmps that first manage stormwater by dispersing runoff as sheet flow over pervious areas or into infiltration BMPs (i.e., routing runoff as sheetflow to rain gardens, through forested riparian buffers, into wetlands, to level spreaders, etc.).
- Encourage the "disconnection" of impervious land cover created during development.
- Define "pre-development condition" as "open meadow condition" for all stormwater and development design calculations.
- For "brownfields" sites or other sites where soils contamination is present, infiltration of stormwater recharge should be avoided if adverse impacts to ground water quality will occur.
- Where high water tables, subsurface contamination, prevalent sinkhole conditions or other site constraints preclude achieving the recommended infiltration volume, implement other conservation development design techniques and BMPs to reduce as much as possible the total volume of stormwater released to streams.
- Infiltrate or discharge stormwater within the same subbasin in which it originates.
- Implement infiltration BMPs and conservation design practices to eliminate the need for, or reduce the size of, stormwater basins for flood peak attenuation. Where such structures are necessary, first consider wet retention ponds, then extended detention basins over dry detention basins to provide additional pollutant removal and infiltration of stormwater prior to its release to streams.

- Protect and vegetate steep slopes and road embankments and stabilize gravel and dirt roads to reduce runoff and erosion.
- Pre-treat stormwater discharges from land uses with potential for very high pollutant loadings ("hotspots") prior to infiltration.
- Prioritize first order streams and streams supporting "sensitive resources" for water quality protection from sediment and nonpoint source pollutants and stormwater discharge rates and volumes that contribute to excessive instream erosion.
- Where on-site conditions make any or all of these measures impracticable, pursue off-site stormwater mitigation using infiltration and other BMPs preferably within the same subbasin or watershed.
- Where stormwater is conveyed onto or through an adjacent property, design and construct the conveyance channel to protect the property from erosion and flood damage, and obtain easements from the property owner for the portion of land needed for conveyance or discharge of stormwater.
- Incorporate the following in municipal ordinances to insure permanent operation and maintenance of stormwater management facilities:
  a) designate an entity responsible for maintaining the facility.
  b) provide an operation and maintenance plan suitable for implementation by that entity.
  c) provide an initial escrow fund to cover initial maintenance expenses.
  d) establish that the municipality has the right but not the obligation to enter the property or facility to perform maintenance if needed and to be reimbursed for those expenses by the entity responsible for maintenance.

Objective 5-3

In urban areas and areas designated for concentrated (urban) growth, provide flexibility in stormwater quantity control requirements and prioritize implementation of stormwater quality controls.

Key Strategies

- Strive to achieve the *Watersheds* strategies for runoff water quantity controls to the maximum extent practicable.
- Achieve *Watersheds* stormwater quality control strategies at all sites.
- Strive to establish a minimum forested riparian buffer.

Objective 5-4

Design stormwater infiltration and conveyance systems in karst (limestone) terrain to minimize the risk of sinkhole formation and aquifer contamination.

Key Strategies

- Identify the type of limestone underlying the site to determine how conducive it is to sinkhole formation.
- If the risk of sinkhole formation exists:
  a) Avoid points of release of concentrated stormwater flows.
  b) Identify active and historic sinkholes on the site and avoid those areas for infiltration and release of concentrated overland flows.
  c) Design infiltration systems where soil depth is sufficient to disperse percolating water.
- If on-site conditions absolutely preclude stormwater infiltration, pursue opportunities for off-site stormwater mitigation of equal benefit within the same subbasin or watershed.

Bridge design allows passage of floodwaters in floodplain.

Objective 5-5

Design and/or retrofit transportation and urban stormwater systems to achieve the principles of comprehensive stormwater management everywhere practicable.

Key Strategies

- Implement *Watersheds* goals and strategies of comprehensive stormwater management.
- Where site conditions preclude achieving any of the *Watersheds* comprehensive stormwater management objectives and strategies, pursue opportunities to implement off-site stormwater mitigation within the same subbasin or watershed.

Objective 5-6
Protect 100-year floodplains from development to allow unimpeded passage of flood flows.

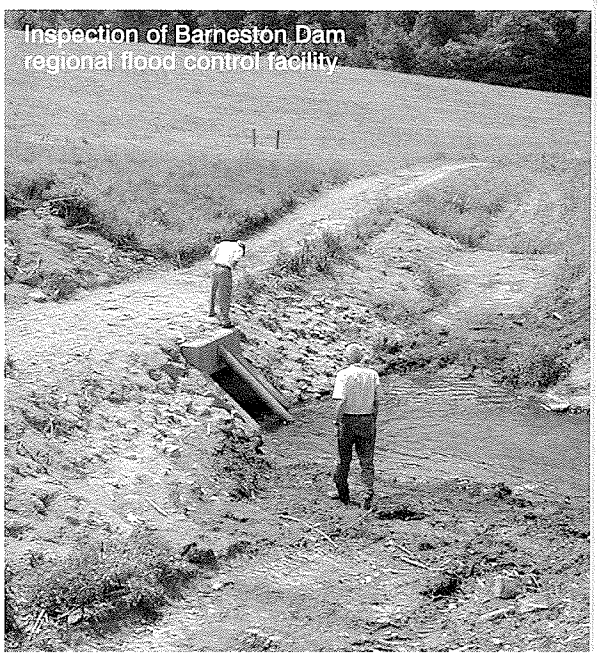
Key Strategies
- Enforce municipal floodplain management ordinances.
- Implement adopted Act 167 stormwater management criteria to avoid extending the 100-year floodplain by increasing flood flows.
- Establish forested riparian buffer networks along major streams to protect floodplains and provide flood water attenuation and storage.
- Pursue opportunities for land preservation in 100-year floodplains.

Objective 5-7
Pursue opportunities to attenuate or mitigate flood flows, giving preferential consideration to nonstructural approaches and alternatives.

Key Strategies
- Identify stream segments where excessive erosion, downcutting, and/or sedimentation has exacerbated flooding conditions, and prioritize for natural stream channel restoration.
- Restore natural stream channel conditions and stability and floodplain conditions to improve natural conveyance and attenuation of flood flows within the stream channel, floodplain and associated wetlands.
- Pursue opportunities to remove existing structures from floodplains and to reclaim and restore floodplain lands to natural conditions.

Objective 5-8
Implement flood warning and mitigation/reduction methods to help protect communities located in floodplains and below major reservoirs.

Key Strategies
- Maintain Emergency Action Plans for dams as required under state law.
- Where suitably located, utilize USGS stream gaging network for flood monitoring and alerts for local emergency management officials.
- Maintain operation of the Brandywine Creek Watershed flood control facilities.
- Establish and implement road closure and detour plans for roads that flood frequently.


Inspection of Barneston Dam regional flood control facility

Objective 5-9

Prepare and implement watershed-based comprehensive stormwater management plans that implement the *Watersheds* goals and strategies and fulfill the requirements of state stormwater management programs.

Key Strategies

- Complete comprehensive stormwater management plan and study for East Valley Creek as a "pilot" project.
- Establish an approach to watershed stormwater management planning that allows efficient completion of future studies yet integrates the principles of comprehensive stormwater management.
- Provide consistent implementation and enforcement of ordinances resulting from adopted Act 167 stormwater plans throughout the subject watershed.
- Support multi-municipal efforts in coordinating and planning stormwater management approaches and criteria.

Objective 5-10

Develop and implement comprehensive stormwater management programs within all municipalities and transportation agencies to include:

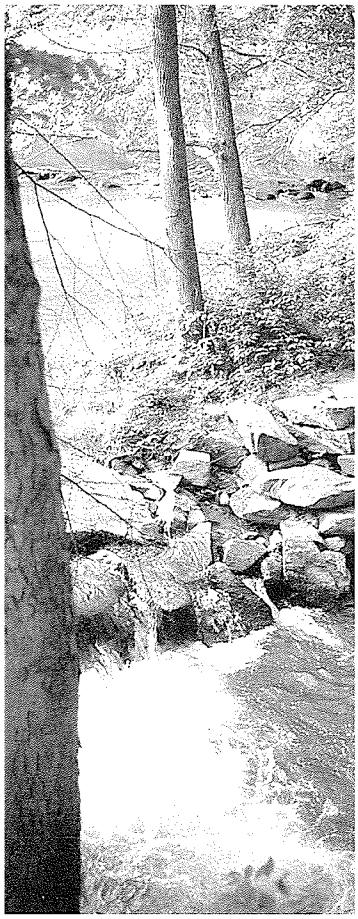
- Public education and participation.
- Illicit discharge detection and elimination.
- Construction site runoff control.
- Post-construction stormwater management for new projects and development.
- Maintenance and proper operation of existing stormwater facilities.
- Pollution prevention and "good housekeeping" practices.

Key Strategies

- Support multi-municipal efforts in coordinating and developing plans required under NPDES Phase II stormwater regulations.
- Encourage state agencies to prepare and provide public education materials for use by all municipalities.
- Encourage municipalities not mandated by NPDES Phase II regulations to develop and implement similar programs.

Erosion Under a Silt Fence

Goal 6: Protect Watershed Water Balances



Objective 6-1

Achieve post-development hydrologic conditions that are consistent with the natural hydrologic characteristics of the watershed and stream system and that sustain and enhance:

- Ground water recharge and subbasin ground water balances,
- Stream baseflows,
- Stable stream channel processes,
- Flood carrying capacity of the receiving streams and their floodplains, and
- Water quality conditions necessary to meet at least state water quality standards, support natural aquatic species and their habitats, and protect sources of public drinking water supplies.

Key Strategies

- Consider land application of treated wastewater over stream discharge everywhere practicable.
- Implement conservation development design practices and "comprehensive stormwater management" for new development to maximize infiltration of rainfall and stormwater.
- Reduce the need for ground water and stream withdrawals through water conservation and re-use.
- Implement objectives and strategies for the *Watersheds* Goal 3: Protect Natural Resources, Goal 4: Improve Water Quality, Goal 5: Reduce Stormwater Runoff and Flooding, and Goal 6: Protect Watershed Water Balances, throughout the study watersheds.

Objective 6-2

Reduce peak daily and average annual per capita water withdrawals through water conservation and re-use.

Key Strategies

- Increase water conservation and re-use by all users.
- Expand public education programs for water conservation and re-use.
- Adopt and enforce municipal ordinances requiring water conservation plumbing fixtures and technologies in new construction.
- Support implementation of innovative technologies for water conservation and re-use.
- Re-use treated wastewater everywhere practicable, particularly for turf and pasture irrigation and industrial uses.
- Reduce unaccounted-for-water toward a target of 15% by water utilities (excluding fire fighting, line flushing and other controlled utility management uses).
- Reduce ground water infiltration to wastewater sewer lines to less than 5,000 gallons per day per inch-mile (an inch-mile is defined as a mile of sewer line times the diameter of the sewer line in inches).

Objective 6-3

Develop and coordinate planning for new or expanded water and/or wastewater facilities and water sources in conjunction with the affected municipalities and counties.

Key Strategies

- Involve affected municipalities and counties in the planning and alternatives evaluation process to consider community values and needs of all water users.
- Implement objectives and strategies and the Integrated Water Resources Planning process for ***Watersheds*** Goal 7: Integrate Utility and Municipal Planning to Meet Future Water Supply and Wastewater Needs.
- Conduct a balanced evaluation of all viable alternatives for water supply sources, facilities and infrastructure; wastewater facilities; infrastructure; and effluent disposal that considers the economic, engineering, local land use planning, environmental and regulatory implications of each alternative.

Objective 6-4

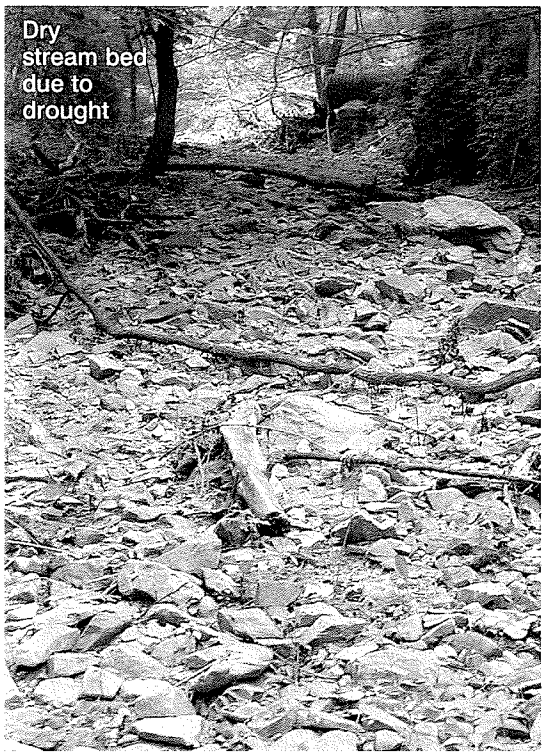
Consider individual and cumulative impacts of withdrawals, discharges and recharges on natural resources and existing water users.

Key Strategies

- Conduct sufficient technical investigation to insure that new withdrawals and/or effluent disposal options will meet the planned need and that the individual and cumulative impacts will not impair existing water users, streams, springs, or other "sensitive resources."

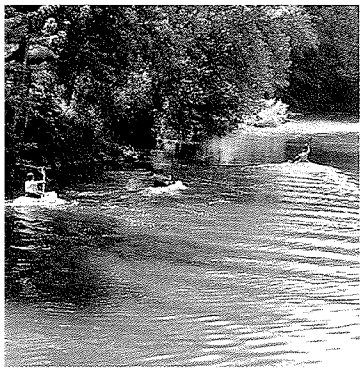
Objective 6-5

Protect and maintain natural stream flows during low flows and droughts.


Dry stream bed due to drought

Key Strategies

- Support the PAFBC and/or other agency efforts to develop methods and guidance for establishing habitat-based instream flow protection and pass-by requirements for southeast PA Piedmont streams.
- Cease or replace instream withdrawals when stream flows are equal to or less than the minimum stream flows necessary to protect instream aquatic habitat as determined by the PAFBC.
- Where no specific PAFBC guidelines or requirements exist for defining minimum instream flows to protect aquatic habitat, apply the following thresholds:
  a) For all first order streams, Exceptional Value and High Quality streams and streams supporting other "sensitive resources" cease or replace instream withdrawals when stream flows are equal to or less than 25% of the average daily stream flow at the point of withdrawal.
  b) For all other streams, cease or replace withdrawals when stream flows are equal to or less than the $Q_{7\text{-}10}$ flow at the point of withdrawal.



Objective 6-6

Protect aquifers and stream baseflows by applying net cumulative ground water withdrawal management targets.

Key Strategies

- Support and encourage USGS, PAFBC, DRBC, PADEP and/or other agencies to develop methods to quantify the effects of cumulative ground water withdrawals on reducing stream baseflows, and the effects of the resulting reduction in baseflow on instream habitats for southeast PA Piedmont streams for use as the basis of regulatory decision-making for ground water and instream withdrawals.
- In the absence of the above, support implementation of the DRBC regulations for the Southeast PA GWPA (Ground Water Protected Area), and consider the following ground water withdrawal management targets on a voluntary basis throughout the study area for evaluating potential impacts and benefits of proposed withdrawal and recharge projects:
  a) For protection of first order streams: maintain the net volume of cumulative ground water withdrawals BELOW 50% of the volume of the 1 in 25 year average annual baseflow within each first order stream drainage area, unless a more detailed hydrogeologic analysis or instream flow study for the drainage area determines that a larger net withdrawal volume can be safely taken while sustaining the ground water and instream resources of that drainage area.
  b) For protection of baseflow-sensitive resources: maintain the net volume of cumulative ground water withdrawals BELOW 50% of the volume of the 1 in 25 year average annual baseflow in each subbasin that contains streams designated as Exceptional Value and High Quality, instream sources of community water supplies (where instream withdrawals are not directly and continuously supported by reservoir storage), and state designated instream fisheries, unless a more detailed hydrogeologic analysis or instream flow study for the subbasin determines that a larger net withdrawal volume can be safely taken while sustaining the ground water and instream resources of that subbasin.
  c) For all other areas: maintain the net volume of cumulative ground water withdrawals BELOW 100% of the volume of the 1 in 25 year average annual baseflow within all other subbasins.
- Maintain an updated database of county-wide permitted ground water use and recharges to facilitate calculation of ground water balances.
- Support and encourage multi-municipal efforts to develop Integrated Water Resources Plans (IWRPs) to better quantify water users, needs, conflicts, and to integrate land use and water resources planning and management.
- Where justified with adopted IWRPs, submit to DRBC with request for reduction of subbasin ground water withdrawal limits per DRBC's Southeastern Pennsylvania GWPA regulations and guidelines.
- Support state legislation in PA to establish regulatory ground water withdrawal allocation and management programs consistent with the goals and objectives of ***Watersheds.*** In the absence of such regulation, consider expansion of DRBC Southeastern Pennsylvania GWPA throughout the Delaware River Basin within Chester County.

Objective 6-7

Balance the use of ground water and surface water sources to support planned growth while protecting aquifers and stream baseflows from over-withdrawal.

Key Strategies

- Consider ground water as a primary source for additional supplies in subbasins where existing net ground water withdrawals are well below their net ground water withdrawal target.
- Consider a mix of surface and ground water sources for additional supplies in subbasins where existing ground water withdrawals are approaching their net ground water withdrawal target.
- Consider surface water as a primary source for additional supplies in subbasins where existing ground water withdrawals are at or above their net withdrawal target.

Objective 6-8

Plan water supply and wastewater sources and facilities that seek to maintain the natural watershed water balance of each subbasin.

Key Strategies

- Consider land application of treated wastewater effluent over stream discharge everywhere practicable, and particularly where the source of water supply is ground water.
- Consider water sources/effluent disposal options that are within the same subbasin, then options within the same watershed.
- Consider options that use existing water supply withdrawals, water/wastewater facilities, and/or effluent disposal facilities, prior to options for new sources or facilities.

Spray irrigation system

- Avoid net export of water or wastewater from the subbasin except when such exports or imports provide greater overall net benefits for water quality or low flow conditions.
- Avoid increases in net inter-basin transfers of water between the Schuylkill River Basin, Delaware River Basin, Christina River Basin, Chesapeake Bay Basin, and Lower Susquehanna River Basin except when such exports and imports provide greater overall net benefits for water quality or low flow conditions.
- When exports or transfers are planned, apply best water resources management principles to minimize the impacts of the exports on the source and maximize the benefits of the imports to the receiving watershed system.

Objective 6-9

Locate large water withdrawals and wastewater effluent disposal facilities where they provide the greatest benefit and least impact to watershed aquifers and streamflows.

Key Strategies

- Locate wastewater land application systems to provide the greatest benefit to ground water recharge and stream baseflows as is practicable.
- Locate large ground water withdrawals as near to the mouth of a subbasin and watershed as practicable.
- Locate instream wastewater discharges upstream of stream withdrawals (except where impacts to drinking water supply intakes may occur) and as close to the headwaters of the receiving stream as practicable to provide benefits of additional flow to the maximum length of stream possible.
- Locate large stream withdrawals downstream of discharges, and as close to the mouth of a subbasin and watershed as practicable.
- Where wastewater discharges are planned for locations upstream of water supply intakes, ensure sufficient treatment to protect the source waters, minimize impacts to water supply treatment requirements, and avoid public health concerns.

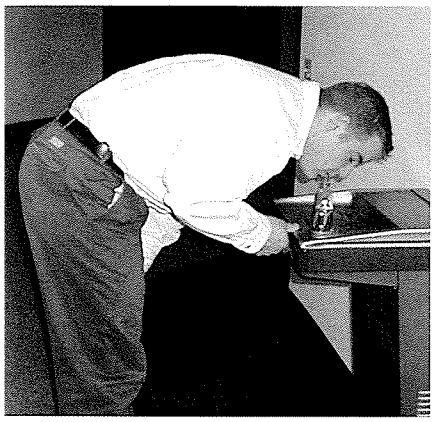
Objective 6-10

Protect aquifers and stream baseflows from unnecessary withdrawals during periods of low flow and drought events by reducing water use.

Key Strategies

- Reduce all non-essential water uses (as defined by state regulations) by all users of individual wells and community supplies by at least 5% during drought watch declarations.
- Encourage reduction of all water uses by at least 5% and non-essential water uses by 10% during drought warning declarations.
- Reduce all non-essential water uses by at least 15% and reduce essential water uses to the maximum extent practical during drought emergency declarations.
- When water supply shortages are imminent, give priority to essential water supply uses over recreational uses of surface waters.
- Water supply utilities prepare water emergency management plans for meeting water supply needs during drought conditions, as required by state regulations, and provide plans to and coordinate with appropriate municipalities and county(ies) for assistance in effective implementation.

Goal 7: Integrate Utility and Municipal Planning to Meet Future Water Supply and Wastewater Needs



Objective 7-1

Provide a safe, clean, long-term supply of water that meets the needs of all users.

Key Strategies

- Pursue development of Integrated Water Resources Plans (IWRPs) by municipalities, counties, utilities and other key stakeholders to evaluate water resources availability, anticipate water use needs, and develop strategies for best utilizing available resources for meeting future public, private, natural resources, recreational, and agricultural water use needs.
- Implement water conservation education and incentives.
- Facilitate availability of assistance for small water systems to achieve system reliability and regulatory compliance.

Objective 7-2

Concentrate planned utility service areas to support designated growth areas.

Key Strategies

- Encourage the expansion of community water supply and wastewater facilities to support planned growth in Urban and Suburban landscapes and Suburban Centers. Where housing densities are greater than 1 dwelling unit per acre, community wastewater service is recommended; where densities are greater than two dwelling units per acre, community wastewater service should be required.
- Restrict the extension of community water supply and wastewater facilities in Rural and Natural landscapes, except where determined by Integrated Water Resources Planning or similar municipal/utility alternatives evaluation process to be the most suitable solution to meet both the identified need and comprehensive planning objectives, and where both the municipality(ies) and the utility have jointly committed to implementing measures to avoid undesired connections and growth along the rural pipeline corridor.
- Support the use of satellite systems and service areas to meet the needs of Rural Centers, Villages, cluster developments and other isolated developed areas surrounded by Rural landscapes and where:
  a) Ground water quality is unsafe and in-home treatment is not practicable,
  b) The quantity of ground water resources or well yields are no longer sufficient to provide safe and reliable supplies to existing individual well users,
  c) Cluster communities are planned, and individual septic systems (on-lot or off-lot) are not a viable alternatives.
  d) Septic discharges have significantly impaired ground water quality, and/or
  e) Local conditions create widespread septic system failures or failed percolation tests.

Objective 7-3

Coordinate planning among municipalities, counties and utilities (including municipal, municipal authority, private, and investor-owned utilities) using an Integrated Water Resources Planning (IWRP) process, to insure consistency of system development and infrastructure expansion with local land use plans, ordinances, adopted resource management plans, and *LANDSCAPES*.

Key Strategies

- Each municipality or group of municipalities delineate and adopt planned growth areas where community water and/or wastewater service(s) are desired within their comprehensive plan and implement zoning standards consistent with those delineations and *LANDSCAPES*.
- Utilities and municipalities enter into agreements to implement the municipality's designated planned service areas and establish a process for coordination, planning, approval and limitations for extension of service or infrastructure, and file the agreements with PUC (when involving a PUC-regulated utility).
- Where extension of facilities or infrastructure beyond the municipality's planned service area is deemed necessary (through IWRP or similar process) to reach a satellite source or service area, the municipality and utility jointly implement measures to avoid customer connections in areas not included in the municipal planned service area or in the identified area of need (i.e., zoning enforcement and agreements between the municipality and utility).
- Utilities coordinate with the affected county(ies) prior to finalizing plans for expansion of infrastructure or submitting for state approvals.

Objective 7-4

Plan treatment/disposal facilities and select sources of water supply and locations and methods of discharges based on a thorough evaluation of alternatives involving affected municipalities and counties in the process.

Key Strategies

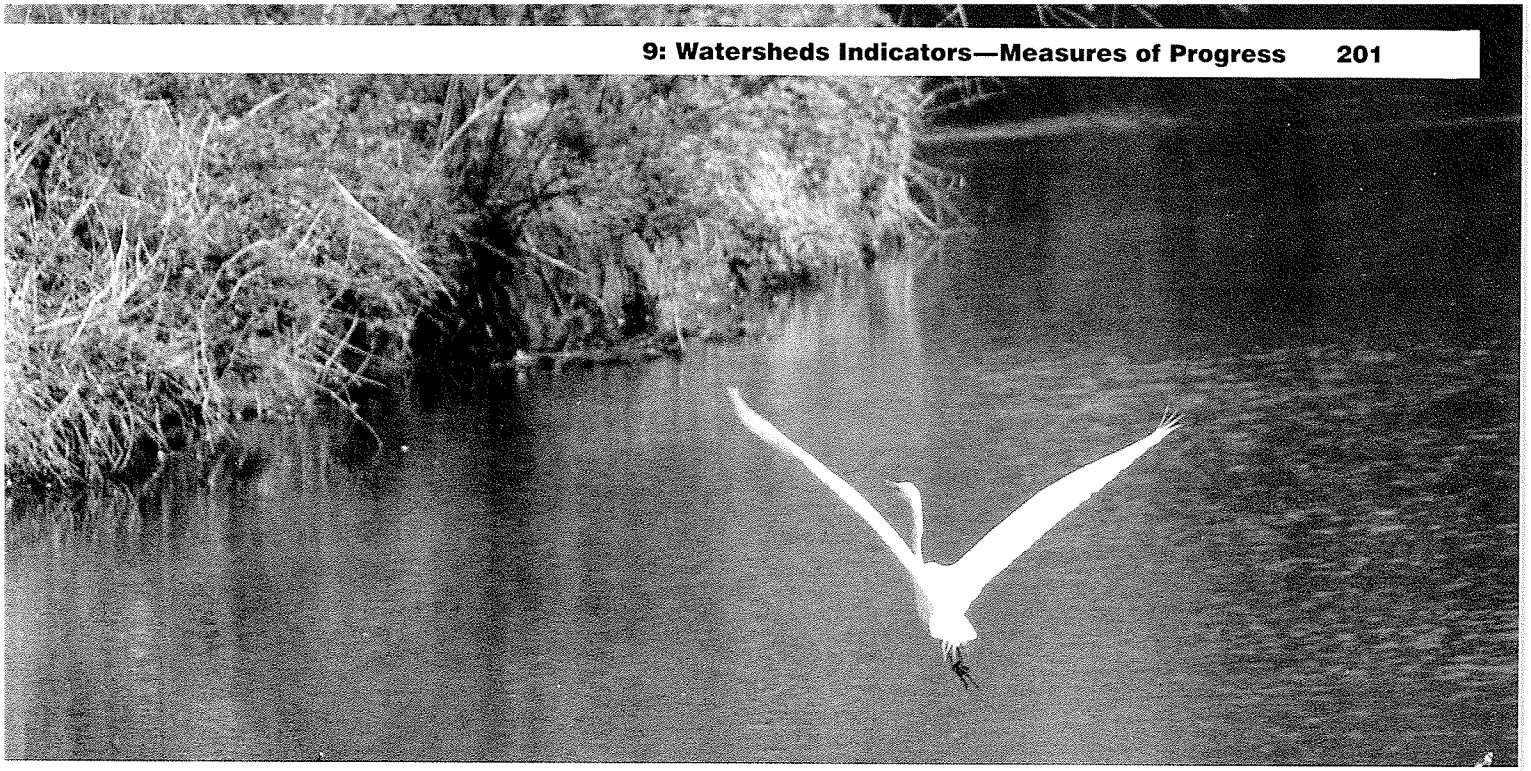
- Develop infrastructure planning in conjunction with the affected municipalities and counties, utilizing the Integrated Water Resources Planning process (presented in Part 6) or similar alternatives evaluation process.
- Identify and evaluate all viable alternatives for meeting new demand such as ground water sources, surface water sources, existing facilities, water conservation, and re-use of treated effluent.
- Consider economic, water quality, engineering, local land use planning, and environmental implications and other regulatory requirements in the evaluation of alternatives and facility planning.
- Consider satellite systems for remote service areas where it can be demonstrated that resources and capabilities exist to ensure long-term reliability and integrity of the system.
- Implement objectives and strategies for *Watersheds* Goal 3: Preserve Natural Resources, Goal 4: Improve Water Quality, and Goal 6: Protect Watershed Water Balances.

Objective 7-5

Identify and prioritize sources of public drinking water supplies for protection from pollutants.

Key Strategies

- Identify water wells, reservoirs and surface water intakes used for public drinking water supplies and address their protection in municipal comprehensive plans and ordinances.
- Develop and implement well and wellhead protection programs and source water protection assessments and plans.
- Implement comprehensive stormwater management and riparian buffer network ordinances, soil and instream erosion controls, and/or land preservation strategies for lands discharging to reservoirs and instream sources of public water supplies.
- Implement on-lot septic system clean-out programs.
- Encourage hazardous materials storage, handling and transportation practices to avoid or minimize uncontrolled releases to waterways.
- Establish emergency notification procedures to alert downstream water suppliers and reservoir owners and operators of releases of hazardous materials to streams and reservoirs.
- Implement withdrawal management targets within supporting subbasins to protect instream baseflows.
- Encourage voluntary treatment of constituents in wastewater discharges that contribute to pervasive taste and odor problems in public water supply systems.
- Locate and design wastewater discharges appropriately to avoid impacts to sources of public water supplies and (where practicable) to provide instream flow replacement for withdrawals.
- Implement agricultural and landscape management BMPs to reduce nutrients, sediment and other nonpoint source pollutants from entering ground water, streams and reservoirs.
- Develop and implement lake management plans and ongoing monitoring programs (e.g. Trophic State Index monitoring) for water supply reservoirs to identify and address water quality problems and sources.
- Implement other strategies to protect surface water quality and ground water recharge, and to minimize soil and instream erosion upstream of reservoirs and water supply intakes.



WATERSHEDS Indicators

Measures of Progress

Consistent with the goals of ***Watersheds*** is the desire to measure progress towards achieving those goals over time. Like **LANDSCAPES**, ***Watersheds*** is a long-range plan that can only be realized over a period of years. To this end, ***Watersheds*** proposes to add measurable indicators to the *Landscapes Progress Report,* first published in 2000, to monitor trends and assist in water resources decision making.

The *Landscapes Progress Report* was developed to fulfill the County's commitment to review the "state of the County," including the desire to measure progress towards achieving the goals of **LANDSCAPES** and the desire to keep the Plan active and functional. The intent of the Report is to review recent advancements, identify areas of success, and identify areas where work is needed. By using indicators to monitor trends, the County hopes to encourage positive action where it is needed most.

Landscapes Indicators

The *Landscapes Progress Report* (Report) includes an overall *Landscapes Index* and an assessment of 18 indicators within seven categories. The Report (published semi-annually) provides a reliable account of the indicators measured so that long-term trends toward achieving the goals of **LANDSCAPES** can be assessed. Positive trends indicate a measure of success while negative trends indicate where both deficiencies exist and where actions are needed. As a way of measuring cumulative progress, the *Landscapes Index* provides a generalized picture of overall progress based on the trends of all of the indicators. Individual indicators show trends for specific subjects and can show where the greatest progress is being made and where greater efforts should be focused.

The intent of the *Landscapes Index* is to show a trend line indicating the degree to which progress has been made towards achieving the goals of **LANDSCAPES.** At present, the indicators that monitor specific subjects are not a complete measure of all aspects of **LANDSCAPES.** To that end, indicators developed as part of ***Watersheds*** will further contribute to the value of the *Landscapes Index* as an overall tool for measuring change.

The existing 18 indicators that contribute to the *Landscapes Index* were selected for their relevance to **LANDSCAPES,** their understandability by the general public, and their measurability on a yearly basis. Each indicator has a base year which serves as a starting point for measuring trends. In addition, the data for each indicator has been converted to a base year value of 100. This permits the calculation of a single index from different types of data, provides a common base year for each type of indicator, and allows for the comparison of yearly data to the base year. The *Landscapes Index* is calculated by combining all of the indicators into an average value. The current indicators used to develop the *Landscapes Index* are included in Table 9-1.

Watersheds Indicators

Several of the existing indicators included in the *Landscapes Index* will also serve as indicators for the ***Watersheds*** Plan, including: Protected Farmland, Eased Land, Park Land, Community Water & Sewer, Stream/Water Protection (Exceptional Value watersheds), Historic Resources and Plans, and municipalities with ordinances consistent with **LANDSCAPES** and ***Watersheds.*** Given the clear desire to create additional indicators that will further add to the value of the *Landscapes Index,* two additional ***Watersheds*** indicators will be established (Table 9-2) to expand the series of water resource-based indicators aimed at measuring progress towards both **LANDSCAPES** and ***Watersheds*** goals. These indicators will be updated annually as data are available and will be published semi-annually as part of the *Landscapes Index,* beginning with year 2000 data.

CCWRA is in the process of assessing additional indicators for their potential value to the *Landscapes Index* (Table 9-3). Although substantial information exists for several of these indicators, their value as yearly measures must be adequately assessed. A specific set of indicators will be developed by the CCWRA as part of the implementation activities scheduled for this plan. In developing these indicators, consideration will be given to the need for the indicators to be understandable to the general public and measurable on a yearly basis.

Table 9-1: Relevant Components of the *Landscapes Index*

Sub-Index Category	Indicators
Preserved Land Sub-index	Protected Farmland *
	Eased Land *
	Park Land *
Proposed Development Sub-index	Proposed Housing Units Consistent with ***Landscapes***
	Non-residential Development Consistent with ***Landscapes***
	Community Water & Sewer *
Housing Sub-index	Housing Affordability
	Residential Loans in Urban Areas
	Residential Lot Size
Transportation Sub-index	Traffic Safety
	Public Transportation Use
	Travel Time
Economy Sub-index	Farm Production
	Employment Performance
Resources Sub-index	Stream/Water Protection *
	Historic Resources & Plans *
Municipal Initiatives Sub-index	Municipal Ordinance Amendments Consistent with ***Landscapes*** *
	Municipal Volunteerism

* Will also be used as ***Watersheds*** indicators
Source: *Landscapes Progress Report*, Chester County Planning Commission, 2000

Table 9-2: New *Watersheds* Indicators for *Landscapes Index*

Indicator	Measurement Value	Source Data
Non-Impaired Streams	% of total assessed stream miles that are not listed as impaired	PADEP 303 (d) List
Biological Diversity	Annual Hilsonhoff Biotic Index Streams Conditions Monitoring Results	USGS/Chester County Annual Streams Conditions Program

Table 9-3: Potential *Watersheds* Indicators under Consideration

Indicator	Measurement Value	Source Data
Ground Water Balances/ Withdrawals	Ground water withdrawals as a percent of total withdrawals	CCWRA
Reservoir Water Quality	Trophic State Index	CCWRA and reservoir owners
Miles of Buffered Stream	Miles	CCWRA
Agricultural Lands Management	Number of agricultural BMPs Installed	CCCD
Pollutants in Streams	Stream sampling for selected pollutants	USGS, PADEP, CCHD
Municipal Implementation	Percent of municipalities implementing comprehensive recommended ordinance tools	CCWRA
Ground Water Recharge	Percent of total volume of wastewater discharges that are land applied	CCWRA
Protection of Drinking Water Sources	Number of source water protection plans/measures in place	CCWRA
Public Involvement in Watershed Stewardship	Total number of members in watershed associations	CCWRA, watershed and conservation organizations
Recreational Use	Numbers of fishing licenses issued/canoe rentals	CCWRA, PAFBC

Management Needs

10

Presented on the following pages are inventories of specific management needs for each of the 21 watersheds. These management needs reflect the final conclusions of the data collection and analyses summarized in Part 3. The inventories list the specific characteristics, problems, and resources of each watershed that should be considered in restoration, protection, land use, and water use planning. These inventories can assist municipalities and other stakeholders in understanding the critical needs within their watersheds. For each watershed, six categories of needs are presented. These inventories provided the basis for defining the priority management objectives (presented in Table 5-3) and the management actions recommended in the individual watershed action plans.

The watershed inventories include six categories of needs:

Resources to be Protected lists the natural, cultural and recreational resources and related characteristics that may warrant particular attention.

Growth and Land Use presents statistics for subbasins and/or watersheds regarding density or rate of growth, and the extent of land uses that may impact the integrity of water resources.

Water Availability and Use describes what significant water uses and withdrawals currently exist, what additional resources exist that may be options for meeting future water demands, as well as particular constraints that exist that warrant consideration as additional water use is planned.

Runoff presents physical and natural characteristics that may contribute to or are caused by excessive stormwater and non-point source pollutant (NPS) runoff.

Water Quality lists the types of stream impairments and ground water quality problems found to exist in the watersheds that warrant restoration or that present potential concerns for protecting sources of drinking water supplies.

Regional Prioritizations present the results from the prioritization exercises (Part 5) that apply (if any) for each watershed or their subbasins.

Brandywine Creek Watershed

Resources to be Protected

- Subbasins B1, B2, B3, B9, B10, B11, and B14— first order stream corridors >35% wooded and/or wetlands
- Designated trout fishery—Beaver Creek
- EV watersheds (subbasin B13)
- HQ streams (subbasins B7, B10, B11, B12, B14, and B15)
- Designated cold-water streams
- Chambers Lake and Marsh Creek water supply reservoirs and fisheries
- Rock Run water supply reservoir
- Struble Lake Recreational Lake and Fishery
- Surface water intakes for public water supplies East Branch—Downingtown, Ingram's Mill, Wilmington; West Branch—Embreeville, Rock Run, Wagontown
- Great Marsh
- >25 PNDI sites
- 11 historic bridges
- Carbonate aquifer underlying extensive portions of watershed
- Struble Trail and planned inter-connecting regional Chester Valley Trail
- Designated Pennsylvania Scenic Corridor
- Multiple recreational/eco-tourism uses
- 56% of total stream miles are first order streams
- 10 large instream wastewater discharges

Growth and Land Use

- Substantial projected population growth by 2020 (subbasins B5, B7, B9, B10, B14, and B15)
- Rapid growth and development—Route 100 north corridor, Route 30 corridor, north of Route 30, Strasburg Road corridor
- Scattered growth throughout remainder of watershed
- Increased residential and commercial water/wastewater demand in growth areas
- Increased residential water and wastewater need for new developments in rural areas
- Increasing number of new septic systems, aging septic systems, and cumulative septic discharges
- Subbasins B1, B6, B7, B8, and B15 — >60% of land area in drainage areas to first order streams
- Subbasin B6— first order stream corridors >70% agricultural land use
- Subbasin B5— first order stream corridors >60% agricultural land use
- Subbasins B4, B11, B12, and B13— first order stream corridors >40% agricultural land use
- Increasing pressures to expand water and wastewater infrastructure, sometimes in areas non-Contiguous to existing infrastructure

Water Availability and Use

- Brandywine Creek watershed accounts for 32% of all combined surface and ground water withdrawals in study watersheds (17.6 billion gallons/year)
- Predominant source of water supply for much of Chester Co. and northern New Castle Co.
- Relatively high net ground water withdrawals 1998— West Valley Creek
- Projected 2020 net ground water withdrawals near net withdrawal threshold—West Valley Creek
- Brandywine Creek watershed accounts for 32% of all combined surface and ground water withdrawals in study watersheds (17.6 billion gallons/year)
- Predominant source of water supply for much of Chester Co. and northern New Castle Co.
- Relatively high net ground water withdrawals 1998— West Valley Creek
- Projected 2020 net ground water withdrawals near net withdrawal target—West Valley Creek
- Relatively high volume of surface water withdrawals (although water supply withdrawals supported by reservoir storage)
- High volume of surface water discharges
- Subbasins B1, B3, B6, B7, B8, and B15— >60% of total stream miles are first order streams
- Water supply reservoirs subject to NPS nutrients and sediments loadings (subbasins B10, B12, and B14)
- Wastewater discharges may affect water quality, introduce pathogens and taste and odor causing compounds for water supply intakes
- Low instream flows during droughts threaten instream water supply intakes
- Need to evaluate effects of quarry pumping and operations on baseflow of West Valley Creek
- Need for source water protection for reservoirs and water supply intakes
- Need for wellhead protection plans for public water supply wells
- Portions of watershed in DRBC GWPA

Runoff

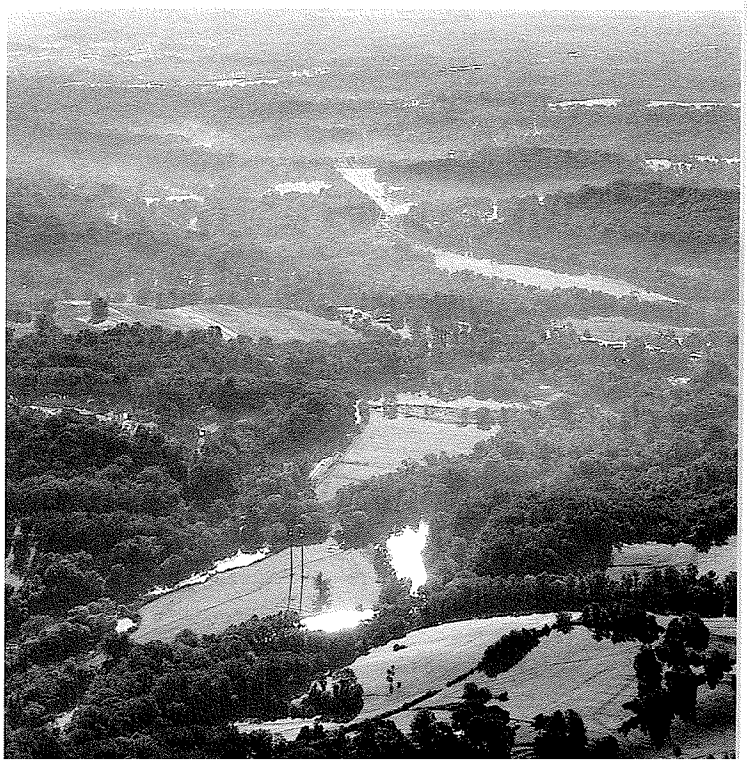
- >40% estimated impervious cover—subbasin B2
- >20% estimated impervious cover—subbasin B15
- >10% estimated impervious cover—subbasins B1, B3, B4, B7, B8, B9, B10, and B14
- Subbasin B2—first order stream corridors >40% impervious cover
- Excessive estimated average annual rainfall runoff—subbasin B2 (20 in/yr), B6, and B15
- Excessive increase in estimated average annual rainfall runoff—by 2020—subbasins B2 and B15
- Flooding—Downingtown (Parke Run, East Branch Brandywine Creek), West Valley Creek (Route 100), lower East and West Branches, mainstem in Chester Co. and New Castle Co., Upper East and West Branches in Honey Brook Twp., Caln Twp (from Rt. 30 runoff), Valley Run Creek; Business Rt. 30 (Valley Twp), Doe Run at Rt. 82, Doe Run at Rt. 841, Marchwood Development; Whitford Rd.
- Instream erosion/sedimentation and hydromodifications in some segments and tributaries downstream of developed areas (Marchwood, Exton, West Chester, Downingtown, Coatesville, Sadsbury, Parksburg), several locations on Buck Run, Sadsbury Twp.
- 20 municipalities to be required to comply with NPDES Phase II stormwater management requirements
- No PA Act 167 Plans yet developed
- 5 flood control and/or water supply dams in PA portion of watershed

Water Quality

- 25% of total stream miles listed as impaired on 303(d) list
- 303(d) listed—mainstem segments and some tributaries (nutrients, pathogens and chlordane)
- 303(d) listed—West Branch segments and some tributaries (nutrients and siltation from agriculture and chlordane)
- 303(d) listed—East Branch segments and some tributaries (flow alteration and siltation)
- TMDL promulgated for chlordane in mainstem Brandywine
- NPS TMDLs under development for sediment, nitrogen, phosphorus and bacteria
- Low flow TMDLs promulgated for phosphorus, nitrogen and dissolved oxygen
- Some locations of ground water contamination due to failing septic systems and Superfund/contaminated waste sites
- NPS runoff—agricultural and developed areas
- Lower Brandywine Creek—elevated levels of suspended solids, nitrogen and phosphorus
- Upper East and West Branches—elevated levels of phosphorus
- Elevated bacteria concentrations throughout watershed, including upstream of 3 water supply reservoirs
- Widespread areas of high levels of naturally occurring radon in ground water
- Exploding populations of resident and migratory geese contributing to nutrients in reservoirs and streams
- Fish consumption advisories posted below Coatesville, at Chadds Ford, and in Delaware—PCBs, chlordane, and dioxin
- Need to address combined sewer overflows at City of Wilmington
- Relatively high mean BOD, COD, TP and dissolved P concentrations for watershed from available surface water quality data
- Relatively high total lead, BOD and COD in ground water from available water quality data
- USGS/Chester Co. biological monitoring indicates slightly impacted conditions (West Valley Creek, West Branch below Honey Brook and Coatesville)
- Malfunctioning sewer systems at Sadsbury, Pomeroy and Pomeroy Heights
- Scattered locations of aging septic systems

Regional Prioritizations

- West Valley Creek subbasin identified as highest ranking overall priority subbasin among all subbasins in Brandywine Creek watershed and in County for water quality restoration, stormwater management, stream preservation, and ground water management
- Brandywine Creek watershed ranked among highest overall priority watersheds for water quality restoration and stormwater management
- Brandywine Creek watershed ranked among highest overall priority watersheds for stream/resources preservation
- Subbasins B15, B2, B4, and B9 ranked highest overall priority subbasins in Brandywine Creek watershed for water quality restoration, stormwater management and stream/ resources preservation



Chester Creek Watershed

Resources to be Protected

- Subbasin Ch1—first order stream corridors >35% wooded and/or wetlands
- West Chester Reservoir
- 2 public water supply intakes
- HQ streams (subbasin Ch1)
- 1 historic bridge
- 53% of total stream miles are first order streams
- 5 large instream wastewater discharges

Growth and Land Use

- Substantial projected population growth by 2020 (subbasins Ch1 and Ch2)
- Subbasin Ch2 >60% of land area in drainage areas to first order streams
- Increasing numbers of new and aging septic systems and cumulative septic loadings

Water Availability and Use

- Relatively high volume of surface water discharges from wastewater systems
- Wastewater stream discharges may affect water quality and introduce pathogens and taste and odor compounds at water supply intake (subbasin Ch1)
- Phosphorus NPS loadings causes eutrophication in West Chester Reservoir (subbasin Ch2)
- Low flows during drought conditions threaten suspension of public water supply withdrawals, possibly exacerbated by golf course withdrawals (subbasin Ch1)
- Subbasin Ch2 >60% of total stream miles are first order streams
- Need for source water protection for public water supply reservoir and intakes
- Headwaters of watershed within DRBC GWPA

Runoff

- >20% estimated impervious cover 2020 for watershed
- >20% estimated impervious cover—subbasins Ch1 and Ch2
- Excessive estimated average annual rainfall runoff (subbasin Ch2)
- Development located within floodplains prior to floodplain regulations (subbasin Ch1)
- Flooding at several locations in/near West Chester Borough
- Erosion of stream banks along almost all tributaries in East Goshen Twp.
- Extensive developed areas with no stormwater management facilities
- PA Act 167 stormwater management plan to be adopted and implemented
- All municipalities required to comply with NPDES Phase II stormwater management regulations

Water Quality

- 13% of total stream miles listed as impaired on 303(d) list
- 303(d) listed—some segments and tributaries (flow variability from stormwater runoff and industrial point sources)
- USGS/Chester Co. biological monitoring indicates slightly impacted conditions in Chester Co.
- USGS/Chester Co. biological monitoring indicates Goose Cr. moderately impacted conditions
- Widespread areas of high levels of naturally occurring radon in ground water
- Exploding populations of resident and migrating geese contributing to nutrients in reservoirs and streams
- Concerns of water quality impacts of public, small package and individual wastewater treatment systems and discharges
- Locations of leaking underground storage tanks
- Relatively high mean COD and TP concentrations for watershed for available surface water quality data
- Highest estimated TKN, TP, and TSP annual loading rates 1998 of all watersheds (due to combined point and nonpoint sources)

Regional Prioritizations

- Chester Creek watershed ranked among highest overall priority watersheds for water quality restoration and stormwater management
- Subbasin Ch2 ranked as overall priority for water quality restoration, stormwater management and stream/resources preservation in Chester Creek watershed

Christina River Watershed

Resources to be Protected

- Subbasin Cr5—first order stream corridors >35% wooded and/or wetlands
- 1 public water supply intake
- 1 large instream wastewater discharge

Growth and Land Use

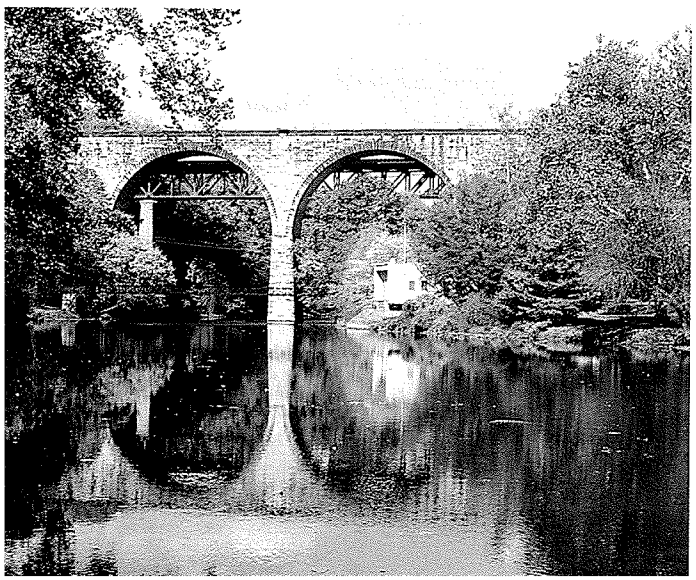
- Substantial population growth by 2020—subbasin Cr4

Water Availability and Use

- Need to address projected future water supply shortages for northern New Castle Co.
- Increasing nitrogen in source waters of public water intakes

Runoff

- >20% estimated % impervious cover 1998 and 2020
- >40% impervious cover—subbasin Cr4
- >30% impervious cover—subbasin Cr3
- >20% impervious cover—subbasin Cr2 and Cr6
- Subbasins Cr3 and Cr4—first order stream corridors >30% impervious cover
- Subbasin Cr2—first order stream corridors >20% impervious cover
- Excessive estimated average annual rainfall runoff for entire watershed (over 13 in/yr)
- Excessive estimated average annual rainfall runoff—subbasins Cr2, Cr3, Cr4, and Cr6
- Excessive increase in estimated average annual rainfall runoff by 2020—subbasins Cr4 and Cr5
- No PA Act 167 Plan for Christina River or major tributaries
- 1 PA municipality required to comply with NPDES Phase II stormwater management regulations



Water Quality

- 82% of total stream miles listed as impaired on 303(d) list
- Excessive levels of bacteria, phosphorus and iron
- Fish consumption advisories in tidal reaches due to PCBs and dioxin
- Need to address numerous combined sewer overflows at City of Wilmington
- 303(d) listed—most segments and tributaries (nutrients, dissolved oxygen, PCBs and pathogens)
- Low flow TMDL promulgated for N, P, and DO
- NPS TMDL under development for N, P, sediment, and bacteria
- Relatively high mean BOD concentrations for watershed for available surface water quality data
- Relatively high mean TP concentrations for available surface water quality data
- Relatively high mean Pb concentrations for available surface water quality data for available surface water quality data
- High concentrations of total lead in ground water
- High estimated NO_2/NO_3 annual loading rate in baseflow
- Highest estimated annual loading rate for Cu 1998
- Widespread areas of moderately high levels of naturally occurring radon in ground water (subbasin Cr6)
- Substantial numbers of contaminated sites in northern New Castle Co. (Superfund, RCRA, and leaking underground storage tanks)
- Impacts of effluent from 10 wastewater disposal facilities on water quality

Regional Prioritizations

- Subbasin Cr4 ranked overall priority for water quality restoration, stormwater management and ground water management in Christina River watershed
- Subbasin Cr6 ranked overall priority for stream/resources preservation in Christina River watershed

Conestoga Creek Watershed

Resources to be Protected

(none identified in study area)

Growth and Land Use

- First order stream corridors >50% agricultural land use

Water Availability and Use

(none identified in study area)

Runoff

- Excess average annual rainfall runoff

Water Quality

- <1% of total stream miles (in study area) listed as impaired on 303(d) list
- 303(d) listed—some segments and tributaries for nutrients and dissolved oxygen from agriculture
- Widespread areas of relatively high levels of naturally occurring radon in ground water
- Need for nutrient management plans for confined animal operations
- Livestock and agricultural runoff impacts to stream water quality
- Need for effective closure plan for Lanchester Landfill

Regional Prioritizations

(none identified)

Crum Creek Watershed

Resources to be Protected

- EV watersheds—subbasin Cm2
- HQ streams—Subbasin Cm2
- Documented naturally reproducing brown trout population—subbasin Cm2
- 2 water supply reservoirs—Springton and lower Crum Creek
- 1 public water supply intake
- 1 historic bridge
- 57% of total streams are first order streams

Growth and Land Use

- Subbasin Cm2 >60% of land area in drainage areas to first order streams
- Failing and aging septic systems

Water Availability and Use

- Relatively high volume of surface water withdrawals (water supply withdrawals supported by reservoir storage)
- Subbasin Cm2 >60% of total stream miles are first order streams
- Need for source water protection for public water supply reservoirs and intakes
- Phosphorus NPS loadings causing eutrophication in Springton Reservoir
- Re-circulation of phosphorus occurring within Springton Reservoir
- Taste and odor compounds affecting water supply intakes
- Impact of 2 impoundments on continuous stream baseflow
- Loadings of phosphorus and sediment into Springton Reservoir likely from excessive instream erosion from runoff from developed lands and roads
- Headwaters of watershed included within DRBC GWPA

Runoff

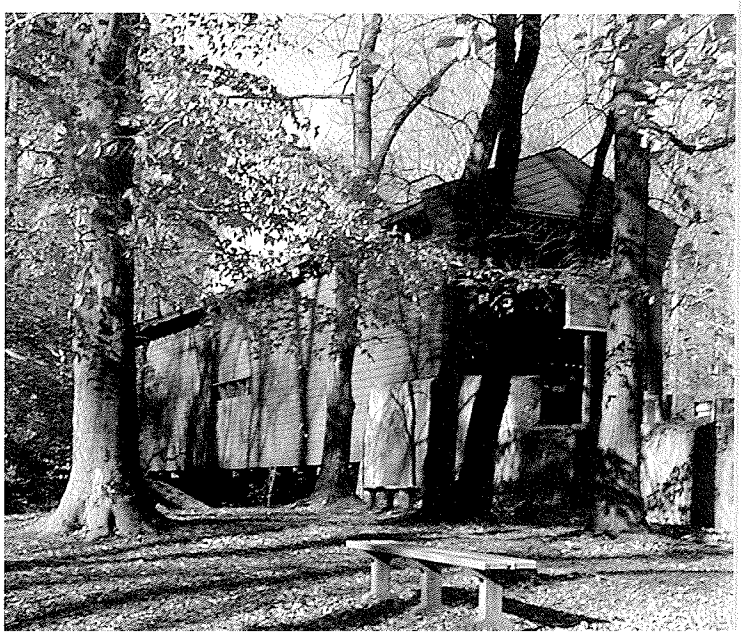
- >20% impervious cover—subbasin Cm1
- Excessive average annual rainfall runoff—subbasin Cm1
- Subbasin Cm1—first order stream corridors >20% impervious cover
- Excessive runoff from developed lands and roads causing excessive instream erosion throughout watershed, and particularly severe in subbasin Cm1 (Lower Crum Creek and Little Crum Creek), Trout Run (subbasin Cm1)
- Widespread lack of stormwater management facilities from older developments
- Strong need for retrofitting to install stormwater management facilities where they currently do not exist
- Springton Reservoir provides some flood control protection for lower Crum Creek corridor
- High density of road crossings (91 crossings) contributes substantial uncontrolled runoff to streams
- PA Act 167 stormwater plan under development
- 2 water supply dams in watershed
- All municipalities required to comply with NPDES Phase II stormwater management regulations

Water Quality

- 33% of total stream miles listed as impaired on 303(d) list
- 303(d) listed impairments—siltation flow variability and alterations
- Historic agricultural impacts to water quality
- Widespread areas of relatively high levels of naturally occurring radon in ground water
- Bacteria from failing septic systems and nonpoint sources
- Uncontrolled direct discharges to streams from numerous sewage lift stations during flood conditions
- Individual wastewater package systems discharging to reservoir
- Potential impacts of numerous wastewater treatment facilities upstream of reservoir and water supply intake
- Exploding populations of resident and migratory geese contributing to nutrients in reservoirs and streams
- High likelihood of direct impacts from uncontrolled releases of hazardous materials from roadways due to lack of stormwater/catchment facilities

Regional Prioritizations

- Subbasin Cm1 ranked highest priority for water quality restoration and stormwater management in Crum Creek watershed
- Subbasin Cm2 ranked highest priority for stream/resources preservation and ground water management in Crum Creek watershed



Darby Creek Watershed

Resources to be Protected

- 1 large instream wastewater discharge

Growth and Land Use

- Subbasin D3
  >60% of land area in drainage areas to first order streams
- All subbasins—first order stream corridors
  >20% impervious cover
- Substantial number of aging septic systems

Water Availability and Use

- Subbasin D1 (Cobbs Creek)
  >80% of total stream miles are first order streams
- Subbasin D3
  >60% of total stream miles are first order streams
- Headwaters of watershed included within DRBC GWPA

Runoff

- >20% estimated % impervious cover 1998 and 2020 (subbasins D1, D2, and D3)
- Excessive average annual rainfall runoff—subbasins D1 and D2
- Flooding—Darby Borough and Easttown (Sugartown Rd)
- Development located within floodplain prior to floodplain regulations
- Extensive developed areas with no stormwater management facilities
- PA act 167 Plan under development
- All municipalities required to comply with NPDES Phase II stormwater management regulations

Water Quality

- 50% of total stream miles listed as impaired on 303(d) list
- 303(d) listed—siltation and flow variability from urban stormwater runoff
- USGS/Chester Co. biological monitoring indicates slightly impacted conditions in Chester Co.
- Widespread areas of relatively high levels of naturally occurring radon in ground water
- Need to address numerous combined sewer overflows
- Relatively high mean TP concentrations for available surface water quality data
- Relatively high nitrite/nitrate concentrations in ground water from available water quality data
- Among the highest estimated NO_2/NO_3 annual loading rate in baseflow of all watersheds

Regional Prioritizations

- Subbasin D2 ranked highest priority for water quality restoration, stormwater management and ground water management in Darby Creek watershed
- Subbasin D3 ranked highest priority for stream/resources preservation in Darby Creek watershed

Elk Creek Watershed

Resources to be Protected

- Watershed discharges directly to Chesapeake Bay
- Subbasin E2—first order stream corridors >35% wooded and/or wetlands
- EV watersheds (subbasin E5)
- HQ streams (subbasins E1, E4, E5, and E6)
- 5 PNDI sites
- 3 historic bridges
- 56% of total stream miles are first order streams

Growth and Land Use

- Subbasins E1 and E6 >60% of land area in drainage areas to first order streams
- Subbasin E1—first order stream corridors >60% agricultural land use
- Subbasin E4, E5, and E6—first order stream corridors >50% agricultural land use
- Subbasins E2 and E3—first order stream corridors >40% agricultural land use
- Increasing rate of growth in Chester Co. portion of watershed
- Increasing commercial development in Oxford area

Water Availability and Use

- No ground water withdrawal regulatory oversight in PA for this watershed
- Subbasins E3 and E6 >60% of total stream miles are first order streams

Runoff

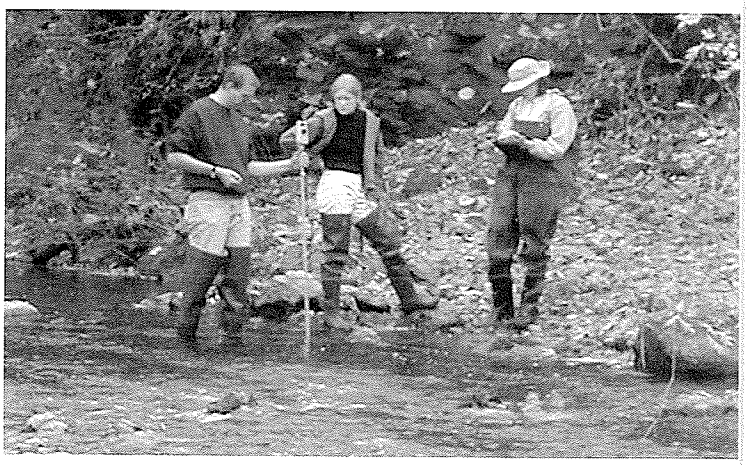
- >10% estimated impervious cover—subbasin E6
- Excessive average annual rainfall runoff—subbasins E2, E5, and E6
- Stream erosion at numerous locations on Big Elk Creek
- Stream erosion at New London Creek
- Flooding in Elkton, MD
- No PA Act 167 Plan yet developed

Water Quality

- Not yet assessed by PADEP
- USGS/Chester Co. biological monitoring indicates slightly impacted conditions
- Potential pesticide problem upstream of Elkview
- Widespread areas of relatively high levels of naturally occurring radon in ground water
- Livestock and agricultural runoff impacts to stream water quality
- Relatively high nitrite/nitrate concentrations in ground water
- High estimated NO_2/NO_3 annual loading rate in baseflow
- Need to improve treatment by Lincoln University Village wastewater system

Regional Prioritizations

- Subbasin E6 ranked overall priority for water quality restoration in Elk Creek watershed
- Subbasin E2 ranked overall priority for stormwater and ground water management in Elk Creek watershed
- Subbasin E1 ranked overall priority for stream/resources preservation in Elk Creek watershed



French Creek Watershed

Resources to be Protected

- Subbasins F2, F3, and F4—first order stream corridors >35% wooded and/or wetlands
- EV watersheds (subbasins F2, F3, and F4)
- HQ streams (subbasins F1 and F2)
- 8 PNDI sites
- Designated Pennsylvania Scenic River
- 5 historic bridges
- 58% of total stream miles are first order streams

Growth and Land Use

- 62% of land area in watershed comprised of drainage areas of first order streams
- Subbasin F4 >70% of land area in drainage areas to first order streams
- All subbasins— first order stream corridors >40% agricultural land use

Water Availability and Use

- 64% of total stream miles are first order streams
- Subbasin F4 >70% of total stream miles are first order streams
- Subbasin F2 >60% of total stream miles are first order streams
- Watershed included within DRBC GWPA

Runoff

- >10% impervious cover—subbasin F1
- Excessive average annual rainfall runoff—subbasin F1
- Flooding—lower French Creek at Phoenixville; Park Rd; Trythall Rd. at Rock Run; Kulp and Halteman Rds.; Wells Rd. north of Rt. 724; Coventryville Rd.; Pughtown Rd.; Hoffecker and Laurelwood Roads; Temple and Kutz Dr.; railroad overpass at Bridge Street
- Erosion and sedimentation at French Creek Rd and Beaver Hill Rd., Horseshoe Trail, Sheeder Mill and French Creek Rd., St. Andrews Lane (West Vincent Twp)
- No PA Act 167 Plan yet developed
- 1 dam in watershed (for recreation)
- 5 municipalities required to comply with NPDES Phase II stormwater management regulations

Water Quality

- No streams listed as impaired on 303(d) list
- USGS/Chester Co. biological monitoring indicates slightly impacted conditions near Phoenixville
- Widespread areas of relatively high levels of naturally occurring radon in ground water
- Relatively high mean COD concentrations for watershed for available surface water quality data
- Ground water contamination at Ludwig's Corners, Kimberton, Temple Rd. at Shenkel Rd.

Regional Prioritizations

- French Creek watershed ranked among highest overall priority watersheds for stream/resources preservation
- Subbasin F1 ranked overall priority for water quality restoration in French Creek watershed
- Subbasin F2 ranked overall priority for stormwater and ground water management in French Creek watershed
- Subbasin F4 ranked overall priority for stream/resources preservation in French Creek watershed

Gulph Creek Watershed

Resources to be Protected

- Carbonate aquifer underlies extensive areas of watershed

Growth and Land Use

- Densely developed watershed

Water Availability and Use

- Watershed included within DRBC GWPA

Runoff

- Excessive average annual rainfall runoff in 2020
- >20% estimated % impervious cover 1998 and 2020
- First order stream corridors >20% impervious cover
- Flooding
- All municipalities required to comply with NPDES Phase II stormwater management regulations
- No PA Act 167 Plan yet developed

Water Quality

- 24% of total stream miles listed as impaired on 303(d) list
- 303(d) listed—metals from unknown source
- Widespread areas of high levels of naturally occurring radon in ground water

Regional Prioritizations

(none identified)

Northeast Creek Watershed

Resources to be Protected

- Subbasin N1—first order stream corridors >35% wooded and/or wetlands
- Watershed discharges directly to Chesapeake Bay
- 2 PNDI sites
- 61% of total PA stream miles are first order streams
- 1 historic bridge
- 1 large instream wastewater discharge

Growth and Land Use

- Subbasin N2—first order stream corridors >60% agricultural land use
- No watershed association in place

Water Availability and Use

- Subbasin N2 >60% of total stream miles are first order streams
- No ground water withdrawal regulatory oversight in PA for this watershed

Runoff

- Excessive average annual rainfall runoff—subbasin N2
- No PA Act 167 Plan yet developed

Water Quality

- 28% of total stream miles listed as impaired on 303(d) list (in MD)
- Not yet assessed by PADEP
- Widespread areas of relatively high levels of naturally occurring radon in ground water
- Relatively high concentrations of total lead in ground water

Regional Prioritizations

- Subbasin N2 ranked overall priority for water quality restoration and stream/resources preservation in Northeast Creek watershed
- Subbasin N1 ranked overall priority for stormwater and ground water management in Northeast Creek watershed

Octoraro Creek Watershed

Resources to be Protected

- EV watersheds (subbasin Oc2)
- HQ streams (subbasins Oc1 and Oc5)
- Octoraro Reservoir
- 2 public water supply intakes
- Designated PA Scenic River
- Carbonate aquifer underlying portions of watershed
- 12 PNDI sites
- 2 historic bridges
- 56% of total stream miles are first order streams

Growth and Land Use

- Subbasin Oc1
  >60% of land area in drainage areas to first order streams
- Subbasins Oc1, Oc4, Oc5—
  first order stream corridors >70% agricultural land use
- Subbasin Oc3—
  first order stream corridors >60% agricultural land use
- Subbasin Oc2—
  first order stream corridors >50% agricultural land use
- Increasing commercial development in Oxford area

Water Availability and Use

- Relatively high volume of surface water withdrawals
  (water supply withdrawals supported by reservoir storage)
- Subbasin Oc1
  >60% of total stream miles are first order streams
- High nitrate in surface water causes interruption of public water supply intake (subbasin Oc5) and inter-basin transfers of water from Susquehanna River for blending to meet drinking water standards (subbasin Oc3).
- Need for source water protection for reservoir and water supply intake

Runoff

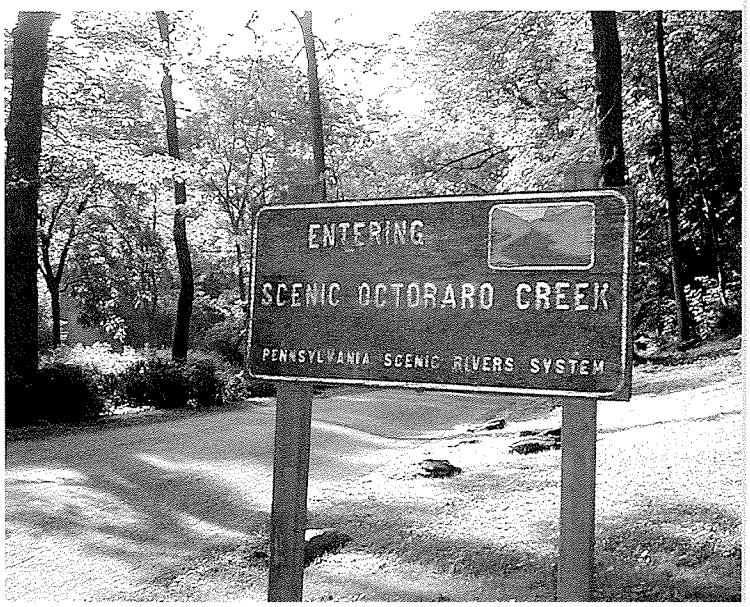
- >10% estimated impervious cover—subbasin Oc3
- Excessive average annual rainfall runoff—
  subbasins Oc1, Oc3, Oc4, and Oc5
- Excessive average annual rainfall runoff in 2020—
  subbasin Oc2
- Erosion of East Branch Octoraro Creek at West Fallowfield Twp., Green Belt Dr.; Bert Reel Park; north side of Valley Road; Compass Rd. Bridge
- Flooding—Limeville Rd.; Quarry Rd.; Pennington Farms
- 1 dam in watershed (water supply)
- No PA Act 167 Plan yet developed

Water Quality

- 303(d) listed—some segments and tributaries
  (nutrients and siltation from agriculture)
- 12% of total stream miles listed as impaired on 303(d) list
- USGS/Chester Co. biological monitoring indicates slightly impacted conditions
- Widespread areas of high levels of naturally occurring radon in ground water
- Exploding populations of resident and migrating geese contributing to nutrients in for available surface water quality data
- Reservoirs and streams
- Relatively high mean COD concentrations for watershed
- Relatively high and widespread nitrite/nitrate concentrations in ground water
- High concentrations of total lead in ground water
- High estimated NO_2/NO_3 annual loading rate in baseflow
- Highest estimated Pb annual loading rate 1998
- Localized MTBE contamination from leaking underground storage tank at Cochranville
- Oxford Mobile Home Park wastewater treatment system problem
- Potential organic pollution in Valley Creek, from small wastewater treatment Facility

Regional Prioritizations

- Octoraro Creek watershed ranked among highest overall priority watersheds for stream/resources preservation
- Subbasin Oc4 ranked overall priority for water quality restoration and ground water management in Octoraro Creek watershed
- Subbasin Oc2 ranked overall priority for stormwater and stream/resources preservation in Octoraro Creek watershed



Pequea Creek Watershed

Resources to be Protected

- EV watershed (subbasin Peq)
- HQ streams (subbasin Peq)
- Carbonate aquifer underlies portions of watershed
- 89% of total stream miles in study area are first order streams

Growth and Land Use

- 63% of land area within study portion of watershed (including portion within Chester Co.) comprised of drainage areas to first order streams
- First order stream corridors >60% agricultural land use

Water Availability and Use

- 64% of total stream miles (within study portion of watershed) are first order streams

Runoff

- Excessive average annual rainfall runoff

Water Quality

- Widespread areas of high levels of naturally occurring radon in ground water
- Management of runoff and waste from confined animal operations
- 53% of total stream miles (in study area) listed as impaired on 303(d) list
- 303(d) listed—some segments and tributaries (nutrients and suspended solids from agriculture)
- Relatively high concentrations of total lead in ground water

Regional Prioritizations

(none identified)

Pickering Creek Watershed

Resources to be Protected

- Subbasin Pc1—first order stream corridors >35% wooded and/or wetlands
- HQ streams (Pc1 and Pc2)
- Public water supply reservoir—Pickering Reservoir
- 1 public water supply intake
- 1 PNDI site
- 56% of total stream miles are first order streams

Growth and Land Use

- Subbasin Pc2 >60% of land area in drainage areas to first order streams
- First order stream corridors >40% agricultural land use
- Rapid growth occurring in headwaters (subbasin Pc2)

Water Availability and Use

- Relatively high volume of surface water withdrawals (water supply withdrawals supported by reservoir storage)
- Phosphorus NPS runoff causes eutrophication in Pickering Reservoir (Pc1)
- Need for source water protection for Pickering Reservoir
- Watershed within DRBC GWPA

Runoff

- >10% estimated impervious cover—subbasin Pc2
- Severe erosion of Pickering Creek
- Flooding—Horseshoe Trail; lower Pine Creek Rd.; Rt. 401; Yellow Springs and Pine Creek Rd.; Horseshoe Trail near Rt.113, St. Matthews Rd. and Malehorn Rd.
- 1 dam in watershed (water supply)
- No PA Act 167 yet developed
- 6 municipalities required to comply with NPDES Phase II stormwater management regulations

Water Quality

- 3% of total stream miles listed as impaired on 303(d) list
- Widespread areas of high and relatively high levels of naturally occurring radon in ground water
- Exploding populations of resident and migrating geese contributing to nutrients in reservoir and streams
- Relatively high concentrations of total lead in ground water from available water quality data
- Runoff from Matthews Meadows treatment facility

Regional Prioritizations

- Pickering Creek watershed ranked among highest overall priority watersheds for stream/resources preservation
- Subbasin Pc2 ranked overall priority for water quality restoration, stormwater management, stream/resources preservation, and ground water management in Pickering Creek watershed

Pigeon Creek Watershed

Resources to be Protected

- HQ streams (subbasin Pgn)
- Low natural stream baseflow
- 67% of total stream miles are first order streams

Growth and Land Use

- 73% of land area in watershed comprised of drainage areas of first order streams
- First order stream corridors >40% agricultural land use

Water Availability and Use

- Very low 1 in 25 year average annual baseflow
- 70% of total stream miles are first order streams
- Management and monitoring of commercial spring water extraction
- Watershed within DRBC GWPA

Runoff

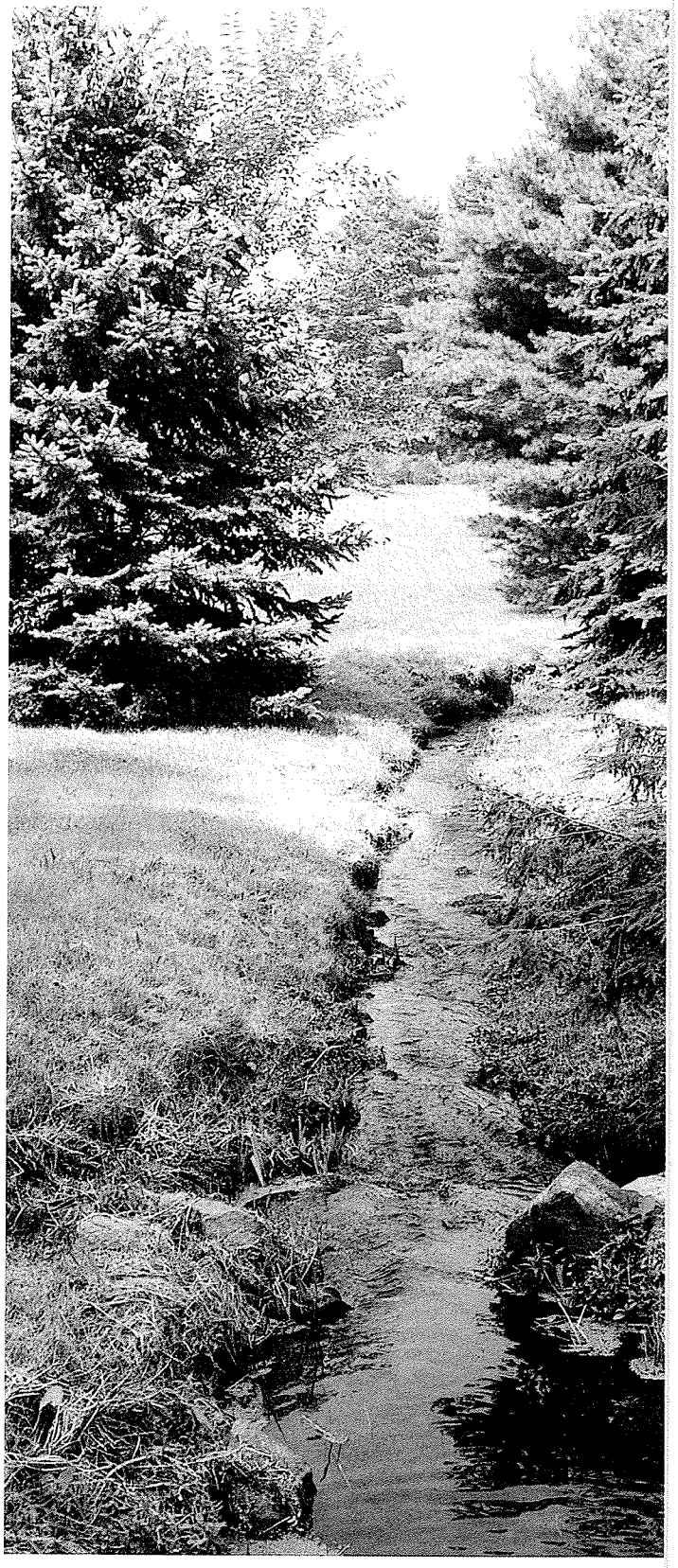
- Flooding—Chestnut Hill Rd.; Jones Rd.; Kulp and Haltemus Rd.
- 3 municipalities required to comply with NPDES Phase II stormwater management regulations
- No PA Act 167 Plan yet developed

Water Quality

- No streams listed as impaired on 303(d) list
- Relatively high annual volume of individual septic system discharges
- Widespread areas of relatively high levels of naturally occurring radon in ground water
- Relatively high soluble phosphorus concentrations in ground water

Regional Prioritizations

(none identified)



Red Clay Creek Watershed

Resources to be Protected

- Subbasin RC4—first order stream corridors >35% wooded and/or wetlands
- Public water supply reservoir—Hoopes Reservoir
- 1 public water supply intake
- 6 PNDI sites
- Carbonate aquifer underlies portions of watershed
- 60% of total stream miles are first order streams

Growth and Land Use

- Rapid growth occurring in Chester Co. portion of watershed land area in drainage areas to first order streams
- Subbasin RC4 >60% of land area in drainage areas to first order streams
- Subbasins RC1 and RC2—first order stream corridors >40% agricultural land use
- Subbasin RC5—first order stream corridors >50% agricultural land use
- Substantial numbers of aging septic systems
- Increasing numbers of new septic systems and volumes of septic discharges

Water Availability and Use

- Relatively high volume of surface water discharges
- Relatively high volume of surface water withdrawals
- 65% of total stream miles are first order streams
- Subbasin RC1 >80% of total stream miles are first order streams
- Subbasin RC4 >70% of total stream miles are first order streams
- Subbasin RC5 >60% of total stream miles are first order streams
- Impacts of sedimentation and taste and odor compounds on water supply intakes
- Water quality impacts to water supply intakes during low stream flows
- Impacts of New Castle Co. water supply intakes on baseflow during droughts
- Need for source water protection of public water supply reservoir

Runoff

- >20% estimated impervious cover—subbasin RC3
- >10% estimated impervious cover—subbasin RC2, RC4, and RC5
- Subbasins RC3 and RC4—first order stream corridors >30% impervious cover
- Subbasins RC3—first order stream corridors >20% impervious cover
- Excessive average annual rainfall runoff—subbasins RC3 and RC5
- Flooding—Hillendale Road, New Garden Twp.; Kennett Square Borough; Wooddale
- 1 large dam in DE (water supply)
- No PA Act 167 Plan yet developed
- 1 PA municipality required to comply with NPDES Phase II stormwater management regulations

Water Quality

- 91% of total stream miles listed as impaired on 303(d) list
- 303(d) listed—some segments and tributaries (flow alteration, priority organics, pesticides, siltation, dissolved oxygen in PA; nutrients, bacteria, zinc and PCBs in DE)
- NPS TMDLs under development for N, P, sediments, and bacteria
- Low flow TMDLs promulgated for N, P, and DO
- TMDL promulgated for zinc from historic operations
- USGS/Chester Co. biological monitoring indicates moderately impacted conditions (East and West Branches)
- Widespread areas of relatively high levels of naturally occurring radon in ground water
- Mainstem—elevated levels of bacteria, nutrients, metals and organics.
- Increasing nitrate concentrations throughout watershed
- Elevated levels of phosphorus throughout watershed
- Fish consumption advisories in PA and DE due to PCBs, Chlordane, and dioxin
- Livestock, mushroom, and agricultural runoff impacts to stream water quality
- Relatively high mean BOD, COD, and TP concentrations for watershed from available surface water quality data
- Relatively high nitrite/nitrate and total lead concentrations in ground water
- Need to upgrade Kennett wastewater treatment facility

Regional Prioritizations

- Subbasin RC2 ranked overall priority subbasin for water quality restoration, stormwater management, stream/resources preservation and ground water management in Red Clay Creek watershed

Ridley Creek Watershed

Resources to be Protected

- Subbasin Rd1—first order stream corridors >35% wooded and/or wetlands
- HQ streams (Rd1 and Rd2)
- 1 public water supply intake
- 5 PNDI sites
- 45% of total stream miles are first order streams
- 1 large instream wastewater discharge

Growth and Land Use

- Subbasin Rd2 >60% of land area in drainage areas to first order streams

Water Availability and Use

- Relatively high volume of surface water withdrawals
- Subbasin Rd2 >60% of total stream miles are first order streams
- Low stream flows during droughts have caused interruptions in water supply withdrawals
- Taste and odor compounds may affect water supply intake
- Need for source water protection for water supply intake
- Headwaters of watershed included in DRBC GWPA

Runoff

- >10% impervious cover (subbasins Rd1 and Rd2)
- Extensive developed areas with no stormwater management facilities
- Excessive stream erosion along almost all tributaries in East Goshen Twp.
- PA Act 167 Plan for Lower Ridley Creek to be updated
- No PA Act 167 Plan for Upper Ridley Creek

Water Quality

- No streams listed as impaired on 303(d) list
- USGS/Chester Co. biological monitoring indicates slightly impacted conditions in Chester Co.
- Some areas of relatively high levels of naturally occurring radon in ground water
- Relatively high mean TP concentrations for available surface water quality data
- Relatively high nitrite/nitrate concentrations in ground water
- High estimated NO_2/NO_3 annual loading rate in baseflow

Regional Prioritizations

- Subbasin Rd2 ranked as priority subbasin for water quality restoration, stormwater management, stream/resources preservation, and ground water management in Ridley Creek watershed

Schuylkill River Drainages

Resources to be Protected

- Subbasin S3—first order stream corridors >35% wooded and/or wetlands
- HQ streams (subbasin S4)
- Several large regional water supply intakes at and downstream of Chester County reach of Schuylkill River
- Designated PA Scenic River
- Designated Schuylkill River National Heritage area
- 1 large instream discharge in study area

Growth and Land Use

- Subbasin S5—first order stream corridors >60% agricultural land use
- Subbasin S4—first order stream corridors >50% agricultural land use
- Subbasins S2 and S3—first order stream corridors >40% agricultural land use
- Schuylkill River corridor from Phoenixville to Reading experiencing greatest rate of growth of entire Schuylkill River corridor

Water Availability and Use

- Very low 1 in 25 year average annual baseflow in study subbasins
- Relatively high net ground water withdrawals—subbasins S1 and S2
- Relatively high volume of surface water discharges
- Relatively high volume of surface water withdrawals (water supply withdrawals supported by reservoir storage)
- Schuylkill River—quality of upstream wastewater discharges and NPS runoff impacts water quality at water supply intakes (algae, alkalinity, pH, salts, cryptosporidium, and pathogens)
- Several regional water supply intakes located in Schuylkill River at and downstream of Chester Co.
- Need to implement source water protection recommendations from Schuylkill River source water assessment
- All subbasins in study area included within DRBC GWPA

Runoff

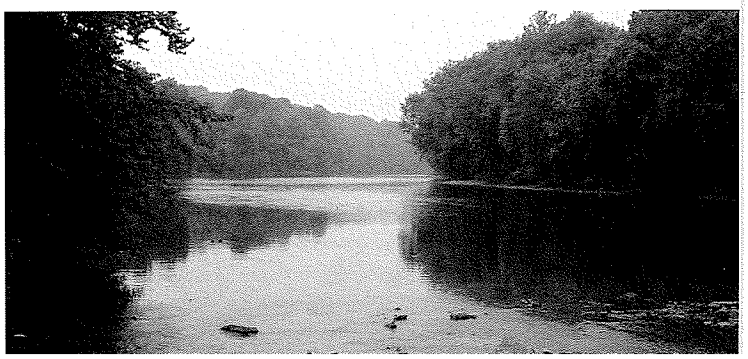
- >30%estimated impervious cover—subbasin S1
- >20% estimated impervious cover—subbasins S2, S5 and S6
- >10% estimated impervious cover—subbasin S4
- Subbasin S1—first order stream corridors >20% impervious cover
- Excessive average annual rainfall runoff—subbasins S1, S2, S4, and S5
- Excessive increase in average annual rainfall runoff by 2020—subbasin S1
- Streambank erosion—Meadowbrook Creek and Schuylkill River confluence
- Flooding—Kulp and Halteman Rds.; Wells Rd. north of Rt. 724; River Road
- No PA Act 167 Plan yet developed
- All municipalities within Schuylkill drainages subbasins required to comply with NPDES Phase II stormwater management regulations

Water Quality

- 40% of total stream miles listed as impaired on 303(d) list
- 303(d) listed—some segments (acid mine drainage, metals from industrial point sources, flow alteration from development, nutrients from agriculture)
- Some areas of relatively high levels of naturally occurring radon in ground water
- Relatively high soluble phosphorus and total lead concentrations in ground water from available water quality data
- Exploding populations of resident and migrating geese contributing to nutrients in reservoirs and streams
- Restoration of Black Rock silt basins
- Schuylkill River source water assessment has identified problems within Schuylkill River watershed including:
  - Alkalinity, conductivity, sodium, chloride, bromide, iron, manganese, total organic carbon, and turbidity have increased in the mainstem over the past decade
  - Increased solids, salts and metals believed to be from increased development, acid mine drainage, and deicing chemicals
  - Flow variability and nutrients are most common causes of impaired streams
  - 2 raw sewage discharges need to be eliminated (New Philadelphia and Middleport)
- Combined sewer overflows need to be reduced (i.e., Bridgeport and Norristown)

Regional Prioritizations

- Subbasin S1 ranked overall priority subbasin for water quality restoration, stormwater management, stream/resources preservation, and ground water management in Schuylkill River drainages



Stony Run Watershed

Resources to be Protected

- HQ streams (subbasin Stn)
- Low natural stream baseflow
- 53% of total stream miles are first order streams

Growth and Land Use

(none identified)

Water Availability and Use

- Very low 1 in 25 year average annual baseflow
- Watershed within DRBC GWPA

Runoff

- >10% estimated impervious cover
- Excessive estimated average annual rainfall runoff
- No PA Act 167 Plan yet developed
- Entire watershed municipalities required to comply with NPDES Phase II stormwater management regulations

Water Quality

- No streams listed as impaired on 303(d) list 303(d)
- Some segments and tributaries (siltation and flow variability from urban stormwater runoff)
- Relatively high annual volume of individual septic system discharges
- Widespread areas of relatively high levels of naturally occurring radon in ground water
- Relatively high soluble phosphorus concentrations in ground water from available water quality data
- Highest estimated NPS total suspended solids annual loading rate 1998

Regional Prioritizations

- Stony Run watershed ranked among highest overall priority watersheds for stream/resources preservation

Trout Creek Watershed

Resources to be Protected

- Large volume public water supply wells
- Carbonate aquifer underlies extensive portions of watershed
- 63% of total stream miles are first order streams

Growth and Land Use

- 79% of land area is developed
- >60% of land area in drainage areas to first order streams

Water Availability and Use

- High net ground water withdrawals 1998
- Projected 2020 net ground water withdrawals exceed withdrawal management target
- >60% of total stream miles are first order streams
- Watershed within DRBC GWPA

Runoff

- >30% estimated % impervious cover 1998
- >40% estimated % impervious cover 2020
- First order stream corridors >30% impervious cover
- Excessive average annual rainfall runoff
- Excessive increase in average annual rainfall runoff by 2020
- Flooding
- No PA Act 167 Plan yet developed
- Entire watershed required to comply with NPDES Phase II stormwater management regulations

Water Quality

- 3% of total stream miles listed as impaired on 303(d) list
- 303(d) listed—siltation and flow variability from urban stormwater runoff
- Highest estimated NPS annual loading rate for BOD COD TKN, TP, TSP, Zn 1998
- Widespread areas of high levels of naturally occurring radon in ground water

Regional Prioritizations

(none identified)

Valley Creek Watershed

Resources to be Protected

- EV watershed (entire watershed)
- Designated instream trout fishery
- Carbonate aquifer underlies extensive portions of watershed
- 1 historic bridge
- 2 PNDI sites
- Valley Forge National Historic Park and associated historic resources located at mouth of watershed
- 56% of total stream miles are first order streams
- 2 large instream wastewater

Growth and Land Use

- Rapid commercial and residential growth
- PA Turnpike, Rt. 30, and Rt. 202 highway corridors
- Expansion of highways and highway access for Rt. 202 and PA Turnpike underway

Water Availability and Use

- Artificial hydrology and baseflow conditions due to long term pumping and discharges from quarry operations
- Relatively high volume of surface water withdrawals (some offset by discharges from quarry operations)
- Need for wellhead protection plans for public water supply wells
- Headwaters of watershed are within DRBC GWPA

Runoff

- >20% estimated impervious cover 1998 and 2020
- First order stream corridors >20% impervious cover
- Excessive average annual rainfall runoff
- Flooding—Valley Forge National Historic Park; Valley Creek Rd; Ravine Road; Winthrop Bridge; Rt. 30 (near Clews Saab); Yellow Springs Rd from PA Turnpike runoff; Swedesford Rd.; Chesterbrook Blvd.; North Valley Rd.
- >200 locations of excessive erosion/sedimentation identified by Trustee Council for the Valley Creek restoration plan
- Carbonate geology prone to formation of sinkholes
- Need to protect Valley Forge National Historic Park from flooding, erosion and sedimentation
- PA Act 167 stormwater management plan to begin 2002
- Entire watershed municipalities required to comply with NPDES Phase II stormwater management regulations

Water Quality

- 33% of total stream miles listed as impaired on 303(d) list
- 303(d) listed—some segments and tributaries (metals, suspended solids, turbidity from unknown source, PCBs from industrial point sources)
- Relatively high concentrations of total lead in ground water
- USGS/Chester Co. biological monitoring indicates slightly to moderately impacted conditions
- Industrial and landfill sites exist within watershed that continue to impact water quality due to toxics residue
- Fish consumption advisory due to PCBs
- PCBs in substrate sediment

Regional Prioritizations

- Valley Creek watershed ranked among highest overall priority watersheds for water quality restoration and stormwater management

White Clay Creek Watershed

Resources to be Protected

- Subbasin WC4 and WC9—first order stream corridors >35% wooded and/or wetlands
- EV watershed (subbasin WC8)
- 2 public water supply intakes
- Offstream water supply storage impoundment
- Designated Federal Wild and Scenic River/Watershed
- 7 PNDI sites
- Carbonate aquifer underlies portions of watershed
- 1 historic bridge
- 55% of total stream miles are first order streams
- 2 large instream wastewater discharge

Growth and Land Use

- Subbasins WC7 and WC10 >80% of land area in drainage areas to first order streams
- Subbasins WC4 and WC5 >70% of land area in drainage areas to first order streams
- Subbasins WC1, WC4,WC6, WC8, and WC9 >60% of land area in drainage areas to first order streams
- Subbasin WC8—first order stream corridors >60% agricultural land use
- Subbasins WC3 and WC10—first order stream corridors >50% agricultural land use
- Rapid growth occurring in Chester Co. portions of watershed
- Relatively high volume of surface water withdrawals (water supply withdrawals supported by off-stream storage and tidal dam)
- Subbasin WC4 > 70% of total stream miles are first order streams

Water Availability and Use

- Subbasins WC1, WC4, WC6, WC8, and WC9 >60% of total stream miles are first order streams
- Need to address projected water supply demands in northern New Castle Co.
- Taste and odor compounds may affect water supply intakes
- Need for source water protection

Runoff

- >50% estimated impervious cover— subbasin WC2
- >30% estimated impervious cover— subbasin WC5
- >10% estimated impervious cover— WC1 and WC7
- Subbasin WC2— first order stream corridors >30% impervious cover
- Subbasin WC2— first order stream corridors >30% impervious cover
- Subbasins WC5 and WC6—first order stream corridors >20% impervious cover
- Excessive average annual rainfall runoff— subbasins WC2, WC5, WC6, and WC8
- Excessive increase in average annual rainfall runoff by 2020— subbasin WC2
- Streambank erosion—Broad Run near Watson Mill Rd.
- Flooding: Church Hill Rd.; London Tract Rd.; Rt. 896 and Parsons Rd.; Walker Rd.; Sharpless Rd. in preserve
- 2 PA municipalities required to comply with NPDES Phase II stormwater management regulations
- No PA Act 167 Plan yet developed

Water Quality

- 77% of total stream miles listed as impaired on 303(d) list
- 303(d) listed—some segments and tributaries (nutrients, dissolved oxygen and siltation in PA; bacteria, nutrients, zinc and PCBs in DE)
- Low flow TMDLs promulgated for N, P, and DO
- NPS TMDLs under development for N, P, sediment, and bacteria
- USGS/Chester Co. biological monitoring indicates slightly impacted conditions
- Zinc water quality criteria often exceeded in lower mainstem
- Widespread areas of relatively high levels of naturally occurring radon in ground water
- Elevated nutrients, bacteria, temperature and suspended solids, particularly in DE
- High nitrates in PA
- Relatively high mean COD, TP and dissolved P concentrations for watershed for available surface water quality data
- Relatively high nitrite/nitrate and total lead concentrations in ground water from available water quality data
- Expansion of Southern Chester County Regional Authority Landfill
- Gasoline contamination in ground water— London Grove Mobile Home Park
- Possible contaminated runoff into Somerset Lake

Regional Prioritizations

- White Clay Creek watershed ranked among highest overall priority watersheds for stream/resources preservation
- Subbasin W2 ranked overall priority subbasin for water quality restoration and stormwater management in White Clay Creek watershed
- Subbasin WC5 ranked overall priority subbasin for ground water management in White Clay Creek watershed
- Subbasin WC8 ranked overall priority subbasin for stream/ resources preservation in White Clay Creek watershed.

Glossary
of Terms and Acronyms

A

Algae
Simple, rootless plants that grow in bodies of water in relative proportion to the amounts of nutrients available. Blue-green algae are primitive algae, typically found in water high in phosphorus that form scum blooms that congregate at the water's surface. Diatoms are algae that have silica in their cell walls.

Algal Bloom
An unusual or excessive abundance of algae.

Aquifer
A geologic formation, group of formations, or part of a formation that contains sufficient saturated, permeable material to yield useful quantities of ground water to wells and springs.

B

Bacteria
Single celled organisms having no cellular nucleus. Pathogenic bacteria are capable of causing disease. Coliform bacteria are prolific in the intestines of warm blooded animals and are used as an indicator of fecal waste pollution.

Bankfull Depth
The mean water depth that occurs during a bankfull stream flow event.

Bankfull Discharge
The volume of stream flow that over time creates and/or maintains the shape, geometry, gradient and sinuosity (i.e. meander pattern) of the stream channel.

Bankfull Width
The mean water width that occurs during a bankfull stream flow event.

Baseflow
Portion of stream discharge derived from ground water; the sustained discharge that does not result from direct runoff or from water diversion, reservoir releases, piped discharges, or other human activities.

Benthic
Bottom terrain (generally submerged under water) of a surface water body, from shoreline to greatest depths.

Best Management Practices (BMPs)
Methods, measures or practices to prevent or reduce surface runoff and/or water pollution, including but not limited to, structural and non-structural controls, operation and maintenance procedures, other requirements and scheduling and distribution of activities.

BGY
Billion gallons per year.

Bioengineering
An applied science that combines structural, biological, and ecological concepts to the design, engineering and restoration of streams, lakes, and wetlands.

Biota
Animal, insect and plant life, collectively including flora and fauna of a specific habitat or region (such as aquatic biota).

BMP
Best management practice

BOD
Biological oxygen demand

Buffer
An area maintained in permanent vegetation and managed to reduce the impacts of adjacent land use.

C

CCCD
Chester County Conservation District

CCDCD
Chester County Department of Community Development

CCDES
Chester County Department of Emergency Services

CCHD
Chester County Health Department

CCPC
Chester County Planning Commission

CCPRD
Chester County Parks and Recreation Department

CCWRA
Chester County Water Resources Authority

CERCLIS
Comprehensive Environmental Response Compensation and Liability System

CFS
Cubic feet per second

Channelization
The practice of straightening a waterway to remove meanders in order to increase the volume and/or rate of discharge. Sometimes concrete is used to line the sides and bottom of the channel.

Clean Water Act
The Federal Water Pollution Control Act of 1948, amended beginning in 1956 to become the Federal Water Pollution Control Act of 1972. Congress passed the original Clean Water Act in 1972 and amended it with the Water Quality Act of 1987. The major impact of the 1987 amendments was to include a permitting process and requirements for municipal storm water discharges.

COD
Chemical oxygen demand

Cone of Depression
The depression of the water table or potentiometric surface caused by pumping from a well, wellfield, or surface water body within its area of influence.

Confluence
The point at which two streams join or intersect to form one single larger stream.

Conjunctive Use
Use of ground water and surface water supplies together to meet the water needs of an area to avoid over-reliance or over-withdrawal of either resource.

Cu
Copper

CWA
Clean Water Act

D

DE
Delaware

DE-DNREC
Delaware Department of Natural Resources and Environmental Control

Detention/Retention Basin
Impoundment constructed to detain/retain stormwater for extended periods of time and allow for the retention of pollutants in the pond through deposition of sediments and attached pollutants.

Discharge
1) Release of water at a given point into a water body. 2) The rate and volume of flow of water such as in a stream, generally expressed as cubic feet per second.

DMWA
Downingtown Municipal Water Authority

DO
Dissolved oxygen

Downcutting
Process of the stream channel bottom being rapidly and excessively eroded creating a deeply incised stream channel.

DRBC
Delaware River Basin Commission

DVRPC
Delaware Valley Regional Planning Commission

E

Ecosystem
The system formed by the interaction of a community of organisms with their environment.

Ecosystem Management
The careful and skillful use of ecological, economic, social, and managerial principles in managing ecosystems to produce, restore, or sustain ecosystem integrity and desired uses, products, and services over the long term.

EIA
Environmental impact assessment

EIS
Environmental impact statement

Ephemeral Stream
A stream or portion of a stream that flows only in direct response to precipitation. It receives little or no water from springs and no long-continued supply from melting snow or other sources. Its channel is at all times above the water table. The term may be arbitrarily restricted to streams which do not flow continuously during periods of one month.

Erosion
The wearing away of land surface by water or wind which occurs naturally from weather or runoff, but is often intensified by human activities.

ET
Evapo-transpiration

EV
Exceptional Value

Eutrophic
Habitats, particularly soils and water, that are rich in nutrients and plant growth. Eutrophic waters generally have high sedimentation at their bottoms. The lower levels of eutrophic waters have very low levels of dissolved oxygen.

Eutrophication
The aging process by which lakes, estuaries, or water bodies are fertilized with nutrients. Natural eutrophication changes the character of a lake or water body very gradually. Cultural eutrophication is the accelerated aging of a lake or water body resulting from human activities. The process by which nutrients increase in the water body, increasing algal growth. Then as algal blooms die off and fall to the bottom, their decay depletes the water body of dissolved oxygen, which in turn reduces the ability of the water body to support fish and other aquatic life.

Evapotranspiration
The total loss of water to the atmosphere by evaporation from land and water surface and by transpiration from plants.

Exotic (or invasive) Species
An organism that is out of its naturally occurring range and environment, and occupying the habitat of native species.

F

Filter Strip
A linear strip of land maintained to slow the velocity of runoff and filter sediment.

First Order Stream
Upper-most perennial tributary in a watershed that has not yet confluenced with another perennial stream. The confluence of two first order streams forms a "second" order stream.

Flooding
Occurs when the total volume of surface water runoff and baseflow entering a stream channel exceeds the capacity of the channel resulting in out-of-bank flow.

Floodplain
That portion of a stream valley adjacent to the channel that is created by erosion and sediment deposited from the stream and covered with water when the stream overflows its banks at flood stage. Also, the nearly level land situated on either side of a channel that is subject to overflow flooding.

Fluvial Geomorphology
The scientific study of the evolutionary processes of streams and the physical relationships between watershed runoff, streamflow, erosion, sedimentation, soils, geology, topography, and climate over time.

Forest
A descriptive classification of land type predominated by trees and woody vegetation and characterized by high structural diversity, greater than 25 percent canopy shading, and by the significant accumulation of organic duff on the soil surface.

G

Geomorphology
(See Fluvial Geomorphology)

GIS
Geographic information system

gpd
Gallons per day

Ground Water
Water that occurs in the subsurface and fills or saturates the porous openings, fractures and fissures of under-ground soils and rock units.

GWPA
Ground Water Protected Area

H

Habitat
A place where the physical and biological elements of ecosystems provide a suitable environment and the food, cover, and space resources needed for plant and animal livelihood.

Headwaters
The uppermost tributaries of a stream or river; often refers to first order streams.

HQ
High Quality

Hydrogeology
The science dealing with the relationship of subsurface water (or ground water) and geologic materials.

Hydrologic Function
The capacity of a stream to move or to store water, bedload material, and suspended sediment. Stream gradient, the resultant stream power and size of material are critical factors.

Hydrology
The study of the properties, distribution, circulation, and effects of water on the Earth's surface, soil, and atmosphere.

I

Impaired Stream
A stream or other surface water body determined by field assessment to no longer meet the state water quality standards for its designated protected use.

Impervious Surface
Ground cover that does not allow, or minimally allows, for infiltration of water (e.g., roofs, paved parking lots, and roads) and which increases the volume and speed of runoff after a rainfall.

Impoundment
Any lake, reservoir, pond or other containment of surface water occupying a bed or depression in the Earth's surface and having a discernible shoreline.

Infiltration
Movement of surface water into the soil, where it is absorbed by plant roots, evaporated into the atmosphere, or percolates downward to recharge ground water.

Intermittent Stream
A defined channel in which surface water is absent during a portion of the year, as ground water levels drop below the channel bottom.

in/yr
Inches per year

IWRP
Integrated Water Resources Plan

K

Karst
An area of irregular limestone in which erosion has produced fissures, sinkholes, underground streams, and caverns.

L

Large Woody Debris
A term used to describe logs, tree boles, rootwads, and limbs that are in, on, or near a stream channel.

lbs/yr
Pounds per year

Level Spreader
A low earthen berm constructed perpendicular to the direction of slope and extending across the width of the slope for the purpose of intercepting surface runoff and spreading it behind the berm to enhance infiltration and reduce erosion and runoff from the slope.

Loading
The total amount (generally measured in pounds or kilograms per acre per year) of material (sediment, nutrients, oxygen-demanding material, or other chemicals or compounds) brought into a lake, stream or water body by inflowing streams, runoff, direct discharge through pipes, ground water, the air (aerial or atmospheric deposition) and other sources over a specific period of time (often annually).

M

MCL
Maximum contaminant level

MD
Maryland

Meander
A circuitous winding or bend in the river.

MGD
Million gallons per day

mg/L
Milligrams per liter

mgy
Million gallons per year

MPC
Municipalities Planning Code

MTBE
Methyl Tert-Butyl Ether

N

National Pollutant Discharge Elimination System (NPDES)
Created in 1972 under the Clean Water Act to authorize discharges to local receiving waters only pursuant to government permits, in an effort to reduce point source and nonpoint source pollutants.

Native Species
A naturally occurring plant or other organism that is within its range and normal environment.

NO_2
Nitrite

NO_3
Nitrate

Nonpoint Source
Nutrient and pollution sources not discharged from a single point, e.g. runoff from agricultural fields, feedlots, residential lawns, septic leach fields, or urban streets, etc.

NPDES
National Pollutant Discharge Elimination System

NPS
Nonpoint source

NRCS
USDA Natural Resources Conservation Service

Nutrient
Elements or compounds essential to growth and development of living things (e.g., nitrogen, potassium, phosphorus).

O

O&M
Operation and maintenance

One in 25 (1 in 25) Year Average Annual Baseflow
Statistical value of the baseflow (or low flow conditions) of a stream averaged over a 12-month period that is expected to occur once in every 25 years.

P

PA
Pennsylvania

PADCNR
Pennsylvania Department of Conservation and Natural Resources

PADEP
Pennsylvania Department of Environmental Protection

PAFBC
Pennsylvania Fish and Boat Commission

Parts Per Million (PPM)
A common basis of reporting water analysis. One part per million (PPM) equals one pound per million pounds of water. One part per billion (PPB) equals one pound per billion pounds of water.

PAWC
Pennsylvania-American Water Company

Pb
Lead

PCB
Polychlorinated biphenyls

Perennial Streams
A defined channel containing surface water throughout the year.

PNDI
Pennsylvania Natural Diversity Index

Point Source
Originating from a discrete identifiable source or conveyance structure (i.e., pipe).

Pollution
The process of contaminating air, water and land with impurities to a level that is undesirable and results in a decrease in usefulness of the environment for beneficial purposes.

Polychlorinated Biphenyls (PCBs)
A group of at least 50 widely used compounds containing chlorine. PCBs can accumulate in food chains and are thought likely to produce a variety of harmful side effects, particularly during the reproductive cycle of plants and animals. Many are non-biodegradable.

Pool
Deeper areas of a stream with slow-moving water, often used by larger fish for cover.

Potable Water
Drinking water. Water whose chemical constituents do not exceed the limits set forth in state water quality standards for human consumption.

Potentiometric Surface
A surface which represents the pressure head in a confined or unconfined aquifer and is defined by the levels to which water will rise in a well that fully penetrates the aquifer.

PPB
Parts per billion

PPM
Parts per million

PSWC
Philadelphia Suburban Water Company

PUC
Pennsylvania Public Utilities Commission

Q

$Q_{7\text{-}10}$
Statistical value of baseflow (or low flow condition) of a stream averaged over a period of 7 consecutive days that is expected to occur once in every 10 years.

R

Recharge
The replenishment of ground water through the infiltration of rainfall, other surface waters, or land application of water or treated wastewater.

Recharge Area/Zone
An area (or zone) that, due to its pervious ground cover, karst topography, or permeability, contributes significantly to ground water recharge.

Retention
The prevention of direct discharge of stormwater runoff into receiving waters by temporary containment in a pond or depression; examples include systems which discharge by percolation to ground water, exfiltration, and/or evaporation processes and which generally have residence times of less than three days.

Retention Time
The length of time that water, nutrients, or other chemical substances remain in a lake, impoundment or standing pool.

Riffle
Shallow section of a stream or river with rapid current and a surface broken by gravel, rubble, or boulders.

Riparian
Pertaining to anything connected with or immediately adjacent to the banks of a stream or other body of water.

Riparian Forest Buffer
An area of trees, usually accompanied by shrubs and other vegetation, adjacent to a body of water and managed to maintain the integrity of stream channels and shorelines to 1) reduce the impact of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals, and 2) supply food, cover, and thermal protection to fish and other wildlife.

Riprap
Stones of varying size used to dissipate energy or stabilize a soil surface.

Runoff
Surface water (usually rainfall) that is not evaporated, transpired, used, or infiltrated into the ground water system, and thus flows over land to a surface water body.

S

Satellite System
A community water or wastewater system that serves a localized development or small community from a nearby or onsite source or disposal site, and does not rely on inter-connection to a larger regional system.

Scour
Local removal of soil, sediment, or other channel material from a streambed by flowing water.

Sediment
Fragmented material that originated from weathering rocks and decomposing organic material that is transported by, suspended in, and eventually deposited in the streambed.

Sedimentation
Occurs when sediment particles that have been suspended within flowing water are deposited on the stream bottom or floodplain.

Sheetflow
A flow process associated with broad, shallow water movement on sloping ground surfaces that is not channelized or concentrated.

Spring
A point where ground water emerges (or seeps out) onto the surface of the ground, often forming the beginning of a stream.

sq. mi.
Square mile(s)

SRBC
Susquehanna River Basin Commission

STORET
(Federal water database and archive)

Stormwater
Runoff water that results from a storm (usually rainfall) event.

Stream
Includes all rivers, creeks, brooks, tributaries and other flowing surface waters within a natural channel. More specifically, a perennial, intermittent, or ephemeral watercourse having a defined channel (excluding man-made ditches) which contains flow from surface and/or ground water sources during at least a portion of an average rainfall year.

Stream Discharge
Quantity of stream flow per unit of time, generally expressed as cubic feet per second (CFS).

Stream Order
A numerical system (ranking from headwaters to river terminus) used to designate the relative position of a stream or stream segment in a drainage basin.

Streambank
The portion of the channel cross-section that restricts lateral movement of water at normal water levels.

Swale
A depression or wide shallow ditch used to temporarily store, route, infiltrate, filter, or convey runoff.

T

TDP
Total dissolved phosphorus

TKN
Total Kjeldahl Nitrogen

TMDL
Total maximum daily load

TN
Total nitrogen

Total Maximum Daily Load (TMDL)
A regulatory process that determines the volume or quantity of a given pollutant, calculated by watershed computer modeling, that can be assimilated by a receiving stream or water body on an average daily basis while maintaining the state designated water quality standard and designated use of the water body. Where existing pollutant loads to the receiving water body are in excess of the calculated TMDL, the responsibility for reducing the excess pollutant loads is allocated among existing sources of the pollutant to achieve the reductions necessary to re-attain the designated use of the water body.

TP
Total phosphorus

Trophic State Index (TSI)
The trophic state index was developed in 1977 to provide a convenient measure of water quality. The scale is 1 to 100 and uses the three parameters of total phosphorus, chlorophyll-a and Secchi disk depth to categorize lake water quality.

TSS
Total suspended solids

TTHM
Trihalomethanes

Turbidity
Murkiness or cloudiness of water, indicating the presence of suspended sediments, dissolved solids, natural or man-made chemicals, algae, etc.

U

USDA
U.S. Department of Agriculture

USEPA
U.S. Environmental Protection Agency

USGS
U.S. Geological Survey

V

VOC
Volatile organic compounds

VPP
Vision Partnership Program

W

Water Budget
An accounting of the movement of water through the components of the hydrologic cycle in a watershed, including precipitation, evapo-transpiration, surface runoff, ground water recharge, and ground water discharge to stream baseflow.

Water Quality
A state of water represented by a combination of productivity, chemistry, cleanliness and recreational potential.

Water Table
The upper-most level of saturation of pore space or fractures by subsurface water in an aquifer.

Watershed
1) An area of land that drains into a particular river or body of water; usually divided by topography or ridgelines. 2) The total area of land above a given point on a waterway that contributes surface runoff and ground water to the flow at that point. 3) A drainage basin or a major subdivision of a drainage basin.

Watershed Management
Coordinated assessment and characterization of watershed conditions, and planning and implementation of strategies, approaches, tools, and techniques to protect and enhance the quality and quantity of water resources while achieving desired land and water uses.

Wetlands
Low-lying areas inundated or saturated by water at a frequency and duration sufficient to support wetland vegetation (e.g. wetlands include such areas as swamps, marshes and wet meadows). Wetlands remove pollutants through a series of chemical, physical and biological mechanisms.

WMM
Watershed Management Model

Z

Zn
Zinc

Zoning
The practice of dividing land into regions or parcels pertaining to its use or activities within it.

Sources
Scott County MN, Community Development, Division of Water Planning, updated August 2000, used with permission;

Chester County, Pennsylvania Water Resources Compendium, Chester County Water Resources Authority, 2001.

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