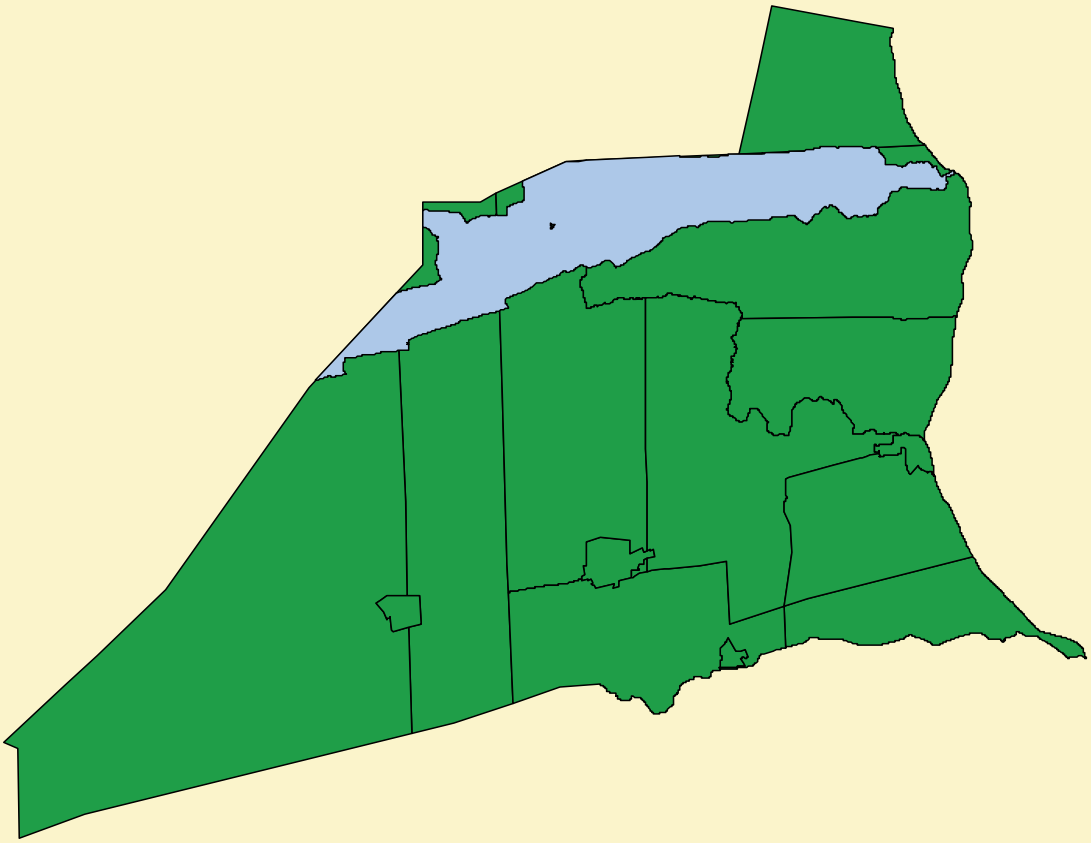
White Deer Watershed
Act 167
Stormwater Management Plan

June 2003



Prepared by Union County
in conjunction with

Union County Courthouse

Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

The preparation of the White Deer Stormwater Management Plan has been funded in part by a grant from the Pennsylvania Department of Environmental Protection Bureau of Watershed Conservation.

WHITE DEER CREEK WATERSHED

ACT 167

STORMWATER MANAGEMENT PLAN

Prepared by Union County Planning Commission
in Conjunction with
Herbert, Rowland & Grubic, Inc.

June 2003

Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

369 East Park Drive
Harrisburg, PA 17111
(717) 564-1121
www.hrg-inc.com

©Herbert, Rowland & Grubic, Inc., 2003

WHITE DEER CREEK WATERSHED

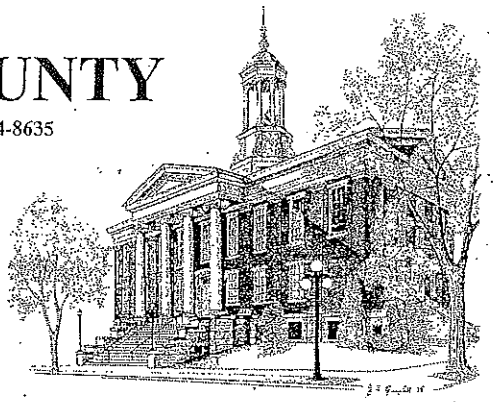
ACT 167

STORMWATER MANAGEMENT PLAN

JUNE 2003

COMMISSIONERS OF UNION COUNTY

103 SOUTH SECOND STREET – LEWISBURG, PENNSYLVANIA 17837-1996 • 570/524-8686 • FAX: 570/524-8635



County Commissioners
W. Max Bossert, *Chairman*
Robert O. Brouse, Jr., *Vice Chairman*
Harry A. VanSickle, *Secretary*

Solicitor
Andrew D. Lyons

County Administrator/Chief Clerk
Patricia P. Nace

RESOLUTION NO. 2003-15

The Board of Commissioners of Union County, Pennsylvania hereby determines that:

WHEREAS, the County of Union recognizes that the inadequate management of accelerated stormwater runoff resulting from development throughout a watershed increases flood flows and velocities, contributes to erosion and sedimentation, overtaxes the carrying capacity of existing streams and storm sewers, greatly increases the cost of public facilities to convey and manage stormwater, undermines floodplain management and flood reduction efforts in upstream and downstream communities, reduces groundwater recharge, and threatens public health and safety; and

WHEREAS, the County of Union understands that a comprehensive program of stormwater management, including reasonable regulation of development and activities causing accelerated erosion, is fundamental to the public health, safety, welfare, and the protection of the people of Union County and all people of the Commonwealth, their resources, and the environment; and

WHEREAS, the County of Union seeks to fully comply with ACT 167 of 1978, the Pennsylvania Stormwater Management Act, which requires counties to prepare and adopt a watershed stormwater management plan for each designated watershed within its jurisdiction.

NOW, THEREFORE, BE IT RESOLVED by the Union County Board of Commissioners that this resolution represents a formal declaration of support for the adoption of the White Deer Creek Watershed Stormwater Management Plan including all text, maps, and technical documentation and appendices.

Adopted this 17th day of June 2003 by the hands and seal set forth.

Union County Commissioners

W. Max Bossert, Chairman

Robert O. Brouse, Jr., Vice Chairman

Harry A. VanSickle, Secretary

ATTEST:

Patricia P. Nace, Chief Clerk

Table of Contents:

Section 1 – Introduction **1**
1.0 Introduction ... 1
1.1 Stormwater Runoff – Its Problems and Its Solutions ... 1
Section 2 – Act 167 Watershed Level Stormwater Management Planning & Implementation **2**
2.0 The Pennsylvania Stormwater Management Act, Act 167 ... 2
2.1 Plan Preparation Strategy ... 3
Stage A - Data Collection and Analysis ... 4
Stage B - Technical Analysis ... 5
Stage C – Public/Municipal Participation ... 6
Stage D - Plan Preparation and Implementation ... 7
Section 3 - White Deer Creek Watershed Characteristics **9**
3.0 General Description ... 9
3.1 Political Features ... 9
3.2 Natural Features ... 10
3.3 Hydrology ... 11
3.4 Existing Stormwater Drainage Problem Areas ... 11
3.5 Suggested Solutions ... 12
3.6 Problem Area Remediation approach ... 12
3.7 Significant Obstructions ... 13
3.8 Designation of Stormwater Hotspots ... 14
Section 4 – Watershed Technical Analysis – Modeling **16**
4.0 Hydrologic Model ... 16
4.1 Modeling Results & Release Rates ... 16
4.2 Reservoir Modeling ... 17
Section 5 – Technical Standards and Criteria for Control of Stormwater Runoff **19**
5.0 Introduction ... 19
5.1 Water Quality Volume (WQ_v) ... 19
5.2 Recharge Volume Requirements (Re_v) ... 22
5.3 Channel Protection Storage Volume Requirements (Cp_v) ... 24
5.4 Overbank and Extreme Event Flood Protection Requirements (Release Rates) ... 28
5.5 Design Example: Computing Stormwater Storage Volumes ... 29
Section 6 – Runoff Control Techniques and Their Efficiencies **34**
6.0 Acceptable Urban Best Management Practices (BMP) Options ... 34
Section 7 – Municipal Handbook **36**
7.0 Introduction - Why Stormwater Matters ... 36
7.1 Declining Water Quality ... 37
7.2 Intent of the Act 167 Plan ... 37
7.3 Suggested Best Management Practices ... 37
7.4 BMP Maintenance ... 38
7.4.1 Overview of BMP Maintenance ... 39
7.4.2 Routine Maintenance Needs ... 40
7.4.3 Nonroutine Maintenance ... 41
7.4.4 Maintenance Responsibilities ... 43
7.4.5 Estimating Routine Costs ... 44
7.4.6 Estimating Nonroutine Costs ... 44
7.4.7 Planning Ahead ... 44
7.4.8 Access for Maintenance ... 44
7.4.9 Maintenance Agreements ... 45
7.5 Effective Site Planning ... 45

7.5.1 Some Important Principles of Effective Site Planning 45
7.5.2 Resources for Identifying and Mapping Sensitive Areas 46
7.5.3 Important Functions of Sensitive Areas and How They are Best Protected 47
7.5.4 Preserving Natural Hydrologic Conditions 48
7.5.5 Reducing or Disconnecting Impervious Surface Areas 49
7.5.6 Preserving Natural Drainage Features 50
7.5.7 Protecting Natural Depression Storage Areas 50
7.6 Site Planning and Land-Use Techniques to Minimize Efforts of Development 50
7.6.1 Setbacks and Buffers 51
7.6.2 Cluster Development 52
7.6.3 Zoning Restrictions 53
7.6.4 Conservation Easements 53
7.6.5 Development Designed to Fit Site Topography 53
Section 8 – Plan Review Adoption and Updating Procedures 54
8.0 Plan Review and Adoption 54
8.1 Procedure for Updating the Plan 55
Section 9 – Priorities for Implementation of Technical Standards and Criteria 57
9.0 Summary of Plan Conclusions and Recommendations 57
Section 10 - Model Act 167 Stormwater Management Ordinance 58

Tables:

Table 2.0 - Existing Municipal Ordinance Matrix, White Deer Creek Watershed 4
Table 2.1 - White Deer Creek Watershed Plan Advisory Committee (WPAC) 6
Table 2.2 - White Deer Creek Watershed Municipal Engineer's Committee (MEC) 7
Table 2.3 - White Deer Creek Watershed Legal Advisory Committee (LAC) 7
Table 3.0 - Municipalities Lying Within The Watershed 9
Table 3.1 - Classification of Stormwater Hotspots 15
Table 4.0 - Storage – Outflow Information 18
Table 4.1 - Reservoir Flow Information 18
Table 5.0 - Summary of the Watershed-Wide Stormwater Criteria 19
Table 7.0 - Summary of BMP Descriptions 38
Table 7.1 - Components of a Maintenance Program 39
Table 7.2 - Inspection Checklist 41

Figures:

Figure 5.0 - Relationship Between Impervious Cover and Water Quality Volume 20
Figure 5.1 - Relationship Between Re_v and Site Impervious Cover 23
Figure 5.2 - Example of Conventional Stormwater Detention Pond 26
Figure 5.3 - Design Example: The Meadows 30
Figure 7.0 - Water Balance at a Developed and Undeveloped Site 36

Plates:

1. White Deer Creek Watershed
2. Hydrologic Soils
3. Stormwater Problem Areas
4. White Deer Subwatersheds
5. Significant Obstructions
6. Existing Land Use
7. Future Land Use
8. Limestone Areas
9. Flood Zones & Wetlands

Appendices:

A Review of Related Documents
B Review of Existing Municipal Ordinances
C Union County Rainfall Data
D Stormwater Credits for Effective Site Planning
E Computation of Peak Discharge for Water Quality Storm
F Computation of Channel Protection Storage Volume
G Watershed Data and Release Rate Computations
H Stormwater Problem Areas and Possible Solutions

KEY SYMBOLS AND ACRONYMS USED IN THE PLAN

A – Drainage Area
Ao – Orifice Area
BMP – Best Management Practice
cfs – Cubic Feet per Second
CN – Curve Number
Cp_v – Channel Protection Storage Volume
DEP – Pennsylvania Department of Environmental Protection
do – Orifice Diameter
ED – 24 Hour Drawdown of the Water Quality Volume
EPA – Environmental Protection Agency
FIA – Federal Insurance Administration
FEMA – Federal Emergency Management Agency
GIS – Geographic Information System
HEC-HMS – Hydrologic Engineering Center Hydrologic Modeling System
HSG – Hydrologic Soil Group
I – Percent Impervious Cover
Ia – Initial Abstraction
LAC – Legal Advisory Committee
MEC – Municipal Engineer's Committee
NPDES – National Pollutant Discharge Elimination System
NRCS – Natural Resource Conservation Service (previously SCS)
NWI – National Wetlands Inventory
P – Precipitation Depth
PENNDOT – Pennsylvania Department of Transportation
PSP – Project Study Plan
PUD – Planned Unit Development
Qa – Post Development Runoff Depth
q_i – Peak Inflow Discharge
q_o – Peak Outflow Discharge
q_u – Unit Peak Discharge
Re_v – Recharge Volume
R_v – Volumetric Runoff Coefficient
S – Soil Specific Recharge Factor
SCS – Soil Conservation Service
T – Lag Time
t_c – Time of Concentration
TDR – Transfer of Development Rights
TR-20 – Technical Release No. 20 Project Formulation-Hydrology, Computer Program
TR-55 – Technical Release No. 55 Urban Unit Hydrology for Small Watersheds
UCPC – Union County Planning Commission
USDA – United States Department of Agriculture
USGS – United States Geological Survey
V_r – Volume of Runoff
V_s – Volume of Storage
V_t – Total Volume
V_v – Volume of Voids
WPAC – Watershed Plan Advisory Committee
WQ_v – Water Quality Storage Volume

WHITE DEER CREEK WATERSHED
ACT 167
STORMWATER MANAGEMENT PLAN

Section 1 – Introduction

1.0 Introduction

This plan has been created for the White Deer Creek Watershed in Union County, Pennsylvania, and is intended to comply with the Pennsylvania Stormwater Management Act, Act 167, of 1978. The White Deer Creek Watershed is located in northern Union County and encompasses portions of northeastern Centre County and southern parts of Clinton and Lycoming Counties. The watershed consists of approximately 46.6 square miles draining eastward from the Bald Eagle State Forest in the western part of the watershed to its confluence with the West Branch of the Susquehanna River near the Village of White Deer. The focus of this plan is to create and implement a watershed-wide set of standards and criteria to manage stormwater runoff.

1.1 Stormwater Runoff – Its Problems and Its Solutions

The water that runs off the land into surface waters during and immediately following a rainfall event is referred to as stormwater. In a watershed undergoing urban expansion, the volume of stormwater resulting from a particular rainfall event increases because of the reduction in pervious land area (i.e., natural land being covered by pavement, concrete, or buildings). That is, the alteration of natural land cover and land contours to residential, commercial, industrial, and even agricultural uses results in decreased infiltration of rainfall and an increased rate and volume of runoff.

As development has increased, so has the problem of dealing with the increased quantity of stormwater runoff. Failure to properly manage this runoff has resulted in greater flooding, stream channel erosion and siltation, as well as reduced groundwater recharge and degradation of water quality. This process occurs every time the land development process causes changes in land surface conditions.

Frequently individual land development projects are viewed as separate incidents, and not necessarily as an interconnected hydrologic and hydraulic system. This school of thought is exacerbated when the individual land development projects are scattered throughout a watershed (and in many different municipalities). However, it is has been observed and verified that the cumulative nature of individual land surface changes dramatically influences flooding conditions. This cumulative effect of development in some areas has resulted in flooding of both small and large streams with property damages running in the millions of dollars and even causing loss of life. Therefore, given the distributed and cumulative nature of the land alteration process, a comprehensive (i.e., watershed-level) approach must be taken if a reasonable and practical management and implementation approach and/or strategy are to be successful.

Section 2 – Act 167 Watershed Level Stormwater Management Planning & Implementation

2.0 The Pennsylvania Stormwater Management Act, Act 167

The Pennsylvania Stormwater Management Act, Act 167 of 1978, provides the framework for improved management of the storm runoff impacts associated with the development of land. The purposes of the Act are to encourage the sound planning and management of storm runoff, to coordinate the stormwater management efforts within each watershed, and to encourage the local administration and management of a coordinated stormwater program.

Prior to adoption of the original Act 167 Plan, stormwater management decisions were made at the municipal level through enforcement of local ordinances based upon whatever storm runoff control philosophy each of the local municipalities opted to use. Because this fragmented system does not allow for or require analysis of impacts beyond municipal boundaries, adequate runoff control at-site in one municipality could have a detrimental impact on a municipality downstream. The Act 167 Plan includes an evaluation of how sites relate to the entire watershed in terms of the timing of peak flows; contribution to peak flows at various downstream locations and the impact of the additional runoff volume generated by development of sites. To effectively implement an Act 167 stormwater management plan it is necessary to understand the following strengths and limitations of the process:

Strengths

- An Act 167 Plan provides a watershed-wide analysis of runoff impacts associated with new land development to address the needs of all watershed municipalities.

- An Act 167 Plan provides engineering standards for individual site evaluation and design in a model ordinance applicable to all watershed municipalities.

- An Act 167 Plan retains the decision-making authority at the municipal level for approval of drainage designs as part of the subdivision and land development process.

- An Act 167 Plan provides standards to help ensure that peak runoff flows throughout the watershed will not increase with development to help prevent the creation of new problem areas or the worsening of existing problems.

Limitations

- An Act 167 Plan establishes a process for decision-making. It establishes the existing interrelationships between the various parts of a watershed in terms of peak flows and the "timing" of those peak flows. The peak flows and timing relationships provide for development of a runoff control philosophy geared towards minimizing the storm runoff impacts of new development.

- Storm runoff criteria are based on controlling "design" storm events applied uniformly over the entire watershed. Natural storms, which may vary in duration, intensity, total depth of rainfall throughout the watershed and pre-storm conditions such as frozen ground and snow or ice accumulation, may, in certain instances, create runoff events that cannot be effectively controlled.

- The runoff control standards developed, as part of an Act 167 Plan, will not correct existing drainage related problem areas.

- An Act 167 Plan will not prevent the inundation of floodplain areas. These areas are intended by nature to carry storm runoff. The backwater from a river or stream causes inundation of floodplain areas. The stormwater management methods developed as part of this Act 167 Plan are not intended to identify or mitigate this type of flooding.

- An Act 167 Plan is not a land use plan. Runoff controls developed in the Plan are not based upon controlling the location, type, density or rate of development throughout the watershed. The stormwater runoff performance standards are based on the assumption that development will occur throughout the watershed. The Plan is designed to provide for new development as indicated in future land use scenarios yet control the associated storm runoff impacts.

Act 167 is essentially a three-step process of runoff control which works as follows:

1. Documentation of the existing state of storm runoff in the study area. Included herein is the documentation of the existing physical characteristics of the study area (e.g., land use, soils, slopes, storm sewers, etc.), documentation of existing storm drainage problems and flow obstructions, and documentation of the peak flow and timing relationships. The existing condition establishes the baseline situation against which all runoff control measures will be judged.

2. Preparation of the Plan to control storm runoff from new development. The Plan includes runoff control performance standards for new development *and* a process for site specific evaluation and design. The performance standards do not dictate the control methods to be used but rather will indicate the necessary end product. The runoff control philosophy is designed to prevent new problem areas from developing.

3. Development of priorities for implementation. With the accomplishment of the first two aspects of the Act 167 process, the third aspect involves developing a prioritized list of actions aimed at improving the current state of storm runoff in the study area. Essentially this means preparing a strategy for dealing with the existing storm drainage problem areas within each municipality.

One especially important aspect of the Act 167 process is the need to periodically update the Plan. Act 167 specifies that a Plan must be updated every five years. This guarantees a dynamic system of runoff control sensitive to changing study area characteristics.

2.1 Plan Preparation Strategy

The "White Deer Creek Watershed - Act 167 - Stormwater Management Plan" has been prepared for Union County by Herbert, Rowland & Grubic, Inc. in an attempt to comply with the strategy outlined in the Act 167 Stormwater Management Plan - Phase 1 - Scope of Study, dated August 14, 2000. This Plan preparation strategy is a four-stage process that includes the following:

Stage A: Data Collection and Analysis
Stage B: Technical Analysis

Stage C: Public/Municipal Participation
Stage D: Plan Preparation and Implementation

Stage A - Data Collection and Analysis

A.1 - Data Collection/Review/Analysis

This task involved the necessary efforts to gather, review and analyze the required data to complete the technical and institutional planning steps for the White Deer Creek Act 167 Watershed Stormwater Management Plan. The data that was collected included existing municipal ordinances, related studies, soils, geologic, flow obstruction, rainfall, etc.

A comprehensive review of related documents was performed and a coordinated list of the goals and objectives from each of the project documents was developed (Appendix A). In addition, a municipal survey and field observations were reviewed for data relevant to problem areas and significant obstructions located within the watershed.

A.2 - Municipal Ordinance Reviews/Evaluations

This task involved the detailed review of the municipal ordinances in order to prepare a municipal ordinance comparison matrix. This matrix, as depicted in Table 2.0, is intended to display, for both the actual preparation of the implementation plan and also for the municipal education process, the current stormwater management provisions in the various municipal ordinances for all watershed-municipalities. The objective of the matrix is to easily and effectively display the similarities and differences, as well as the consistency/inconsistency, between the various municipal ordinances in the watershed. The matrix was used to develop ordinance provision recommendations, for the various municipalities, that are based on the standards and criteria developed in the Plan. For a detailed review of existing Municipal Ordinances see Appendix B.

Table 2.0 - Existing Municipal Ordinance Matrix, White Deer Creek Watershed

Municipality	Zoning	Floodplain	Subdivision & Land Development	Within Subdivision & Land Development			
				Stormwater	Floodplain	Road	E&S
Gregg Twp.	Yes, 1990	Yes, 1988	Yes, 1991	Sect 4.15	Sect 4.17	Sect 4.5-4.7	Sect 4.16
Hartley Twp.	Yes, 1996	Yes, 1988	County, 1990	---	---	Sect 422-426	Sect 480.3
Lewis Twp.	No	Yes, 1987	County, 1990	---	---	Sect 422-426	Sect 480.3
West Buffalo Twp.	Yes	No	County, 1990	---	---	Sect 422-426	Sect 480.3
White Deer Twp.	Yes, 1999	Yes, 1979	Yes, 1990	Sect 4.15	Sect 4.17	Sect 4.5-4.7	Sect 4.16
Washington Twp.	County	Yes	Yes	Sect 4.15	Sect 7.07	Sect 4.03	Sect 7.08
Greene Twp.	Yes	No	Yes				
Miles Twp.	No	Yes	County, 1990	---	---	Sect 422-426	Sect 480.3

A.3 - Data Preparation For Technical Analysis

This task involved the engineering work necessary to compile the information collected under Task A.1 into a geographic information system (GIS) that was used for the technical tasks. Included was the preparation of “land characteristics” GIS data layers for modeling and display purposes.

In addition, Task A.3 involved the delineation of subwatersheds for use in the development of a hydrologic model of the White Deer Creek Watershed. The subwatersheds were delineated based on major tributary drainage courses, natural drainage divides, significant obstructions, and other points of interest. Field reconnaissance was also used to confirm the limits of the watershed and locations of drainage divides.

Stage B - Technical Analysis

The technical analysis involved developing a strategy to manage stormwater runoff from new land development. Since stormwater runoff has a direct impact on flooding, water quality and groundwater recharge, this analysis considers the following objectives:

- Implement non-point source pollution removal methodologies
- Maintain groundwater recharge
- Reduce channel erosion
- Manage overbank flood events
- Manage extreme flood events

These objectives are accomplished under Subtasks B.1 to B.4.

B.1 - Evaluate Water Quality Requirements

1. Rainfall records were analyzed to identify a rainfall depth that produces 90% of an annual runoff volume.

2. Water quality volume computational methodology was developed.

B.2 - Groundwater Recharge/Infiltration Requirements

1. Hydrologic soil groups and geology as well as natural and man-made features within watershed were analyzed to determine general areas of suitability for infiltration practices.

2. Computational methodology for recharge and infiltration was developed.

B.3 - Streambank Erosion Requirements

1. Streambank erosion standards were developed in the form of channel protection volume computation methodology.

B.4 - Overbank and Extreme Event Requirements (Release Rates)

1. Hydrologic modeling, quantitative computations and evaluations were developed to analyze runoff characteristics of the watershed under existing and future conditions. It also established the release rates for the 2-, 5-, 10-, 25-, 50- and 100-year events.

B.5 - Compilation of All Technical Standards

1. Standards and criteria were developed for various types of land development activities. These standards provide for the application of best management practices for the implementation of stormwater control measures.

B.6 - Implementation of Technical Standards and Criteria

1. A model stormwater ordinance (Section 10) was developed to effectively implement the stormwater management standards and criteria developed by this plan.

Stage C – Public/Municipal Participation

Coordination efforts and activities continued throughout the duration of the project and were organized to include the necessary meetings.

Three committees were established to educate and solicit input and comment from the public, municipal governments (elected officials, engineers and solicitors) and other interest groups such as watershed associations. These committees are: 1) Watershed Plan Advisory Committee (WPAC); 2) Municipal Engineers Committee (MEC); and 3) Legal Advisory Committee (LAC). Due to the large area of the watershed that is covered by state forest and small land area in some municipalities there was limited participation in the WPAC, MEC, and LAC from these areas.

The WPAC consists of representatives from each municipality in the watershed as well as the Conservation District and interest groups (watershed associations, for example). The WPAC meetings were held to provide education on the planning process to elected municipal officials, conservation district and interest groups, in addition to receiving advice from the municipal officials to assure the Plan fits the needs of the municipalities.

Table 2.1 - White Deer Creek Watershed Plan Advisory Committee (WPAC)

Name	Municipality/Organization
Rick Bair	Miles Township
Mary Ann Bower	Clinton County Conservation District
Ralph E. Brungart	Greene Township
Tom Corbett	Lycoming County Conservation District
Robert B. Donaldson	Centre County Planning Office
Larry Gearhart	White Deer Township Resident
A.J. Golfieri	White Deer Township Resident
H. Jerome Grafius	White Deer Township Resident
Sally Heckert	White Deer Township Resident
Ralph Hess	White Deer Township
Cathy Hill	Washington Township
Tim Holladay	Clinton County Planning Department
Robert & Clovis Hunter	White Deer Township Resident
Eugene Kahley	Hartley Township
James Kendter	Pennsylvania Department of Transportation
Julie Kinter	White Deer Township Resident
Durla Lathia	Pennsylvania Department of Environmental Protection
Lynn Manahan	Pennsylvania Department of Environmental Protection
Van McBryan	White Deer Creek Watershed Association

Kevin McJunkin	Lycoming County Economic Development & Planning
Park Messimer	White Deer Township Resident
Larue & Betty Myers	White Deer Township Resident
Dale Nonmaker	White Deer Creek Watershed Association
Ken Permar	White Deer Township
Lake Randall	Mid-Penn Engineering Incorporated
Ted Retallack	Union County Conservation District
Harold Rudy	Miles Township
Henry Sanders	Lewis Township
Joan Sattler	Pennsylvania Department of Environmental Protection
Robert Schnitzler	PA American Water Company
Larry Seibert	White Deer Township
Robert Sweitzer	Centre County Conservation District
Bob Valentine	West Buffalo Township
Jerry Walls	Lycoming County Economic Development & Planning
Rob & Daniel Zettelmoyer	White Deer Township Resident

The Municipal Engineers Committee (MEC) consisted of the municipal engineer from each municipality within the Watershed (and any invited engineering, technical or scientific individuals). The MEC provided a technical forum to assist the County and Consultant during the preparation of the technical portions of the Plan by evaluating watershed modeling, water quality efforts and establishing overall technical standards.

Table 2.2 - White Deer Creek Watershed Municipal Engineer's Committee (MEC)

Municipality/Organization	Name
White Deer & Hartley Townships, Union County	Lake Randall

The Legal Advisory Committee (LAC) includes the solicitors representing municipalities in the watershed. A meeting with the LAC was convened to educate the municipal solicitors on the ordinance adoption and implementation requirements of the Plan and to receive comments and direction in the finalization of the model ordinance.

Table 2.3 - White Deer Creek Watershed Legal Advisory Committee (LAC)

Municipality/Organization	Name
White Deer Township	Peter Matson

A municipal official's handbook, tailored to the watershed, was developed to provide guidance for municipalities to implement innovative stormwater management and best management practices. Included in this handbook is methodology to implement nonstructural stormwater management measures including conservation planning. Since facility maintenance is always a concern to municipal officials, maintenance provisions for these practices is included in this handbook.

Stage D - Plan Preparation and Implementation

D.1 - Plan Report Preparation

The general framework for the White Deer Creek Act 167 Plan has been developed from various sources, namely Act 167 itself, the DEP Stormwater Management Guidelines, The Pennsylvania Handbook of Best Management Practices for Developing Areas, and the 2000 Maryland Stormwater Design Manual. The basic methodology used to quantify the watershed rainfall-runoff response and to develop the runoff control criteria for new development has been adapted to the White Deer Creek Watershed from the above referenced documents. As part of the development of the White Deer Creek Plan, the Union County Planning Commission (UCPC) has used the Geographic Information System (GIS) and ArcInfo Software. The existing land use data was digitized into the UCPC system. Land use, soils and zoning coverages were also used in the watershed modeling process.

Section 3 - White Deer Creek Watershed Characteristics

3.0 General Description

The White Deer Creek Watershed is situated in northern Union County and encompasses portions of northeastern Centre County and southern parts of Clinton and Lycoming Counties in north-central Pennsylvania. The watershed encompasses approximately 46.6 square miles. A general watershed map is presented as Plate 1. The major tributaries to White Deer Creek include: Tunis Run, Sand Spring Run, Mile Run, Lick Run, and Kettle Hole. White Deer Creek flows in an easterly direction and empties into the Susquehanna River.

The major routes in the White Deer Creek Watershed include Interstate 80, US Route 15, S.R. 1010 and White Deer Creek Road. Interstate 80 enters the watershed in White Deer Township and passes through the watershed for approximately 13 miles east to west, then exits through Lewis Township. Interstate 80 runs parallel to White Deer Creek but crosses it in White Deer Township. Interstate 80 crosses Lick Run in White Deer Township and Mile Run in West Buffalo Township. S.R. 1010 (Sugar Valley Narrows Road/White Deer Pike) parallels Interstate 80 along White Deer Creek and Sand Spring Run. White Deer Creek Road parallels White Deer Creek from the confluence with Sand Spring Run to McCall Dam State Park in the western end of the watershed. US Route 15 runs north-south for approximately seven tenths of a mile. US Route 15 crosses White Deer Creek in White Deer Township.

Land use in the watershed is primarily forestland, and agriculture (cash crops, forage crops, and pasture). The Bald Eagle State Forest encompasses almost the entire Western two thirds of the watershed, however there are some small portions of the Tadaghton State Forest along the northern edge of the watershed. The majority of the agricultural activity exists in the eastern portion of the watershed. There are some pockets of developed area primarily adjacent to S.R. 1010 Sugar Valley Narrows Road/White Deer Pike, with mixed commercial and residential use in and around the US Route 15 corridor.

3.1 Political Features

The majority of the watershed is contained within Union County; however, portions of the watershed are also located in Centre, Lycoming, and Clinton Counties. Portions of the following municipalities are within the White Deer Creek Watershed as indicated in Table 3.0.

Table 3.0 - Municipalities Lying Within The Watershed

Municipality	Approximate Area In Watershed (sq. miles)	Percent of Watershed (percent)
Gregg Township	0.08	0.2
Hartley Township	1.67	3.7
Lewis Township	6.79	14.9
West Buffalo Township	7.09	15.6
White Deer Township	18.70	41.0
Miles Township	9.14	20.0
Greene Township	0.56	1.2
Washington Township	1.53	3.4

The townships are of the 2nd Class and employ the township supervisor style of government.

3.2 Natural Features

The White Deer Creek Watershed is located in the Northern Appalachian Mountain section of the Valley and Ridge Physiographic Provinces. Narrow valleys surrounded by steep mountains characterize the terrain of the basin. The elevations within the watershed vary from a minimum of approximately 450 feet at the confluence of the Susquehanna River and White Deer Creek up to a maximum of approximately 2100 feet above sea level along the periphery of the watershed. Due to the terrain the main stream, White Deer Creek, runs through the valley with many small tributaries feeding it from the steep mountains that line the periphery of the watershed. The section of the watershed east of Interstate 80 is significantly less mountainous and is typical of the broad, flat, floodplains of the West Branch of the Susquehanna River.

Soils are grouped into individual soil series as well as soil associations. Soil associations are groups of soils that exhibit a regularly repeating pattern. There are five soil associations in the White Deer Creek Watershed**.** These Soil associations are described as follows:

- Hazlelton-Dekalb-Buchanan - This association consists of nearly level to steep, deep, well drained and moderately well drained soils on mountain side slopes and foot slopes; formed in colluvial material weathered from sandstone and some shale.

- Berks-Weikert-Bedington - This association is gently sloping to steep, shallow to deep, well drained soils on hills and ridges; formed in material weathered from shale and some sandstone.

- Chenango-Pope-Holly - The Chenango-Pope-Holly soils cover nearly level to gently sloping, deep, very poorly drained to moderately well drained soils on floodplains and terraces; formed in alluvial material.

- Allenwood-Watson-Alvira - These soils are nearly level to moderately steep, deep, and well drained, somewhat poorly drained, and poorly drained soils on uplands; formed in material weathered from glacial till.

The United States Soil Conservation Service (SCS) has defined four basic groups of soils having similar hydrologic properties which directly influence the volume and rate of stormwater runoff. The hydrologic soils groups are defined as follows:

Group A	Soils having a high rate of infiltration, even when thoroughly wetted, and consisting chiefly of deep, well to excessively drained sands or gravels.
Group B	Soils having a moderate rate of infiltration when wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse texture.
Group C	Soils having a slow rate of infiltration when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water or soils with moderately fine to fine texture.
Group D	Soils having a very slow rate of infiltration rate when wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high

water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material.

Group B/D & C/D Some soil groups are given a dual classification. This type of classification is applicable when soils are found in both a drained and undrained condition. The first letter (B or C) of the classification is the soil in the drained condition while the second letter (D) is the classification of the soil in the undrained condition. Inspection of topographic or geologic maps as well as a field investigation may be necessary to determine the current hydrologic condition of the soil.

As the soil descriptions imply, runoff potentials increase from a minimum for Group A soils to a maximum for Group D soils.

A map illustrating the distribution of hydrologic soil groups throughout the watershed is provided in Plate 2. The distribution of soil groups throughout the watershed was determined based upon soil series information mapped on the SCS soil survey for Union County. The aggregation of individual soil series into appropriate hydrologic soils groups was performed using SCS Technical Release 55 information.

As the data indicates, the majority of the soils in the watershed are in Soil Groups B and C. The western portion of the watershed consists of mostly B soils in the valleys and C soils on the ridges. However, the eastern portion of the watershed consists of C soils on the ridges with a mixture of B and D soils in the valleys and floodplains.

3.3 Hydrology

The White Deer Creek Watershed is elongated in shape. The total length of the watershed measures approximately 22.7 miles along its long (east-west) axis and is roughly 3.8 miles wide at its widest point. The total area drained is approximately 46.6 square miles. The major tributaries to White Deer Creek include: Tunis Run, Sand Spring Run, Mile Run, Lick Run, and Kettle Hole.

White Deer Creek itself generally flows in an easterly direction from its origin to its mouth on the west branch of the Susquehanna River. In addition to the named tributaries numerous unnamed tributaries feed White Deer Creek through ravines in the steep mountains that define the limits of the watershed.

3.4 Existing Stormwater Drainage Problem Areas

An important goal of Act 167 is to prevent any existing storm drainage problem areas from worsening. The first step toward that goal is to identify the existing problem areas. Each municipality in the White Deer Creek Watershed was provided with an opportunity to update the documentation of existing drainage problems within its borders.

Each municipality in the watershed was contacted to solicit information, via questionnaires, relative to stormwater conditions that are locally perceived as problems. In many cases, these problems may be somewhat localized, and related to local drainage limitations apart from stream flooding and may occur at a high frequency. Also, information relative to stormwater problems in addition to flooding (i.e., accelerated erosion, sedimentation and water pollution) was requested.

A total of 16 problem areas were identified in the eight municipalities in the watershed (Plate 3). The distribution of identified problem types are presented in Plate 3. The majority of the problem areas are

located in the eastern portion of the watershed near White Deer. As is indicated in Plate 3 the predominant problem type reported is flooding, with and without accompanying erosion and sedimentation. Discussion of each of the 16 problem areas can be found in Appendix H.

The identified flooding problems are, in most cases, stream flooding generally caused by stormwater runoff rates exceeding the channel and/or obstruction capacities. Erosion and sedimentation are often reported as accompanying the flooding conditions. Many of the problem areas are located on smaller drainage paths located to the north of the main stem of White Deer Creek. These areas are characterized by very flat topography with the potential for widespread shallow flooding when these streams leave their banks. This scenario coupled with the undersized culverts typically used for driveway and minor roadway crossings creates numerous localized flooding problems.

In addition, there have been some areas of erosion noted along the main stem of White Deer Creek. Most notably is the reach located near the mobile home park, just west of US Route 15, where a dike was constructed. This structure confines higher flows causing more erosive velocities. In particular erosion of the southern banks of White Deer Creek is evident in this area. Other problems noted include backwater and flooding associated with the crossings of S.R. 1011, Interstate 80, T-520, and Gray Hill Road (Covered Bridge). Due to the relatively flat topography of the White Deer Creek's floodplains these structures can inundate large areas if and when they back up water. Erosion has also been documented near the mouth of the creek and near the remnants of the railroad bridge just east of US Route 15. The remaining piers at this location are skewed in such a way that a gravel bar has built up and the erosion of the stream bank is threatening the road.

Again it is important to note that mitigation of the flooding caused by backwater from larger waterways, such as the Susquehanna River, is beyond the scope of Act 167. The methods provided in this Plan are intended to identify problems caused by increased runoff from developments, insufficiently sized collection and conveyance systems, and other situations that might be aggravated by "flash flooding."

3.5 Suggested Solutions

Several types of general solutions to recognized problems exist. These solutions consist of implementation of structural measures such as increasing culvert or bridge openings; construction of storm sewers to drain small areas that regularly pond; and armoring stream banks that experience erosion. In addition, stormwater detention or infiltration facilities could be constructed to help reduce peak flows at downstream problem areas. Measures as simple as ensuring regular inspection for and removal of debris and silt at culverts and storm sewer inlets may help reduce some of the impact at the identified problem areas. Flood proofing of basements may also reduce the damage to homes subject to regular flooding.

All of the suggested solutions offered are to restore or increase hydraulic capacities. It is important to note that the ultimate success of any of these efforts will require that the incremental increases in hydraulic capacity not be offset by future increases in stormwater runoff. The nature of the problems currently encountered in the watershed and the types of solutions increase the importance of effective stormwater management in the basin.

3.6 Problem Area Remediation approach

The Act 167 plan process does not specifically allow for the correction of existing problem areas. However, in addition to simply identifying these problem areas, this plan will provide valuable

information for planners and engineers for the correction of these problems in the future. The ordinance that has been developed as part of this plan will provide the necessary controls to prevent existing drainage problems from being exacerbated by future development. In addition, the hydrologic model can provide valuable information, such as estimated stream flows, at these problem area locations.

With these ideas in mind, planners within the White Deer Creek Watershed should consider the following steps in their efforts to implement solutions to the existing stormwater problem areas:

- Correction of stormwater problem areas should be prioritized based on the frequency of occurrence, potential for injury or property damage, or any other pertinent criteria.

- For those problem areas in need of immediate correction detailed engineering evaluations should be undertaken to determine the cause of the problem, the most appropriate solution, and an approximate cost for the solution. Any proposed solutions should be designed to ensure that the problem would be corrected and not just moved to another location in the watershed.

These steps will allow planners to more easily budget for the projects necessary for the correction of the identified problem areas. As always, adherence to the proposed ordinance is critical as uncontrolled runoff from future development could easily undermine any attempts to correct existing problem areas.

3.7 Significant Obstructions

An obstruction in a watercourse can be defined, borrowing from Chapter 105 of DEP's Rules and Regulations, as follows:

> "Any dike, bridge, culvert, wall, wingwall, fill, pier, wharf, embankment, abutment or other structure located in, along, or across or projecting into any channel or conveyance of surface water having defined bed and banks, whether natural or artificial, with perennial or intermittent flow."

Typically the use of this definition identifies a significant number of potential problematic obstructions, many of which may not directly impact persons, developed property, or municipal infrastructure. Therefore, for the purposes of Act 167, it is necessary to refine the list of obstructions to include only those obstructions that are "significant" on a watershed basis. For the White Deer Creek Watershed Stormwater Management Plan, the following distinction, has been used:

> "Significant obstructions will be those that are identified as being areas where insufficient capacity exists for the necessary storm flows, and where this lack of capacity will either impact persons, property, or municipal infrastructure or those that would act as impoundments and measurably affect watershed modeling."

Using this definition, 15 significant obstructions have been identified within the White Deer Creek Watershed and are shown in Plate 5. A list of the significant obstructions is presented as part of Plate 5, indicating the obstruction number, municipality and approximate flow capacity. Obstruction capacities have been estimated based on their upstream geometry as measured, bed slope and roughness factors (where applicable) consistent with the calibrated watershed model for White Deer Creek. The estimates reflect reasonable flow capacities of the obstructions for "open channel" flow conditions (i.e., where the obstructions are not submerged). These estimated capacities are for illustration only and shall not be used as absolute capacities for stormwater management decisions. The capacity of any obstruction when used

to meet the requirements of this Plan shall be based upon a detailed hydraulic investigation including possible headwater and tailwater conditions, obstruction configuration (abutments, wingwalls, piers, etc.), field measured slopes and other conditions as may affect capacity for design flows.

In addition to this analysis a reservoir analysis was also performed (see Section 4.2) to determine the size of a reservoir necessary to reduce flows at obstructions in the downstream end of the watershed.

3.8 Designation of Stormwater Hotspots

A stormwater hotspot is defined as a land use or activity that generates higher concentrations of hydrocarbons, trace metals or toxins than are found in typical stormwater runoff, based on monitoring studies. Table 3.1 provides a list of designated hotspots. If a site is designated as a hotspot, it has important implications for how stormwater is managed. First and foremost, untreated stormwater runoff from hotspots cannot be allowed to infiltrate into groundwater where it may contaminate water supplies. Therefore, the Re_v requirement is NOT applied to development sites that fit into the hotspot category (the entire WQ_v must still be treated). Second, a greater level of stormwater treatment is needed at hotspot sites to prevent pollutant washoff after construction. This typically involves preparing and implementing a *stormwater pollution prevention plan* that involves a series of operational practices at the site that reduces the generation of pollutants by preventing contact with rainfall.

Under EPA's NPDES stormwater program, some industrial sites are required to prepare and implement a stormwater pollution prevention plan. The stormwater pollution prevention plan requirement applies to both existing and new industrial sites. In addition, if a site falls into a "hotspot" category outlined in Table 3.1, a pollution prevention plan may also be required by the appropriate reviewing authority. Golf courses and commercial nurseries may also be required to implement a plan by the appropriate approval authority.

Table 3.1 - Classification of Stormwater Hotspots

The following land uses and activities are deemed ***stormwater hotspots:***
• vehicle salvage yards and recycling facilities*
• vehicle service and maintenance facilities
• vehicle and equipment cleaning facilities*
• fleet storage areas (bus, truck, etc.)*
• industrial sites
• marinas (service and maintenance)*
• outdoor liquid container storage
• outdoor loading/unloading facilities
• public works storage areas
• facilities that generate or store hazardous materials*
• commercial container nursery
• other land uses and activities as designated by an appropriate review authority
*stormwater pollution prevention plan implementation is required for these land uses or activities under the EPA NPDES stormwater program
The following land uses and activities are not normally considered hotspots:
• residential streets and rural highways
• residential development
• institutional development
• commercial and office developments
• non-industrial rooftops
• pervious areas, except golf courses and nurseries which may need an Integrated Pest Management Plan

While large highways (average daily traffic volume greater than 30,000) and retail gasoline outlet facilities are not designated as stormwater hotspots, it is important to ensure that highway and retail gasoline outlet stormwater management plans adequately protect groundwater.

Section 4 – Watershed Technical Analysis – Modeling

4.0 Hydrologic Model

It is through the development of a hydrologic model and application of the data produced by this model that the Stormwater Management Plan truly assumes a watershed wide status. As part of this Plan the entire White Deer Creek Watershed was modeled using the US Army Corp of Engineer's Hydrologic Modeling System (HMS) which is developed by the Hydrologic Engineering Center (HEC). This model incorporates a variety of parameters to determine the amount of runoff generated during a design rainfall event. The various parameters entered into the model include; subwatershed area, lag time, reach lengths, soil-type and land cover (expressed as a curve number), and design rainfall depths. Detailed modeling computations are supplied in Appendix G. However, the general process for creation of the model is as follows:

1. The entire White Deer Creek Watershed was delineated into smaller subwatersheds based on obstructions and field verification as well as natural subwatershed divides.

2. Hydrologic data, such as existing and predicted future CNs and subwatershed area, was obtained for these subwatersheds from the Union County GIS. Other parameters such as time of concentration (t_c) were computed based on field observations and USGS quad maps.

3. The recharge volume Re_v was determined for the subareas where development is predicted. In order to model the infiltration facilities that will be required to treat the Re_v, a constant rate of flow was removed from the system, through the use of a diversion element, at the subwatersheds where development is expected. This rate of infiltration was estimated based on the required Re_v and the assumption of a minimal soil infiltration rate of 0.5 inches per hour.

4. These hydrologic parameters were incorporated into a HEC-HMS model for further analysis. The model incorporates both the physical and hydrologic characteristics of the subwatersheds and their interconnectivity as well as meteorological information. This model was run and the output hydrographs were analyzed.

The three subwatersheds that are expected to undergo development within the next 5 years are all located in the eastern end of the watershed near the Village of White Deer. Therefore, it is in these areas that the provisions of this plan and resulting ordinance will be implemented. Even in these areas significant development (resulting in significant changes in runoff) are not expected. Nonetheless, hydrologic models of the existing and future runoff conditions were developed for the watershed. Due to the minor amounts of future development, minor increases in flood peaks were observed in the future conditions model.

4.1 Modeling Results & Release Rates

The intent of the release rate percentage concept is to identify the general characteristics of subbasin interactions and combinations and define their relative impacts on total stream flows. This information is used to calculate the assigned release rate percentages (Appendix G).

The general approach employed in the White Deer Creek Watershed was to establish release rate percentages for each subbasin by determining the peak rate of runoff from the subbasin and its

contribution to peak discharges in downstream reaches. This was accomplished using the HEC-HMS modeling program developed by the US Army Corps of Engineers. The specific steps in the approach are as follows:

1. Perform overall watershed modeling using HEC-HMS.

2. Identify the modeled flow contribution that a particular subbasin contributes to each of the modeled downstream reaches.

3. Calculate the release rate percentage for each subbasin at each downstream reach.

4. Assign a single release rate percentage for each subbasin which will adequately protect all downstream reaches.

5. After further analysis of the existing and proposed curve numbers, release rates were computed for subwatersheds 2, 4, and 9 only. This is due to the fact that little future development is expected in the White Deer Creek Watershed during the scope of this Plan. Therefore, all of the subwatersheds except for 2, 4, and 9 had future curve numbers equal to their existing curve numbers.

Using these release rate computation techniques to compute the release rates for White Deer Creek yielded extremely stringent release rates, for some design storms, for these subwatersheds. This is due to the timing of the watershed peaks, namely that the subwatersheds in question reach their runoff peaks long before the entire watershed peak. This is critical due to the fact that release rate percentages are computed by dividing the flow in the subwatershed that occurs at the same time as the overall watershed peak by the peak flow of the subwatershed itself. Therefore, if the former number is much smaller than the latter, very low percentages are computed. Because the subwatersheds expected to experience development in the White Deer Creek Watershed are located near the watershed outlet they reach their runoff peak and are well into their receding limb when the overall watershed reaches its runoff peak. Therefore, the difference between the flow occurring on the receding limb and the subwatershed peak is large and the resulting release percentage is small, in some cases it is less than 50%. This would require the post-development runoff from a development to be reduced to say 50% of the pre-development runoff resulting in the need for a significant amount of storage.

For the reasons outlined above it was determined that a logical approach to this situation is to implement 100% release rates, that is reduce post-development runoff peaks to pre-development runoff peaks. This does not necessarily address the timing of these post-development watershed runoff peak flows at all points in the watershed. However, it does ensure that the post-development runoff peaks leaving each subwatershed are not increased. In addition, this reduces the need for excessively large storage ponds which would be required if the computed release rates were implemented. Due to the fact that the subwatersheds in question are located in the lower reaches of the watershed it does not seem logical to hold back the runoff peaks of these subwatersheds while the overall watershed peak passes through. Rather it would be desirable to allow the runoff from these subwatersheds to pass through the lower reaches of White Deer Creek allowing the overall watershed peak to follow behind it.

4.2 Reservoir Modeling

At the request of the WPAC an analysis was performed to size a possible reservoir in order to control downstream flooding. Structures on the main branch of White Deer Creek that may cause significant

backwater include: the Covered Bridge carrying Gray Hill Road, and the bridges under S.R. 1011 and Harberson Road. Efforts were made to adequately size a reservoir, in order to detain a large volume of runoff, so that these three downstream structures would not be inundated with floodwaters. A desirable reservoir location was to be chosen upstream of these three structures and in an area where water could pond without negatively affecting surrounding property and infrastructure. One possible site would be approximately 5,500-ft downstream of the existing White Deer dam.

The reservoir was modeled in the HMS Basin Model. Table 4.0 presents the storage-outflow information that was input into the reservoir using an initial condition of inflow is equal to the outflow:

Table 4.0 - Storage – Outflow Information

Storage (ac-ft)	Outflow (cfs)
0	0
500	1000
1000	2000
1500	3000
2000	4000
2500	4500
3000	5000

The approximate capacities of the three obstructions were computed using HY8 and were based on field measurements. The flow capacities of the covered and S.R. 1011 bridges were estimated to pass less than the 25-year storm event. The Harberson Road Bridge had an estimated 25-year capacity. These capacities were used as target flows when sizing the reservoir. Table 4.1 compares the flows, during the 50 and 100-yr events, at these structures when a reservoir is simulated.

Table 4.1 - Reservoir Flow Information

Current Structure Capacity (cfs)		**50-yr (cfs)**	**100-yr (cfs)**
Covered Bridge	6200	3714	4741
S.R. 1011 Bridge	8100	3924	5000
Harberson Road Bridge	5000	5153	6542

The peak storage of the reservoir when the 50-year storm was simulated was 1571-ac-ft and the simulated 100-year storm peak storage was 2067-ac-ft. Based on the approximate location of the reservoir, to control the 50-year storm, the dimensions of the reservoir would need to be approximately 25-feet high and 1500-feet wide. This would inundated lands approximately 2200-feet upstream of the reservoir. To control the 100-year storm, the dimensions of the reservoir would need to be approximately 27-feet high and 1500-feet wide. This would inundated lands approximately 2500-feet upstream of the reservoir.

It should be noted that this is a conceptual analysis intended to determine rough storage volumes and an approximate footprint of a facility necessary to meet the goal of reducing the potential for flooding in the eastern end of the White Deer Creek watershed. A detailed design of the reservoir would be required to determine its actual storage requirements and impacts.

Section 5 – Technical Standards and Criteria for Control of Stormwater Runoff

5.0 Introduction

This chapter presents a unified approach for sizing stormwater BMPs in the White Deer Creek Watershed to meet pollutant removal goals, maintain groundwater recharge, and reduce channel erosion. For a summary, please consult Table 5.0 below. The remaining sections describe the sizing criteria in detail and present guidance on how to properly compute and apply the required design volumes.

This chapter also presents a list of acceptable BMP options that can be used to comply with the sizing criteria.

Table 5.0 - Summary of the Watershed-Wide Stormwater Criteria

Sizing Criteria	Description of Stormwater Sizing Criteria
Water Quality Volume (WQ_v) (ac-ft)	$WQ_v = [(P_{90})(R_v)(A)]/12$ P_{90} = rainfall depth in inches and is equal to 1.2 inches R_v = volumetric runoff coefficient, and A = area in acres
Recharge Volume (Re_v) (ac-ft)	Fraction of WQ_v, depending on pre development soil hydrologic group $Re_v = [(S)(R_v)(A)]/12$ S = soil specific recharge factor in inches
Channel Protection Storage Volume (Cp_v)	Cp_v = Extended detention of post-developed one-year, 24 hour storm event
Overbank & Extreme Event Flood Protection Volume (Release Rates)	Controlling peak discharge rates to levels at or below pre development rates through the use of release rate criteria

5.1 Water Quality Volume (WQ_v)

The Water Quality Volume (denoted as WQ_v) is the storage needed to capture and treat the runoff from 90% of the average annual rainfall. The value of P_{90} was determined from analysis of rain gauge data from gauges in and around White Deer Creek. P_{90} represents the depth of rain associated with 90% of the total rainfall events over 0.11 inches (Appendix C).

The following equations are used to determine the storage volume, WQ_v (in acre-feet of storage):

$$WQ_v = \frac{(1.2)\,(R_v)(A)}{12} \qquad P_{90} = 1.2 \text{ inches of rainfall}$$

Where:
- WQ_v = water quality volume (in acre-feet)
- R_v = 0.05 + 0.009(I) where I is percent impervious cover
- A = area in acres*

Treatment of the WQ_v shall be provided at all developments where stormwater management is required. A minimum WQ_v of 0.2 inches per acre shall be met at sites or in drainage areas that have less than 15% impervious cover.

Drainage areas having no impervious cover and no proposed disturbance during development may be excluded from the WQ_v calculations. Designers are encouraged to use these areas as non-structural practices for WQ_v treatment (Appendix D).

The WQ_v is directly related to the amount of impervious cover created at a site. The relationship between WQ_v and impervious cover is shown in Figure 5.0.

*The water quality volume (WQ_v) is required to be controlled only for the specific project site. Treatment of the WQ_v for offsite areas and areas that are not disturbed is not required.

Figure 5.0 - Relationship Between Impervious Cover and Water Quality Volume

Basis for Determining Water Quality Volume

As a basis for design, the following assumptions may be made:

- **Measuring Impervious Cover:** The measured area of a site plan that does not have vegetative or permeable cover shall be considered total impervious cover. Where direct measurement of impervious cover is impractical, Natural Resource Conservation Service (NRCS) land use/impervious cover relationships can be used to estimate impervious cover (see Table 2.2a in TR-55, NRCS, 1986). Estimates shall be based on actual use and homogeneity.

- **Multiple Drainage Areas:** When a project contains or is divided by multiple drainage areas, the WQ_v shall be addressed for each drainage area.

- **Offsite Drainage Areas:** The WQ_v shall be based on the impervious cover for the proposed site. Offsite existing impervious areas may be excluded from the calculation of the water quality volume requirements.

- **BMP Treatment:** The final WQ_v shall be treated by an acceptable BMP(s) from the list presented in Section 6, or an equivalent practice approved by the Municipal Engineer.

- **Subtraction for Structural Practices:** Where structural practices for treating the Re_v are employed upstream of a BMP, the Re_v may be subtracted from the WQ_v used for design.

- **Subtraction for Non-structural Practices:** Where non-structural practices are employed in the site design, the WQ_v can be reduced in accordance with the conditions outlined in Appendix D.

- **Determining Peak Discharge for WQ_v Storm:** When designing flow splitters for off-line practices, consult the small storm hydrology method provided in Appendix E.

- **Extended Detention for Water Quality Volume:** The water quality requirement can be met by providing a 24-hour draw down of a portion of the (WQ_v) in conjunction with a stormwater pond or wetland system. Referred to as ED, this is different than providing the extended detention of the one-year storm for the channel protection volume (Cp_v). The ED portion of the WQ_v may be included when routing the Cp_v.

5.2 Recharge Volume Requirements (Re_v)

The criteria for maintaining recharge is based on the average annual recharge rate of the hydrologic soil group(s) (HSG) present at a site as determined from United States Department of Agriculture (USDA), NRCS Soil Surveys or from detailed site investigations. More specifically, each specific recharge factor is based on the USDA average annual recharge volume per soil type divided by the annual rainfall in Union County (40 inches per year) and multiplied by 90%. This keeps the recharge calculation consistent with the WQ_v methodology. Thus, an annual recharge volume requirement is specified for a site as follows:

Site Recharge Volume Requirement

Percent Volume Method
$Re_v = [(S)(R_v)(A)]/12$

where: R_v = 0.05 + 0.009(I) where I is percent impervious cover
A = site area in acres

Percent Area Method
$Re_v = (S)(A_i)$

where: A_i = the measured impervious cover

Hydrologic Soil Group	Soil Specific Recharge Factor (S)
A	0.40
B	0.27
C	0.14
D	0.07

The recharge volume is considered part of the total WQ_v that must be provided at a site and can be achieved either by a structural practice (e.g., infiltration, bioretention, etc.), a non-structural practice (e.g., buffers, disconnection of rooftops, etc.), or a combination of both.

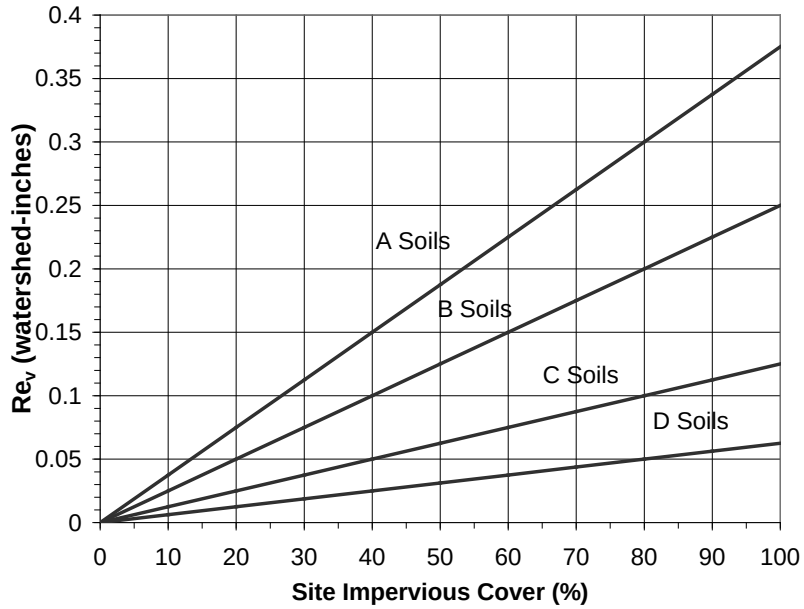
Drainage areas having no impervious cover and no proposed disturbance during development may be excluded from the Re_v calculations. Designers are encouraged to use these areas as non-structural practices for Re_v treatment (see Appendix D).

Note: Re_v and WQ_v are inclusive. When runoff is treated separately, the Re_v may be subtracted from the WQ_v when sizing the water quality BMP.

The intent of the recharge criteria is to maintain existing groundwater recharge rates at development sites. This helps to preserve existing water table elevations thereby maintaining the hydrology of streams and wetlands during dry weather. The volume of recharge that occurs on a site depends on slope, soil type, vegetative cover, precipitation and evapo-transpiration. Sites with natural ground cover, such as forest and meadow, have higher recharge rates, less runoff, and greater transpiration losses under most conditions. Because development increases impervious surfaces, a net decrease in recharge rates is inevitable.

The relationship between Re_v and site imperviousness is shown in graphical form in Figure 5.1.

Figure 5.1 - Relationship Between Re_v and Site Impervious Cover



Basis for Determining Recharge Volume

- If more than one HSG is present at a site, a composite soil specific recharge factor shall be computed based on the proportion of total site area within each HSG. **The recharge volume provided at the site shall be directed to the most permeable HSG available.**

- **The "percent volume" method is used to determine the Re_v treatment requirement when <u>structural practices</u> are used to provide recharge.** These practices must provide seepage into the ground and may include infiltration and exfiltration structures (e.g., infiltration, bioretention, dry swales or sand filters with storage below the under drain). Structures that require impermeable liners, intercept groundwater, or are designed for trapping sediment (e.g., forbays) may not be used. In this method, the volume of runoff treated by structural practices shall meet or exceed the computed recharge volume.

- **The "percent area" method is used to determine the Re_v treatment requirements when <u>non-structural practices</u> are used.** Under this method, the recharge requirements are evaluated by mapping the percent of impervious area that is effectively treated by an acceptable non-structural practice and comparing it to the minimum recharge requirements.

- Acceptable non-structural practices include filter strips that treat rooftop or parking lot runoff, sheet flow discharge to stream buffers, and grass channels that treat roadway runoff (see Section 7.3).

- The recharge volume criterion does not apply to any portion of a site designated as a stormwater hotspot or any project considered as redevelopment. In addition, the Municipal Engineer may alter or eliminate the recharge volume requirement if the site is situated on unsuitable soils, karst, or in an urban redevelopment area. In this situation, non-structural practices (percent area method) shall be implemented to the maximum extent practicable and the remaining or untreated Re_v included in the WQ_v treatment.

- If Re_v is treated by structural or non-structural practices separate and upstream of the WQ_v treatment, the WQ_v is adjusted accordingly.

5.3 Channel Protection Storage Volume Requirements (Cp_v)

To protect channels from erosion, **24 hour extended detention of the one-year; 24-hour storm event** shall be provided. The rationale for this criterion is that runoff will be stored and released in such a gradual manner that critical erosive velocities during bankfull and near-bankfull events will seldom be exceeded in downstream channels.

Due to potential impacts associated with increases in water temperature during extended detention, discharges to streams having verified naturally reproducing wild trout or that is stocked with trout, only 12 hours of extended detention shall be provided.

The method for determining the Cp_v requirement is detailed below. A detention pond or underground vault is normally needed to meet the Cp_v requirement. Schematics of a typical design are shown in Figure 5.2.

The following procedure shall be used to design the channel protection storage volume (Cp_v). The method is based on the Design Procedures for Stormwater Management Extended Detention Structures (MDE, 1987) and utilizes the NRCS, TR-55 Graphical Peak Discharge Method (USDA, 1986).

- Compute the time of concentration (*tc*) and the one-year post-development runoff depth (*Qa*) in inches.

  $$Qa = \frac{(1.2 - Ia)^2}{(1.2 - Ia) + S} \qquad \text{where } S = (1000/CN) - 10,\ Ia = (200/CN) - 2$$

- Compute the ratio *Ia/1.2* where 1.2 is the one-year rainfall depth (Source: PENNDOT IDF).

- With *tc* and *Ia/P*, find the unit peak factor (*qu*) from Appendix F Figure F.1 and compute the one year post-development peak discharge $qi = quAQa$ where A is the drainage in square miles.

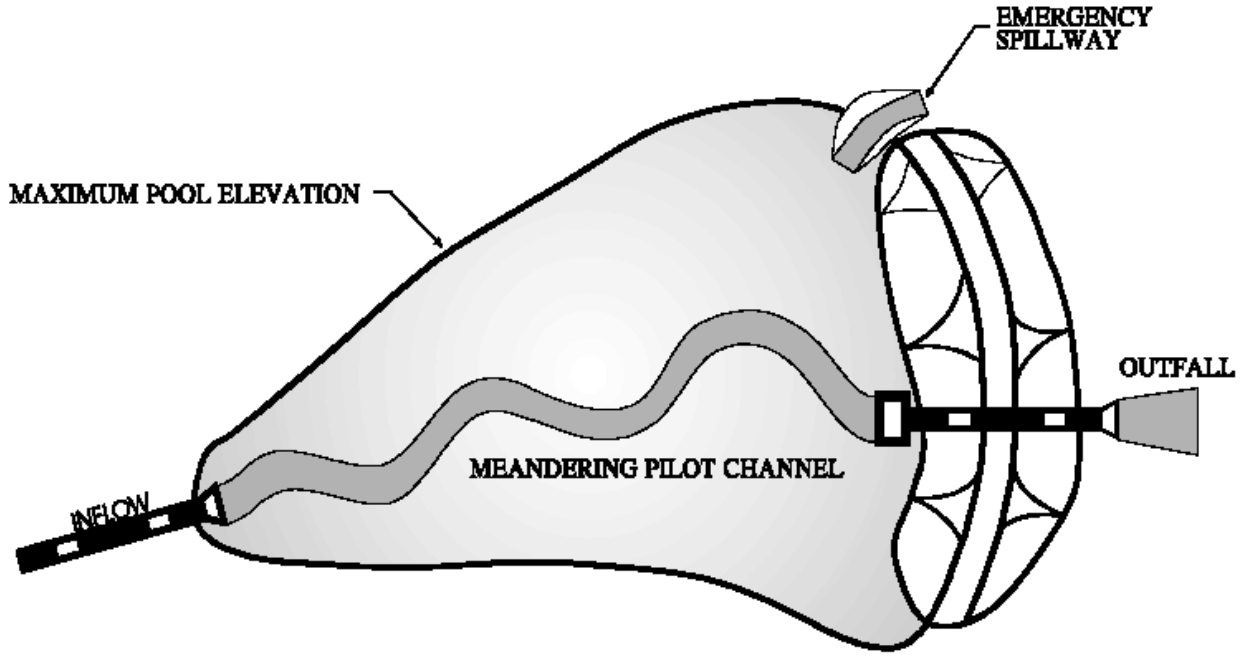
- **If $qi \leq 2.0$ cfs, Cp_v is not required**. Provide for water quality (WQ_v) and groundwater recharge (Re_v) as necessary.

- With *qu*, find the ratio of outflow to inflow (*qo/qi*) for T = 12 or 24 hours from Appendix F Figure F.2.

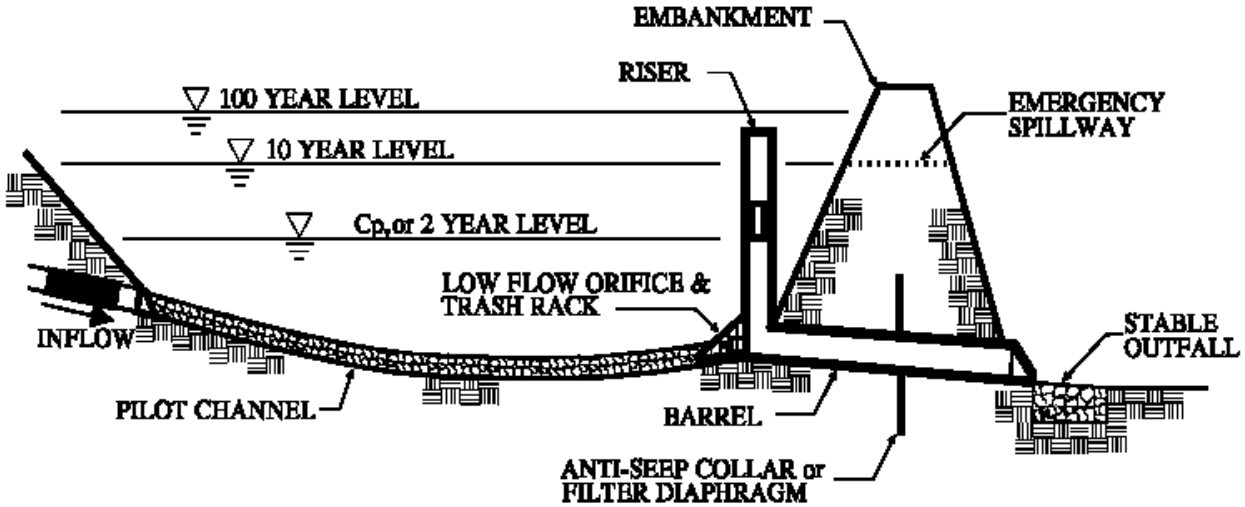
- Compute the peak outflow discharge $qo = (qo/qi)xqi$

- With *qo/qi*, compute the ratio of storage to runoff volume (V_s/V_r).
    - $V_s/V_r = 0.683 - 1.43(qo/qi) + 1.64(qo/qi)^2 – 0.804(qo/qi)^3$
- Compute the extended detention storage volume $V_s = (V_s/V_r)xV_r$ (note: $V_r = Qa$)
- Convert V_s to acre-feet by $(V_s/12)$ x A, where V_s is in inches and A is in acres.
- Compute the required orifice area (*Ao*) for extended detention design:
    - $Ao = \frac{qo}{C(2gho)^{0.5}} = \frac{qo}{4.18(ho)^{0.5}}$
- Where ho is the maximum storage depth associated with V_s.
- Determine the required maximum orifice diameter (*do*) $do = (4Ao/\pi)^{0.5}$
- A *do* of less than 3.0 inches is subject to local jurisdictional approval, and is not recommended unless an internal control for orifice protection is used.

Figure 5.2 - Example of Conventional Stormwater Detention Pond



Plan



Profile

A typical detention facility provides channel protection control (Cp_v) and overbank flood control but not water quality control (WQ_v).

Basis for Determining Channel Protection Storage Volume

The following represent the minimum basis for design:

- The models Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS), Technical Release No. 20 Project Formulation-Hydrology, computer program (TR-55) and Technical Release No. 55 Urban Unit Hydrology for Small Watersheds (TR-20) (or an equivalent approved by the Municipal Engineer) shall be used for determining peak discharge rates.

- Based on PENNDOT IDF the rainfall depth for the one-year, 24-hour storm event in Union County is 1.2 inches.

- Off-site areas shall be modeled as present land use in good condition for the one-year storm event.

- The length of overland flow used in time of concentration (t_c) calculations is limited to no more than 150 feet.

- The Cp_v storage volume shall be computed using the detention lag time between hydrograph centroids as outlined in Appendix F. The detention lag time (T) for the one-year storm is defined as the interval between the center of mass of the inflow hydrograph and the center of mass of the outflow hydrograph. Examples of this technique are shown in the design example.

- Cp_v is not required at sites where the one-year post development peak discharge (q_i) is less than or equal to 2.0 cfs. A Cp_v orifice diameter (d_o) of less than 3.0 inches is subject to approval by the Municipal Engineer and is not recommended unless an internal control for orifice protection is used.

- Cp_v shall be addressed for the entire site. If a site consists of multiple drainage areas, Cp_v may be distributed proportionately to each drainage area.

- Extended detention storage provided for the Cp_v does not meet the WQ_v requirement (that is Cp_v and WQ_v shall be treated separately).

- The stormwater storage needed for the Cp_v may be provided above the WQ_v storage in stormwater ponds and wetlands; thereby meeting all storage criteria except Re_v in a single facility with appropriate hydraulic control structures for each storage requirement.

- Infiltration is not recommended for Cp_v control because of large storage requirements.

5.4 Overbank and Extreme Event Flood Protection Requirements (Release Rates)

As was discussed in Section 4 the release rate for all White Deer Creek Subwatersheds is 100%. This means that all post-development peak flows leaving a particular development will have to be less than or equal to the pre-development peak flows.

To utilize the 100 % release rate for a particular site in the watershed the developer shall follow the following general sequence of actions.

1. Compute the pre-development and post-development runoff for the specific site using an approved method for the 2-,10-,25-,and 100-year storms, using no stormwater management techniques. If the post-development peak rate is less than or equal to the pre-development rate and time of peak of post and pre-development rates are identical, the requirements of Act 167 and this Plan have been met. If the post-development runoff rate exceeds the pre-development rate, proceed to Step 2.

2. Apply on-site stormwater management techniques to provide for WQ_v, Re_v, and Cp_v. Recompute the post-development runoff rate for the 2-, 10-, 25-, and 100-year storms; and if the resulting post-development peak runoff rate is less than or equal to the pre-development peak runoff rate, the requirements of this Plan have been met. Otherwise additional stormwater management measures, possibly detention or retention, will be required and the developer should proceed to Step 3.

3. Design the necessary facilities to meet the pre-development peak runoff rate.

5.5 Design Example: Computing Stormwater Storage Volumes

Design examples are provided only to illustrate how the stormwater management sizing criteria are computed for hypothetical development projects.

Design Example: Residential Development - The Meadows

Site data and the layout of The Meadows subdivision are shown in Figure 5.3.

Step 1. Compute WQ_v Volume

$$WQ_v = \frac{(P_{90})(R_v)(A)}{12}$$

Step 1a. Compute Volumetric Runoff Coefficient (R_v)

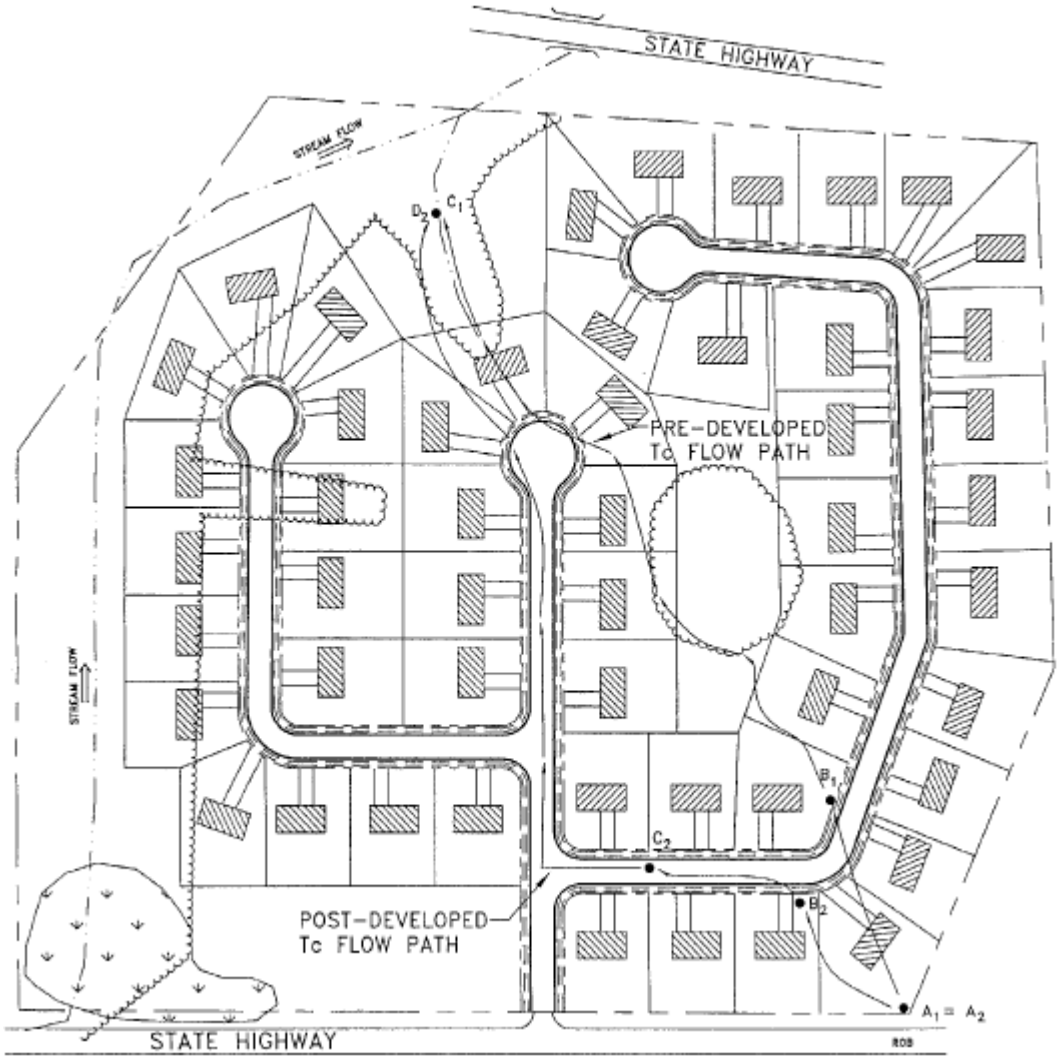
R_v = 0.05 + (0.009) (I); I = 13.8 ac/38.0 ac = 36.3%
= 0.05 + (0.009) (36.3) = 0.38

Step 1b. Compute WQ_v

WQ_v = [(1.2") (R_v) (A)]/12
= [(1.2")(0.38)(38.0 ac)]/12
= 1.44 ac-ft

Check Minimum: [(0.2")(38.0 ac)]/ 12 = 0.63 ac-ft < 1.44 ac-ft
Therefore use WQ_v = 1.44 ac-ft

Figure 5.3 - Design Example: The Meadows



Base Data
Location: Anywhere, PA
Site Area = Total Drainage Area (A) = 38.0 ac
Measured Impervious Area = 13.8 ac; I=13.8/38 =36.3%
Soils Types: 60% "B", 40% "C"
Zoning: Residential (½ ac lots)

Hydrologic Data		
	Pre	Post
CN	63	78
tc	0.35 hr	0.19 hr

Step 2. Compute Recharge Volume (Re_v)

$$Re_v = \frac{(S)(R_v)(A)}{12} \qquad \text{(percent volume method)}$$

or

$$Re_v = (S)(Ai) \qquad \text{(percent area method)}$$

Step 2a. Determine Soil Specific Recharge Factor (*S*) Based on Hydrologic Soil Group

HSG	Soil Specific Recharge Factor (*S*)
A	0.40
B	0.27
C	0.14
D	0.07

Assume imperviousness is located proportionally (60/40) in B and C soils and compute a composite S:

S = (0.27)(0.60) + (0.14)(0.40) = 0.218; Use 0.218 or 21.8% of site imperviousness

Step 2b. Compute Recharge Using Percent Volume Method

Re_v = [(*S*)(R_v)(*A*)]/12
= [(0.218)(0.38)(38 ac)]/12
= 0.26 ac-ft

or

For "B" soils =[(0.27)(.38)(38 ac)]/12 × 60%= 0.19 ac-ft
For "C" soils =[(0.14)(.38)(38 ac)]/12 × 40% = 0.07 ac-ft

Add recharge requirement for both soils for a total volume of 0.26 ac-ft

Step 2c. Compute Recharge Using Percent Area Method

Re_v = (*S*)(*Ai*)
= (0.218)(13.8 ac)
= 3.01 ac

or

For "B" soils = (0.27)(13.8 ac)(60%) = 2.24 ac
For "C" soils = (0.14)(13.8 ac)(40%) = 0.77 ac

Added together = 3.01 acres of the total site impervious area needs to be treated by non-structural practices.

The Re_v requirement may be met by: a) treating 0.26 ac-ft using structural methods, b) treating 3.01 acres using non-structural methods, or c) a combination of both (e.g., 0.13 ac-ft structurally and 1.51 acres non-structurally).

Step 3. Compute Channel Protection Volume

Step 3a. Select Cp_v Sizing Rule

For channel protection, provide 12- or 24-hours of extended detention time (T) for the one-year design storm event.

Given that our stream is not a stocked or reproducing trout stream, we will use a T of 24-hours for the one-year design storm event.

Step 3b. Develop Site Hydrologic and TR-55 Input Parameters

Condition	CN	tc	Runoff (Qa) 1-year storm	Q 1-year
		hours	inches	cfs
Pre-developed	63	0.35	0	0
Developed	78	0.19	.12	2.91

Step 3c. Utilize MDE Method to Compute Storage Volume

Initial abstraction (Ia) for CN of 78 is 0.564: (TR-55) [Ia = (200/CN) - 2]

Ia/P = (0.564)/1.2” = 0.47
tc = 0.19-hours
Figure F.1 (Appendix F), qu = 410-csm/in

Compute the one-year post-development peak discharge qi = (qu)(A)(Qa)
qi = (410-csm/in)(.0593-sq miles)(.12-in)
qi = 2.91-cfs
Since 2.91-cfs > than 2.0-cfs, Channel Protection Volume is required

Knowing qu and T (extended detention time) find qo/qi from Figure F.2 (Appendix F), “Detention Time Versus Discharge Ratios.”

Peak outflow discharge/peak inflow discharge (*qo/qi*) = 0.04

With qo/qi, compute Vs/Vr for an SCS Type II rainfall distribution,

$Vs/Vr = 0.683 - 1.43(qo/qi)+1.64(qo/qi)^2 - 0.804(qo/qi)^3$
Vs/Vr = 0.63

Therefore, the extended detention storage volume, Cp_v is

Cp_v = 0.63(.12-in)(1/12)(38-ac) = 0.24-ac-ft

Step 3d. Define the Cp_v Release Rate

qi is known (2.91-cfs), therefore,
qo = (*qo/qi*) *qi* = (.04)(2.91-cfs) = 0.12-cfs

Step 4. Compute Overbank and Extreme Event Requirements

Compute assuming a release rate of 100%

Step 4a. Compute Pre-Development Runoff Peak Flow

Because CNs have already been determined use TR-55, however other appropriate methods may be used.

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

Where P = 24-hr rainfall (in.)

Source: PENNDOT Intensity Duration Frequency (IDF)

Union County 24 hour Rainfall for Various Frequencies (in.)					
2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
2.6	3.1	3.8	4.6	5.3	6.2

$S = (1000/CN) - 10$

Note: this is not the Soil Specific Recharge Factor used in the Re_v calculation

CN = curve number see step 3b

Summary of Pre-Development Peak Flows (cfs)					
2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
5.3	11.4	23.2	39.7	56.3	80.4

Step 4b. Compute post-development runoff peak flow

Summary of Post-Development Peak Flows (cfs)					
2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
37.5	54.0	79.6	111.2	140.4	178.4

Step 4c. Because post-development flows are greater than pre development flows additional facilities will need to be implemented to reduce the post-development runoff peak flows to pre-development levels.

Note: These allowable outflows may be met through the use of both structural BMPs and non-structural BMPs or a combination of both.

Section 6 – Runoff Control Techniques and Their Efficiencies

6.0 Acceptable Urban Best Management Practices (BMP) Options

This section sets forth six acceptable groups of BMPs that can be used to meet the water quality and/or groundwater recharge volume criteria.

Urban BMP Groups

The majority of different BMP designs can be classified into six general categories for stormwater quality control (WQ_v and/or Re_v):

BMP Group 1. Stormwater Ponds
BMP Group 2. Stormwater Wetlands
BMP Group 3. Infiltration Practices
BMP Group 4. Filtering Practices
BMP Group 5. Open Channel Practices
BMP Group 6. Non-Structural Practices

A combination of structural and/or non-structural BMPs are normally required at most development sites to meet all five stormwater sizing criteria. There are numerous sources for information related to BMPs the following is a brief list:

US Environmental Protection Agency (http://www.epa.gov/)
Department of Environmental Protection (http://www.dep.state.pa.us)
The Center for Watershed Protection (http://www.cwp.org)
The Pennsylvania Handbook of Best Management Practices
2000 Maryland Stormwater Design Manual
New York Stormwater Management Design Manual

BMP Group 1. Stormwater Ponds

Practices that have a combination of a permanent pool, extended detention or shallow wetland equivalent to the entire WQ_v include:

P-1 Micropool Extended Detention Pond
P-2 Wet Pond
P-3 Wet Extended Detention Pond
P-4 Multiple Pond System
P-5 Pocket Pond

BMP Group 2. Stormwater Wetlands

Practices that include significant shallow wetland areas to treat urban stormwater but often may also incorporate small permanent pools and/or extended detention storage to achieve the full WQ_v include:

W-1 Shallow Wetland
W-2 ED Shallow Wetland
W-3 Pond/Wetland System

W-4 Pocket Wetland

BMP Group 3. Infiltration Practices

Practices that capture and temporarily store the WQ_v before allowing it to infiltrate into the soil over a two day period include:

I-1 Infiltration Trench
I-2 Infiltration Basin

BMP Group 4. Filtering Practices

Practices that capture and temporarily store the WQ_v and pass it through a filter bed of sand, organic matter, soil or other media are considered to be filtering practices. Filtered runoff may be collected and returned to the conveyance system. Design variants include:

F-1 Surface Sand Filter
F-2 Underground Sand Filter
F-3 Perimeter Sand Filter
F-4 Organic Filter
F-5 Pocket Sand Filter
F-6 Bioretention*

* may also be used for infiltration.

BMP Group 5. Open Channel Practices

Vegetated open channels that are explicitly designed to capture and treat the full WQ_v within dry or wet cells formed by checkdams or other means include:

O-1 Dry Swale
O-2 Wet Swale

BMP Group 6. Non-Structural BMPs

Non-structural BMPs are increasingly recognized as a critical feature of stormwater BMP plans, particularly with respect to site design. In most cases, non-structural BMPs shall be combined with structural BMPs to meet all stormwater requirements. The key benefit of nonstructural BMPs is that they can reduce the generation of stormwater from the site; thereby reducing the size and cost of structural BMPs. In addition, they can provide partial removal of many pollutants. The non-structural BMPs have been classified into seven broad categories. To promote greater use of non-structural BMPs, a series of credits and incentives are provided for developments that use these progressive site planning techniques in Appendix D.

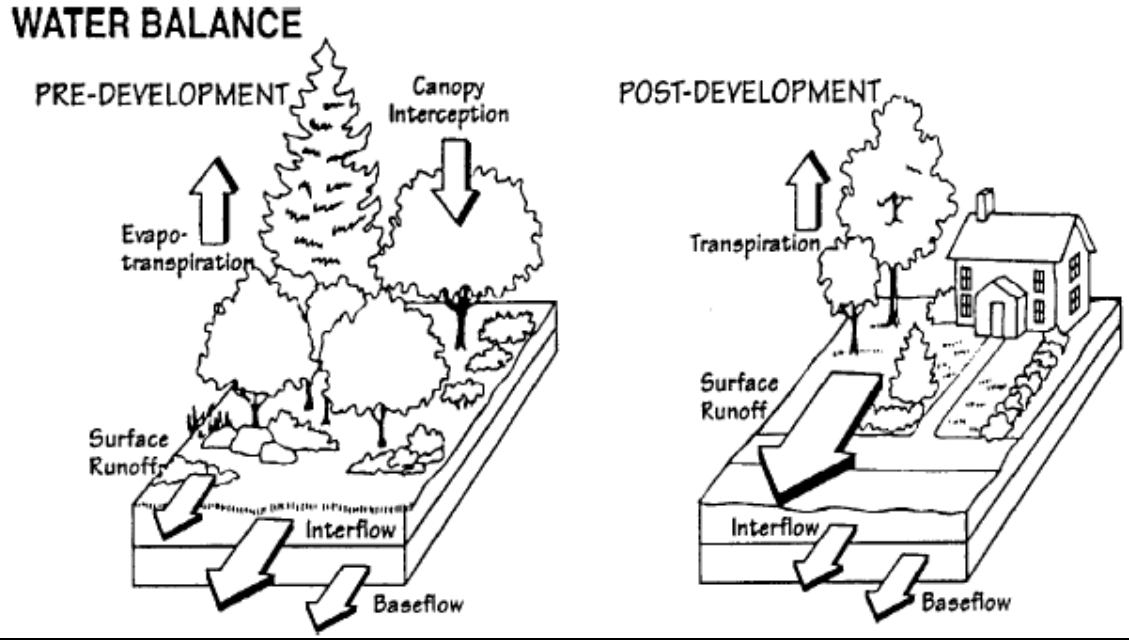
- Natural Area Conservation
- Disconnection of Rooftop Runoff
- Disconnection of Non-Rooftop Impervious Area
- Sheet Flow to Buffers
- Grass Channel
- Environmentally Sensitive Development

Section 7 – Municipal Handbook

7.0 Introduction - Why Stormwater Matters

Urban development has a profound influence on the quality of Pennsylvania's waters. To start, development dramatically alters the local hydrologic cycle (see Figure 7.0). The hydrology of a site changes during the initial clearing and grading that occurs during construction. Trees, meadow grasses, and agricultural crops that had intercepted and absorbed rainfall are removed while natural depressions that had temporarily ponded water are graded to a uniform slope. Cleared and graded sites erode, are often severely compacted, and can no longer prevent rainfall from being rapidly converted into stormwater runoff.

Figure 7.0 - Water Balance at a Developed and Undeveloped Site
(Source: Schueler, 1987)



Surface runoff is minimal in an undeveloped site, but dominates the water balance at a highly impervious site.

The situation worsens after construction. Roof tops, roads, parking lots, driveways and other impervious surfaces no longer allow rainfall to soak into the ground. Consequently, most rainfall is converted directly to stormwater runoff. For example, a one acre parking lot can produce 16 times more stormwater runoff than a one acre meadow each year (Schueler, 1994). The increase in stormwater runoff can be too much for the existing natural drainage system to handle. As a result, the natural drainage system is often "improved" to rapidly collect runoff and quickly convey it away (using curb and gutter, enclosed storm sewers, and lined channels). The stormwater runoff is subsequently discharged to downstream waters such as streams, reservoirs, lakes or estuaries.

7.1 Declining Water Quality

Impervious surfaces accumulate pollutants deposited from the atmosphere, leaked from vehicles, or windblown from adjacent areas. During storm events, these pollutants quickly wash off and are rapidly delivered to downstream waters. Some common pollutants found in urban runoff stormwater include: nutrients, suspended solids, organic carbon, bacteria, hydrocarbons, trace metals, pesticides, chlorides, and debris.

7.2 Intent of the Act 167 Plan

The White Deer Creek Act 167 Plan is intended to provide stormwater management guidance, on a watershed level, in urban planning and the design of land developments. A primary goal of the Act, and thus the Plan, is to prevent future problems resulting from uncontrolled runoff. These problems include flooding, erosion and sedimentation, landslides, and pollution and debris often carried by stormwater runoff. The basic premise of the Act is that those whose activities will generate additional runoff, or increase its velocity, or change the direction of its flow, shall be responsible for controlling and managing it so that these changes will not cause harm to other persons or property either now or in the future.

7.3 Suggested Best Management Practices

Developers, municipalities and others who disturb or develop the land will undoubtedly have an impact on stormwater runoff. It is the responsibility of these parties to mitigate any negative impacts caused by the disturbance. The Plan suggests the use of sound site planning and a number of structural and nonstructural best management practices (BMPs) to mitigate the negative impacts of stormwater runoff from land disturbances and developments.

Table 7.0 lists the suggested BMPs that are described in the Plan and, in detail, in The Pennsylvania Handbook of Best Management Practices.

Table 7.0 - Summary of BMP Descriptions

BMP	Type (structural/vegetative)	Permanence (permanent/temporary)
Bioretention	vegetative	permanent
Constructed Treatment Wetland	structural	permanent
Critical-Area Planting	vegetative	permanent
Filter Bag	structural	temporary
Filter Strip	vegetative	permanent
Grass Swale	vegetative	permanent
Infiltration Trench and Dry Well	structural	permanent
Permanent Vegetative Stabilization	vegetative	permanent
Permeable Paving System	structural	permanent
Pond, Dry	structural	permanent
Pond, Wet	structural	permanent
Riparian Corridor Management	vegetative	permanent
Riparian Forested Buffer	vegetative	permanent
Rooftop Runoff Management	structural	permanent
Sand Filter, Closed	structural	permanent
Sand Filter, Open	structural	permanent
Stream Bank Stabilization	structural/vegetative	permanent
Tree Preservation and Protection	structural	temporary
Trench Plug	structural	permanent
Water Quality Inlets	structural	temporary

7.4 BMP Maintenance

Although the actual time that a BMP facility performs its function is relatively brief (during and immediately following a storm event), it must constantly be able to do so. The facilities must be available at all times because of the random nature of rainfall events and the impracticality of inspecting facilities and maintaining them immediately before a storm event. In addition, pollutant-removal efficiencies will decline over time if BMPs are not adequately maintained. For a BMP to be operational, the BMP operator must establish and sustain a comprehensive, regularly scheduled maintenance program.

BMP maintenance starts by ensuring thorough inspections during construction. Proper construction of the BMP will reduce the maintenance needs of the facility. The municipality needs to develop inspection checklists, and communicate to the inspectors the importance of scheduling and coordinating the BMP construction with other site activities. For more information on BMP maintenance requirements, refer to The Pennsylvania Handbook of Best Management Practices for specific BMP descriptions.

The following criteria will guide the responsible parties with maintenance of BMPs. For more information, refer to specific BMP descriptions. The criteria include access and maintenance easements, routine inspection of outlet structures, sediment disposal, maintenance agreements, and other maintenance aspects specific to wet ponds, extended detention dry ponds, and infiltration trenches.

7.4.1 Overview of BMP Maintenance

Changes in downstream drainage may be too subtle or long in developing to provide adequate warning that the condition of a BMP is deteriorating. By the time problems are apparent, significant damage may have occurred. In many instances, impacts will not be experienced until an event approaching the design storm occurs. Failures triggered by large storm events may be as dramatic as washouts, flooding, and erosion of stream banks (NVPDC 1991). Therefore, preventative maintenance is essential. The components of a maintenance program are listed in Table 7.1.

Table 7.1 - Components of a Maintenance Program

Routine	Nonroutine
• Inspection • Vegetation Management • Insect Control • Debris and Litter Control • Mechanical Components Maintenance	• Bank Stabilization and Erosion Control • Sediment Removal • Outlet Structure Maintenance and Replacement

Although general maintenance tasks can be outlined, actual maintenance needs will vary according to specific site conditions, especially the following elements:

Visibility of the Facility
The needs and preferences of the surrounding community determine, to a large extent, the type and amount of necessary maintenance for aesthetics.

Landscaping
The maintenance needs of different types of vegetation will vary greatly.

Upstream Conditions
The condition of the watershed upstream of the facility will largely determine the amount of sediment and other pollutants that a facility must manage. For example, erosion problems upstream can dramatically increase the amount of sediment entering a pond.

A BMP maintenance program also shall consider the following:

Safety
Most tasks can be carried out by non-technical staff or residents quite effectively; however, a program shall take precautions to ensure the safety of anyone maintaining the BMP.

Need for Professional Judgment
Although many maintenance tasks can be undertaken effectively by a non-professional, a professional should be consulted periodically to ensure that all needs of the facility are met. Some developing problems may not be obvious to those without experience with these facilities.

Financing
A funding mechanism shall be established for paying for long-term maintenance, such as removing sediment.

7.4.2 Routine Maintenance Needs

Inspections
As a minimum, BMPs shall be inspected annually and after any storm larger than the design storm (i.e., peak detention storm, water quality storm, or runoff capture design storm, as appropriate). A sample inspection checklist is provided in Table 7.2. Not all of the checklist items will apply to every BMP.

Terrestrial Vegetation Maintenance
Grasses and plants incorporated in vegetative BMPs, such as filter strips, grass swales, and bioretention facilities, require attention to ensure a robust stand of vegetation. The development of distressed vegetation, bare spots, and rills are an indication that a BMP is not functioning properly. Problems can have many sources, including:

- Excessive sediment accumulation rates which clog the soil pores and produce anaerobic conditions
- Nutrient deficiencies or imbalances, including pH and potassium
- Water logged conditions caused by reduced soil drainage or high seasonal water table
- Invasive weeds

The soil in vegetated areas shall be tested biannually and adjustments made to sustain vigorous plant growth with deep, well-developed root systems. Aeration of soils is recommended for filter strips where high sediment accumulation rates exist. Ideally, vegetative covers should be mowed infrequently, allowing them to develop thick stands of tall grass and other plant vegetation.

Aquatic Vegetation Maintenance
An important, yet often overlooked aspect of routine maintenance of wet ponds and constructed treatment wetlands is the need to regularly monitor and manage conditions to promote a healthy aquatic environment. An indicator of excess nutrients (a common problem) is excessive algae growth in the permanent pool of a wet pond. In most cases, these problems can be addressed by encouraging the growth of more desirable aquatic and semi-aquatic vegetation in and around the permanent pool. Plants shall be selected that are tolerant of varying water levels and have a high capacity to incorporate the specific nutrients that are associated with the problem. If algae proliferation is not addressed, algae-laden water will be washed downstream during subsequent rain events where it may contribute to nuisance odors and introduce stresses to downstream aquatic habitat.

Insect Control
Breeding grounds for mosquitoes and other insects can be created by ponded water. Though perceived as a significant nuisance, mosquitoes are not as big a problem as is often thought. The best control technique for wet ponds is to ensure that the permanent pool does not develop stagnant areas. Wet ponds and constructed treatment wetlands shall include a source of steady dry-weather flow. Promptly removing of floatable debris helps eliminate still surface waters. In larger ponds, fish, which feed on mosquito larvae, could be stocked.

Debris and Litter Removal
Regularly removing debris and litter is well worth the effort and can be expected to help with the following:

- Reduce the chance of clogging in outlet structures, trash racks, and other facility components
- Prevent possible damage to vegetated areas

- Reduce potential mosquito breeding habitats
- Maintain facility appearance
- Reduce conditions for excessive surface algae

Special attention shall be given to removing floating debris, which can clog the outlet device or riser.

Maintenance of Mechanical Components
Each type of BMP may have mechanical components that need periodic attention to ensure their continued performance. Valves, sluice gates, fence gates, locks, and access hatches shall be functional at all times.

Table 7.2 - Inspection Checklist

✓ Obstructions of the inlet or outlet devices by trash and debris
✓ Excessive erosion or sedimentation
✓ Cracking or settling
✓ Animal burrowing
✓ Permanently ponded areas in the bottom of an extended detention dry pond or bioretention facility
✓ Sluggishly draining infiltration devices
✓ Algae growth, stagnant pools, or noxious odors
✓ Poor or distressed stands of grass
✓ Distressed aquatic vegetation
✓ Deterioration of pipes and conduits
✓ Deteriorated emergency spillways
✓ Washouts, bulges, or slumps
✓ Seepage at the toe of wet ponds or constructed treatment wetlands
✓ Unstable side slopes and embankments
✓ Deterioration of downstream channels
✓ Signs of vandalism
✓ Piping along outlet barrel
✓ Deterioration/scouring of energy dissipaters
✓ Outlet protection
✓ Sedimentation in rip rap channels

7.4.3 Nonroutine Maintenance

Bank Stabilization and Erosion Control
The integrity of the banks and bottom of extended detention dry ponds and the visible banks of wet ponds and constructed treatment wetlands must be maintained. The routine task is maintaining a healthy ground cover on the embankments and bottoms of ponds. Areas of bare soil will erode quickly, clogging the facility with soil and threatening its integrity. Therefore, bare areas must be reseeded and stabilized as quickly as possible to avoid erosion. Newly seeded areas shall be protected with an erosion mat that is securely staked to prevent flotation.

Erosion in or around the inlet and outlet of the BMP facility needs to be repaired as soon as possible. Erosion control activities must also extend to areas immediately downstream of the BMP.

The roots of woody growth, such as young trees and bushes, in embankments are destabilizing. Consistent mowing of the embankment will control stray seedlings that take root. Woody growth, such as trees and bushes, further away from the embankment should not pose a threat to the stability of the embankment and can provide important runoff filtering benefits. Trees and bushes should be planted outside maintenance and access areas.

Animal burrows also will deteriorate the structural integrity of an embankment. Muskrats, in particular, will burrow tunnels up to 6 inches in diameter. Efforts shall be made to control excessive animal burrowing. Burrows shall be filled as soon as possible.

Sediment Removal - Wet and Extended Detention Dry Ponds
Sediment will gradually accumulate in many BMPs, including wet ponds, extended detention dry ponds, constructed treatment wetlands, bioretention facilities, and grass swales. Constructed treatment wetlands shall be designed to accommodate sediment accumulation without the need for sediment removal during the life of the facility. To accommodate the sediment, constructed treatment wetlands have variable-height weirs and shall have added embankment freeboard to anticipate sediment accumulations.

For most other BMP applications, accumulated sediment will have to be removed eventually. However, facilities vary so dramatically that no “rules of thumb” exist to guide responsible parties about removing sediment. The specific setting of a BMP will be an important determinant in how often sediment must be removed. Important factors that determine rates of sedimentation are:

- Land uses and condition of the upstream watershed
- Future land-disturbing activities in upstream areas
- Presence of other sediment trapping BMPs in upgradient locations

Removing sediment from swales and bioretention areas generally is not a significant maintenance concern. However, wet ponds and extended detention dry ponds may require a significant investment in sediment removal activities.

Before installing a pond, good practice is to estimate the lifetime sediment accumulation that the pond will have to handle. Several time periods may be considered, representing expected changes in land use in the watershed. To estimate sediment accumulation, an estimate of pond efficiency will be required (refer to the Pennsylvania Handbook of Best Management Practices for Developing Areas). The analysis of watershed sediment loss and pond efficiency can be expedited by using a sediment delivery computer model. In the absence of site-specific sediment loss computations, sediment removal from ponds should be anticipated as follows:

- Extended detention ponds: Once every 2 to 10 years
- Wet ponds: Once every 5 to 15 years

Sediment removal is usually the largest single cost of maintaining a BMP facility; therefore, it is best to plan ahead and set aside the necessary funds in advance.

The sediment removed from a pond must be disposed of. The best solution is to have an onsite area or a site adjacent to the facility, but outside of the floodplain, set aside for the sediment. If such a disposal area is not set aside, transportation and landfill tipping fees can greatly increase the cost.

Disposal of wet sediment is not allowed in many landfills, so the material often must be dried (dewatered) before being disposed of. This extra step adds to the cost and requires a place where wet material can be temporarily placed to dry. The additional cost of sediment removal for a wet pond is partially offset by the longer interval between dredging cycles.

Wet sediment is more difficult and expensive to remove than dry sediment. Ideally, the entire facility can be drained and allowed to dry sufficiently so that heavy equipment can operate on the bottom. Provisions for draining permanent pools shall be incorporated in the design of wet ponds where feasible. Also, low flow channels and outlets shall be included in all ponds to bypass stormwater flow during maintenance. However, in many wet ponds and extended detention dry ponds, periodic rainfall will maintain the sediment in a soft condition, preventing access by heavy equipment. In these cases, sediment may need to be removed from the shoreline by using backhoes, gradalls, or similar equipment.

Sediment Removal - Infiltration Devices
Infiltration devices include infiltration trenches, dry wells, and seepage beds beneath permeable pavements. Infiltration facilities are prone to losing function from clogging by sediment. Therefore, these facilities shall be inspected two to four times a year. One purpose of regular inspection is to determine if the sediment-trapping measures, such as filter fabric or graded sand filter, require routine maintenance. Keeping the sediment filter clean is vital to ensuring the long-term performance of the infiltration trench. Although maintenance must be undertaken more often with infiltration than with other facilities, the costs are significantly less.

For trenches or dry wells, periodic maintenance requirements usually include removing the top 6 to 12 inches of filter gravel and replacing the filter fabric sediment filter covering the aggregate reservoir. A layer of clean filter gravel replaces the gravel removed. The maintenance of permeable pavement systems requires the routine sweeping of surfaces.

A clogged sediment filter is indicated when water cannot flow into the device and instead surcharges. However, suspended sediment may clog the interface of the seepage reservoir and the native soil to which the stored water must eventually exfiltrate. All infiltration devices shall be provided with standpipes to observe water levels. If an overflow condition exists, the observation standpipe should be checked to determine the cause. If the device continues to overflow after the sediment filter is repaired and stays filled with water after a rain, then the aggregate stone must be excavated and the facility rebuilt.

7.4.4 Maintenance Responsibilities

When a maintenance program is designed, safety, cost, and effectiveness of the maintenance need to be balanced. Some maintenance can be cost-effectively undertaken by facility owners, if desired. Minor landscaping tasks, litter removal, and mowing are tasks appropriate for owners to handle.

However, it is usually worth the cost to have a professional do the more difficult work. Mowing and handling a wheelbarrow can be dangerous on the sloping embankments of an extended detention dry pond. Filling eroded areas and soil-disturbing activities, such as resodding or replanting vegetation, also are tasks that a professional landscaping firm might best manage. If not performed properly the first time, not only will the effort have been wasted, but damage may also be done to the facility by creating excessive erosion. Grading and sediment removal are best left to professional contractors. In addition, trained personnel will be able to identify potential problems in their early stages of development when repairs or alterations can be made cost-effectively.

7.4.5 Estimating Routine Costs

The routine costs of maintaining a BMP will be highly site-specific. Factors that influence costs include the type of development on the site and the landscape of the site. Routine maintenance includes inspections, debris and litter control, mechanical components maintenance, vegetation management, and other routine tasks as determined for the specific facility. Quotations should be obtained from firms experienced with the tasks that are relevant for selected BMPs. If high costs are projected, then modifying the design or using alternative BMPs with lower maintenance costs should be considered.

7.4.6 Estimating Nonroutine Costs

Costs for nonroutine maintenance of BMPs is also highly site-specific and will vary greatly depending on the size and depth of the facility, the volume of sediment trapped in the BMP, the accessibility of the BMP, and whether or not onsite disposal of the dredged sediment is possible. In general, maintenance costs for both wet and dry pond are similar unless otherwise noted.

One of the larger fixed costs in dredging a BMP facility is the mobilization and demobilization of the machinery and personnel needed to dredge a BMP. Large wet ponds or flood control dams often will require a waterborne operation during which an excavator or a crane must be mounted to a floating barge and moved into position. The cost of such an operation readily approaches $30,000. For smaller ponds, which can be drained or dredged readily from the banks, the cost of mobilizing and demobilizing for this type of operation will range from between $5,000 to $7,000 (Northern Virginia Planning District Commission (NVPDC), BMP Maintenance in the Occoquan Watershed, Annandale VA, 1992).

The costs of physically dredging the sediment from a BMP once mobilization has taken place depend on the total volume (in cubic yards) of sediment removed. The cost per cubic yard is largely influenced by the depth of the water and the distance between the excavation area and the “staging area” where sediment is transferred to trucks for removal. A further consideration is whether the equipment can easily access the BMP bottom. The cost range for dredging can range from $6 to $15 per cubic yard.

7.4.7 Planning Ahead

The costs of maintaining a BMP over the long run can be considerable, particularly if dredging or other nonroutine maintenance is required. To lessen the immediate financial impact of the nonroutine costs, the party responsible for BMP maintenance should create a sinking fund for this eventuality. For dry ponds, from which sediment must be removed every 2 to 10 years, 10 percent to 50 percent of the anticipated dredging costs should be collected each year. For wet ponds, which need to be dredged every 5 to 15 years, approximately 6 percent to 20 percent of the anticipated costs should be accrued per year. Present value of the assessment can include anticipated interest.

7.4.8 Access for Maintenance

Access for inspections, maintenance personnel, and equipment must be provided to all areas of a facility that must be observed or maintained. The location and configuration of easements must be established during the design phase, built to the design standards during the initial construction of the facility, and maintained regularly. The areas requiring access include the dam embankment, emergency spillway, side slopes, inlets, sediment forebays, riser structures, BMP devices, and pond outlets. To provide access for heavy equipment, a suitable 10-foot-wide roadway in a 20-foot-wide cleared access easement must be provided to the BMP facility. At large or regional facilities, additional easements to both upstream and

downstream areas shall be provided for maintenance access, and additional improvements, such as all-weather roads, access restrictions, and vandalism deterrents shall be considered.

7.4.9 Maintenance Agreements

An agreement providing for long-term maintenance shall accompany the installation of any BMP, including ponds, constructed treatment wetlands, bioretention areas, and grass swales. In many cases the agreements will be incorporated in conventional grounds maintenance contracts.

Maintenance agreements shall be specific regarding schedules and required tasks such as inspections, routine and nonroutine maintenance obligations, and emergency response measures. In addition, the agreement shall include clauses to allow the municipality to conduct the maintenance, if the owner/operator fails to inspect and maintain the facility in accordance with an established maintenance schedule. Typical agreements also include indemnification and hold harmless clauses, and are recorded in the land records of the municipality.

For some facilities, exploring the possibility of obtaining the participation of the local municipality in maintaining the facility may be worthwhile. Easements for BMPs that are not publicly maintained shall include provisions to permit public inspection and maintenance (including reimbursement to the public agency for incurred costs) if a private organization fails in its maintenance responsibility and creates a public nuisance. The owner typically maintains facilities for commercial, industrial, and rental residential developments.

7.5 Effective Site Planning

Avoiding the adverse effects of development requires the preparation of a comprehensive watershed management program. In addition to structural and nonstructural BMPs, elements of a watershed management program include growth management, land-use planning, long-term operation and maintenance, public education, and dedicated funding sources. This section presents techniques for site planning that can enhance land values while reducing the water-resource effects of pending development.

7.5.1 Some Important Principles of Effective Site Planning

A central premise of site planning is that effective site layouts and designs can minimize the need for conventional structural measures, such as storm sewers, thereby reducing the costs of development. Site planning also benefits from an appreciation of the inherent value of natural features in providing essential hydrologic functions and enhancing a site's aesthetic and recreational value.

Efficient site planning can be facilitated by local government ordinances that are flexible in allowing innovative layouts or clustering of development to avoid intruding on sensitive areas or natural drainage features. Similarly, it is helpful if both developers and local governments are open to alternative landscaping approaches, which can both lower long-term maintenance costs and reduce offsite impacts.

A truly comprehensive program for watershed management involves extensive planning by state and local government and coordination with potential developers. A comprehensive program might include:

- Permanently protecting sensitive resources through site acquisition, or negotiation and development of conservation easements, and use of transfer of development rights (TDRs).
- Preserving protective buffers adjacent to waterbodies and wetlands.

- More effectively mitigating the effects of development by using innovative approaches, such as wetland mitigation banking.
- Exploiting opportunities for restoring degraded waterbodies or wetlands.

Site planning and design is a complicated process involving many components. Traditional site planning must address zoning, densities, setbacks, access, traffic patterns, and a number of other factors. Additional site planning elements necessary to meet water-quality and sensitive-area objectives, include:

- Identifying and mapping sensitive areas, amenities, soil, and natural drainage features early in the planning process.
- Developing a plan for avoiding or enhancing sensitive areas.
- Developing a plan for preserving or enhancing the site's natural hydrologic and pollutant filtering functions.

7.5.2 Resources for Identifying and Mapping Sensitive Areas

The site planner can preliminarily identify some sensitive areas by using existing mapping resources available from federal, state, regional, and local entities. Below is a partial list of resources:

- U.S. Fish and Wildlife Service - National Wetlands Inventory (NWI) Maps.
- U.S. Department of Agriculture, Natural Resources Conservation Service - County Soil Surveys and Hydric Soils List.
- U.S. Geological Survey - Topographic maps, hydrologic atlas series maps, and information on the occurrence of karst bedrock in Pennsylvania.
- Federal Emergency Management Agency (FEMA) - Flood insurance study maps.
- Aerial photos (with planimetric features).

The above resources may be available from Planning Commissions, Municipal Offices, and County Conservation Districts.

In general, the materials from these resources are appropriate only for preliminary planning. In most cases, the delineation or quality of a sensitive area can be determined only through on-site evaluation. In particular, proper identification of wetlands requires knowledge of hydrology, soil, and vegetation as mandated by current federal wetland-determination methods. A wetlands scientist can be consulted to provide standard field identification practices to identify wetland and riparian plant and animal species and hydrologic conditions of wetlands and wetlands soil.

Overlay mapping techniques and the use of geographic information systems (GIS) are useful approaches for identifying the most critical areas in need of protection during development.

The sensitive areas must be identified early in the site planning process. Working from a map that compiles information from several "layers" encourages innovative site layout to prevent conflicts with critical areas. Such avoidance early in the project prevents costly reevaluation and redrawing of site plans after the conflict is identified by a permit reviewer or third party.

7.5.3 Important Functions of Sensitive Areas and How They are Best Protected

Certain sensitive areas have unique hydrologic, habitat, or pollution-mitigation characteristics that warrant special protection. The areas are particularly susceptible to damage during site development. These categories include:

- Stream corridors
- Wetlands
- Steep slopes and highly erodible soils
- Karst bedrock

Stream Corridors
Stream corridors include waterways and adjacent riparian lands. Natural waterways provide habitat for fish, aquatic plants, and benthic (bottom dwelling) organisms. Development in waterways may destroy aquatic organisms and introduce large loads of sediment and pollutants into the waterways. Modifying waterways to accommodate development also may destroy the physical features essential to a good habitat, including: stable stream banks and bottom substrates, pools and riffles, meanders, and spawning areas.

Vegetated riparian land adjacent to streams stabilizes the stream bank, filters pollutants from storms and floods, and provides habitats for a variety of amphibians, aquatic birds, and mammals that depend on the proximity to water for their life functions. Development in riparian corridors can impair the functions and subject structures to damage from flooding and the meandering of natural streams.

A filter strip or riparian forested buffer shall be preserved or created along the banks of streams, where possible. Furthermore, consideration shall be given to establishing setbacks for intensive development (e.g., buildings, parking lots, roadways). This will minimize the potential for sediment releases to the streams, as well as maintain the corridor to achieve flood control, water quality, and habitat enhancement objectives. If a development site contains a highly channelized stream, the best interest of both the developer and the aquatic resource may be served by restoring the stream corridor.

Shorelines of ponds, lakes, and wetlands provide many of the same functions as riparian stream corridors provide for streams. Stable vegetated shorelines are particularly valuable in preventing erosion caused by wave action. Protection of shorelines shall be considered when undertaking water dependent development, such as piers and marinas.

Wetlands
Wetlands provide unique habitats for both plants and wildlife, including many sensitive and endangered species. As a consequence, wetlands are valued for aesthetic and recreational reasons. Wetlands also provide valuable flood storage, groundwater recharge, and pollutant-filtering functions.

Wetlands are widely scattered throughout Pennsylvania and commonly are encountered on development sites. Protecting the natural functions of wetlands is a critical element of the site planning process. For moderate to high-quality wetlands, which are very difficult to replace, avoidance is recommended. If the site contains scattered, small, low-quality wetlands, which are more readily replaced, mitigating the wetlands at a central location may be more appropriate, thereby enhancing wetland functions and reducing a potential constraint to development.

Steep Slopes and Highly Erodible Soils
From an erodibility standpoint, the definition of steep can vary depending on surface soil type and underlying geology. In general, extra caution is warranted on a slope exceeding 10 percent (1 foot of vertical drop per 10 feet of horizontal distance). However, even flatter slopes that have soil classified as highly erodible shall be identified as steep.

Disturbing steep slopes with development causes instability of the soil on the slopes. Development destroys vegetation, root systems, and soil structures. High runoff velocities from exposed steep slopes result in destructive and unsightly erosion, denuded slopes that may be difficult to revegetate, and sediment deposition in sensitive areas both on and off the site.

A general rule to be followed in site development is to minimize the area and time of disturbance and to fit the development to the natural terrain. Stabilizing vegetation shall be protected to the maximum extent practicable and disturbed areas shall be immediately revegetated.

Karst Bedrock
Karst bedrock areas are underlain by bedrock containing soluble minerals. Karst areas develop voids and solution channels as groundwater gradually dissolves the bedrock. In these terrains, groundwater flow can be extremely rapid and unpredictable. Furthermore, the concentration of runoff may stimulate the formation of sinkholes. Sinkholes can develop as flowing water exposes and then washes into the mouths of the near surface openings of subterrain channels and caverns. Rapid degradation of groundwater resources can result when sediment or pollutant-laden runoff percolates into karst bedrock aquifers.

Some areas of the White Deer Creek Watershed are underlain by limestone, dolomite, or marl carbonate rocks, which are potentially susceptible to the development of karst conditions (Plate 8). Before introducing site alterations, which could result in concentrated runoff or ponded water, the presence or absence of carbonate bedrock shall be established. If carbonate geology is present, a professional geologist or civil engineer shall be consulted to determine whether sink hole activity is likely. The United States Geological Survey is a good source of information on karst bedrock in Pennsylvania. If an area is prone to sink hole development, site drainage shall be planned to minimize the concentration of runoff. This can be accomplished by reducing the hydraulic connectivity of impervious surfaces and by the use of filter strips. Where they are required, channels or ponds shall be lined.

BMPs for the recharge of groundwater in karst areas provide infiltration opportunities over a very large area. Examples are filter strips, large bioretention facilities, and permeable pavement. These practices mimic the natural process by which rainfall enters the subsurface. Point sources of infiltration, such infiltration trenches or dry wells, shall be avoided.

7.5.4 Preserving Natural Hydrologic Conditions

Natural hydrologic conditions and pollutant-filtering mechanisms may be altered radically by poor development practices. Deleterious activities include introducing impervious surfaces, destroying existing drainage paths, constructing storm sewers, and changing local topography. A traditional drainage approach of development has been to remove runoff from the site as quickly as possible. To provide this convenience, substantial resources have been invested to convey runoff from developing areas. This approach leads ultimately to the expenditure of additional resources for detaining and managing concentrated runoff at some downstream location. In the meantime, developed areas, starved for rainfall infiltration, are deprived of perennial streams and natural habitat.

The recommended alternative approach is to minimize post-development runoff rates, thereby minimizing needs for artificial conveyance and storage. To maintain pre-development hydrologic conditions, areas must be preserved for infiltrating water directly into the ground and to pond runoff on the ground surface from which it is ultimately evaporated or infiltrated. Beneficial results include more stable baseflows in receiving streams, improved groundwater recharge, reduced flood flows, reduced pollutant loads, and reduced costs for conveyance and storage.

Preserving natural hydrologic conditions requires both implementing appropriate stormwater BMPs and practicing alternative site design. Alternative site design measures, which are described below, are essential for limiting increases in the volume of runoff and better controlling runoff quality. Site design practices include minimizing impervious surface area, reducing the hydraulic connectivity of impervious surfaces, preserving natural drainage features, and protecting natural depression storage. A well-designed site will contain a mix of structural BMPs and site design BMPs.

7.5.5 Reducing or Disconnecting Impervious Surface Areas

Minimizing impervious surface areas is probably the most effective way to preserve predevelopment hydrology. Techniques include:

Reducing Building Setbacks
Reducing building setbacks reduces driveway and entry walks and is most readily accomplished along low-traffic streets where traffic noise is not a problem.

Reducing Street Widths
Street widths can be reduced by either eliminating onstreet parking or by reducing roadway widths. Municipal planners and traffic designers are beginning to favor narrower neighborhood streets for non-stormwater reasons that include lower maintenance costs, more taxable land, and creation of a friendlier residential environment.

Limiting Sidewalks to One Side of the Street
A sidewalk on one side of the street may suffice in low-traffic neighborhoods. The lost sidewalk could be replaced with bicycle recreational trails that follow back-of-lot lines. Where appropriate, backyard trails shall be constructed using pervious materials.

Constructing Cluster Developments
Cluster developments can also reduce the amount of impervious area for a given number of lots. The biggest savings is in street length, which also will reduce costs of the development.

Using Permeable Paving Materials
These materials include permeable interlocking concrete paving blocks or porous bituminous concrete. Such materials should be considered as alternatives to conventional pavement surfaces, especially for low-use surfaces such as driveways, overflow parking lots, and emergency access roads.

Reducing the Hydraulic Connectivity of Impervious Surfaces
Impervious surfaces are significantly less of a problem with respect to runoff pollutants if they are not directly connected to an impervious conveyance system (such as storm sewer). Two basic ways to reduce hydraulic connectivity are routing of roof runoff over lawns and reducing the use of storm sewers.

Routing Roof Runoff Over Lawns
Roof runoff can be easily routed over lawns in most site designs. The practice discourages direct connections of downspouts to storm sewers or parking lots. The practice also discourages sloping driveways and parking lots to the street. By routing roof drains and crowning the driveway to run off to the lawn, the lawn is essentially used as a filter strip.

Reducing the Use of Storm Sewers
By reducing use of storm sewers for draining streets, parking lots, and back yards, the potential for infiltrating and filtrating runoff from impervious surfaces can be greatly enhanced. The practice requires greater use of swales and may not be practical for some development sites, especially if there are concerns for areas that do not drain in a "reasonable" time. The practice requires educating local citizens and public works officials, who expect runoff to disappear shortly after a rainfall event.

7.5.6 Preserving Natural Drainage Features

Protecting natural drainage features, particularly vegetated drainage swales and channels, is desirable because of their ability to infiltrate and attenuate flows and to filter pollutants. However, this objective is often not accomplished in modern developments. In fact, commonly held drainage philosophy encourages just the opposite pattern. Streets and adjacent storm sewers typically are located in the natural headwater valleys and swales, thereby replacing natural drainage functions with a completely impervious system. Runoff and pollutants generated from impervious surfaces flow directly into storm sewers with no opportunity for attenuation, infiltration, or filtration.

One method of preserving natural drainage features is to use cluster development to avoid disturbing major swales. Another recommended approach is to develop site plans that keep roads and parking areas higher in the landscape and locate existing swales along back lot lines within drainage easements.

7.5.7 Protecting Natural Depression Storage Areas

Depressional storage areas have no surface outlet or drain very slowly following a storm event. They can be commonly seen as ponded areas in farm fields during the wet season or after large runoff events. Traditional development practices eliminate these depressions by filling or draining, thereby obliterating their ability to reduce surface runoff volumes and trap pollutants. The volume and release-rate characteristics of depressions shall be protected in the design of the development site. The depressions can be protected by simply avoiding the depression or by incorporating its storage as additional capacity in required detention facilities.

7.6 Site Planning and Land-Use Techniques to Minimize Efforts of Development

The surest way to minimize disturbances to sensitive areas and natural features is to avoid them. However, absolute avoidance is not always practical. Further, avoidance alone may not be sufficient for protecting beneficial functions. In understanding the critical functions of sensitive areas, site planners and designers, in cooperation with local zoning officials and plan reviewers, can implement planning concepts

that both protect the resource and add to the value of the development and the community. Some of the concepts most useful for protecting sensitive areas include:

- Providing *setbacks* and *buffers* between development and sensitive areas.
- *Cluster development* clusters the construction activity onto less-sensitive areas without substantially affecting the gross density of development.
- *Zoning overlay districts* identify in advance sensitive areas that generally are unsuitable for intense development.
- *Conservation easements* provide tax incentives for dedicating and preserving sensitive habitats.
- *Development designed to fit site topography* minimizes the amount of grading on the site.
- *Construction phasing* minimizes the time of disturbance by limiting grading activities only to areas where development is imminent.

7.6.1 Setbacks and Buffers

A *setback* is the area between intensive development (i.e., buildings, parking lots, roads) and a protected area, such as a wetland. Setbacks are necessary for:

- Controlling the peripheral effects of development
- Protecting developments
- Providing access for maintenance

For example, a highway or parking lot built directly on the edge of a high-quality wetland may adversely affect water quality and wildlife habitat from pollutant runoff or spray and traffic noise. Setback requirements for structures, particularly adjacent to streams, reflect the fact that streams naturally meander or expand over time. Placing structures in the natural path of a meandering stream virtually guarantees that expensive stabilization measures will be needed in the future as the stream approaches building foundations, threatening their collapse.

Only limited activities are recommended for approval in a setback. The types of activities include minor improvements, such as walkways, foot bridges, and observation decks; roadways necessary for crossing a waterbody; maintenance and repair of existing roads and utilities; and the establishment of landscaped lawns or parks. In general, major modifications to the land surface shall be avoided in setbacks.

Limiting activities in a *floodway* to appropriate uses is similar to a setback requirement. A floodway is the part of the floodplain, centered on the stream, that will convey most of the flow during a high water event. Appropriate uses exclude most buildings and structures. However, other uses that are allowed may adversely affect water quality and habitat. These include:

- Parking lots
- Roadways parallel to the waterbody
- Garages and storage sheds
- Treatment plants and pumping facilities

Within a setback, a *buffer strip* is the transitional vegetated area closest to the waterbody or wetland. The purposes of a buffer are to:

- Minimize erosion
- Stabilize the stream bank or lakeshore
- Filter runoff pollutants from adjacent developments
- Preserve fish and wildlife habitat
- Screen manmade structures and preserve aesthetic values
- Provide access for maintenance or trails

Buffers reflect that natural aquatic systems may not function well in isolation and that a gradual continuum exists from natural riparian or wetland systems to upland. Ideally, a buffer should be maintained or planted in native riparian vegetation to maximize pollutant filtering, soil stabilization, and habitat functions.

7.6.2 Cluster Development

One of the best site planning techniques for minimizing the disturbance of sensitive areas and natural drainage features while allowing for reasonable economic use of the land is to use cluster developments. Cluster development maintains the gross density of the site but clusters the development (i.e., roads, buildings, parking lots, manicured landscape) onto only a part of the site, thereby protecting sensitive areas with no loss in the number of lots. In the traditional development, the entire subdivision is composed of either lots or streets. In the cluster development, natural areas are maintained between clusters of lots. Although the individual lots are smaller in the cluster development, often the impression is one of lower density because of the intermixing of natural areas and green space in the developed areas.

Cluster development may be readily accomplished under the provisions of a planned unit development (PUD). In a PUD, a municipality may allow higher net densities as a tradeoff for protecting sensitive areas, as long as the gross density meets zoning requirements. This approach requires flexibility from both the developer and the local government and shall be accompanied by a resource management plan to ensure long-term management and maintenance of sensitive features and common areas. Ideally, cluster development will allow environmental objectives to be achieved without contributing to suburban sprawl, and without unduly reducing the property owner's return on land value.

The best application of the cluster concept is to avoid sensitive areas. By using clustering, only the areas most suited for development are subject to grading and modifications to accommodate the development and the sensitive areas are set aside and not modified. To meet the development goals in terms of the number of units required, the density is increased in the areas that are most suited for development. This reduces development costs for "engineering" the land to accommodate the development and for mitigation that generally is required for disturbance of streams and wetlands. Clustering has additional benefits in terms of improved aesthetics, increased open space, and reduced infrastructure costs.

When cluster developments are designed, all offsite impacts, including environmental, must be considered. For example, although PUDs often are typified in reference materials by dead-end "cul-de-sac" streets, it is important to traffic flow that all auto trips not be routed from local streets to major arterials. By using loop streets and collector streets to connect adjacent clusters, the traffic pressure on the arterials can be reduced.

7.6.3 Zoning Restrictions

Some local governments place explicit zoning restrictions on wetlands, stream corridors, and woodlands. Using this approach, a municipality identifies sensitive areas on its zoning map.

Tree ordinances are becoming more popular with municipalities. The ordinances protect both woodlands and individual trees.

7.6.4 Conservation Easements

Another useful tool for protecting sensitive areas is a conservation easement. A conservation easement incorporates legal provisions into a property deed that limits the use of the property. Conservation easements allow for the continued private ownership of the land but restrict land uses to current uses or to non-damaging activities. The legal concession may be donated by or purchased from the owner. The land owner also may be compensated by reduced property taxes on the land in the easement.

7.6.5 Development Designed to Fit Site Topography

Too often sites are extensively graded to create site topography to fit a plan that was designed in the office rather than creating a design for the site to avoid the need for major changes in the elevation contours. Not only is mass grading expensive, it requires stripping, stockpiling, and replacing the top soil and results in compaction of the soil, destruction of natural drainageways, and loss of site diversity. By varying lot sizes and building styles and by using at least limited clustering, the need for mass grading can be reduced substantially.

Section 8 – Plan Review Adoption and Updating Procedures

8.0 Plan Review and Adoption

The opportunity for local review of the draft Stormwater Management Plan is a prerequisite to county adoption of the Plan. Local review of the Plan is composed of five parts, namely Watershed Plan Advisory Committee review, Legal Advisory Committee review, Municipal Engineer's Committee review, municipal review, and County review. Local review of the draft Plan is initiated with the completion of the Plan by the UCPC and distribution to the aforementioned parties. Presented below is a chronological listing and brief narrative of the required local review steps through County adoptions.

1. Watershed Plan Advisory Committee Review - This body has been formed to assist in the development of the White Deer Creek Watershed Plan. Municipal members of the Committee have provided input data to the process in the form of storm drainage problem area documentation, storm sewer documentation, proposed solutions to drainage problems, etc. The Committee met on four occasions to review the progress of the Plan. Municipal representatives on the Committee have the responsibility to report on the progress of the Plan to their respective municipalities. Review of the draft Plan by the Watershed Plan Advisory Committee will be expedited by the fact that the members are already familiar with the objectives of the Plan, the runoff control strategy employed and the basic contents of the Plan. The output of the Watershed Plan Advisory Committee review will be a revised draft Plan for municipal and County consideration.

2. Municipal Engineers Committee Review - This body has been formed to educate the Municipal Engineers on the ordinance adoption and implementation requirements of the Plan. The committee met twice to receive comments and direction in the development of the model ordinance. The output of the Municipal Engineers Committee review will be a revised draft model ordinance for municipal and County consideration.

3. Legal Advisory Committee Review - This body has been formed to educate the municipal solicitors on the ordinance adoption and implementation requirements of the Plan. The committee met to receive comments and direction in the development of the model ordinance. The output of the Legal Advisory Committee review will be a revised draft model ordinance for municipal and County consideration.

4. Municipal Review - Act 167 specifies that prior to adoption of the draft Plan by the County, the planning commission and governing body of each municipality in the study area must review the Plan for consistency with other plans and programs affecting the study area. Of primary concern during the municipal review would be the draft White Deer Creek Watershed - Act 167 - Stormwater Management Ordinance that would implement the Plan through municipal adoption. The output of the municipal review will be a letter directed to the counties outlining the municipal suggestions, if any, for revising the draft Plan (or Ordinance) prior to adoption by the County.

5. County Review and Adoption - Upon completion of the review by the Watershed Plan Advisory Committee, Municipal Engineer's Committee, Legal Advisory Committee and each municipality, the draft Plan will be submitted to the Union County Board of Commissioners for their consideration.

The Union County review of the draft Plan will include a detailed review by the County Board of Commissioners and an opportunity for public input through the holding of public hearings. Public hearings on the draft Plan must be held with a minimum two-week notice period with copies of the draft Plan available for inspection by the general public. Any modifications to the draft Plan would be made by the County based upon input from the public hearings, comments received from the municipalities in the study area or their own review. Adoption of the draft Plan by Union County would be by resolution and require an affirmative vote of the majority of members of the County Board of Commissioners.

The adopted Plan would be submitted by the County to DEP for their consideration for approval. Accompanying the adopted Plan to DEP would be the review comments of the municipalities.

8.1 Procedure for Updating the Plan

Act 167 specifies that the County must review and, if necessary, revise the adopted and approved study area plan every five years, at minimum. Any proposed revisions to the Plan would require municipal and public review prior to County adoption consistent with the procedures outlined above. An important aspect of the Plan is a procedure to monitor the implementation of the Plan and initiate review and revisions in a timely manner. The process to be used for the White Deer Creek Watershed Stormwater Management Plan will be as outlined below.

1. Monitoring of the Plan Implementation - The Union County Planning Commission will be responsible for monitoring the implementation of the Plan by maintaining a record of all development activities within the study area. Development activities are defined and included in the recommended Municipal Ordinance. Specifically, the UCPC will monitor the following data records:

    a. All subdivision and land developments subject to review per the Plan which have been approved within the study area.
    b. All building permits subject to review per the Plan which have been approved within the study area.
    c. All DEP permits issued under Chapter 105 (Dams and Waterway Management) and Chapter 106 (Floodplain Management) including location and design capacity (if applicable).

2. Review of Adequacy of Plan - The Watershed Plan Advisory Committee will be convened periodically to review the Stormwater Management Plan and determine if the Plan is adequate for minimizing the runoff impacts of new development. At minimum, the information to be reviewed by the Committee will be as follows:

    a. Development activity data as monitored by the UCPC.
    b. Information regarding additional storm drainage problem areas as provided by the municipal representatives to the Watershed Plan Advisory Committee.
    c. Zoning amendments within the study area.
    d. Information associated with any regional detention alternatives implemented within the study area.
    e. Adequacy of the administrative aspects of regulated activity review.

The Committee will review the above data and make recommendations to the County as to the need for revision to the White Deer Creek Watershed Stormwater Management Plan. Union County will review

the recommendations of the Watershed Plan Advisory Committee and determine if revisions are to be made. A revised Plan would be subject to the same rules of adoption as the original Plan preparation. Should the County determine that no revisions to the Plan are required for a period of five consecutive years, the County will adopt resolutions stating that the Plan has been reviewed and been found satisfactory to meet the requirements of Act 167 and forward the resolution to DEP.

Section 9 – Priorities for Implementation of Technical Standards and Criteria

9.0 Summary of Plan Conclusions and Recommendations

The Pennsylvania Stormwater Management Act, Act 167 of 1978, provides the framework for improved management of the storm runoff impacts associated with the development of land. The purposes of the Act are to encourage the sound planning and management of storm runoff, to coordinate the stormwater management efforts within each watershed, and to encourage the local administration and management of a coordinated stormwater program.

While the White Deer Creek Watershed is largely undeveloped, it is not without stormwater related problems as evident by the results of the municipal data questionnaires and significant obstructions. Act 167 cannot directly correct existing stormwater management problems; however, it will provide the framework, through this Plan, for sound stormwater management in the future. Therefore, future development in the watershed should not create additional stormwater related problems. This Plan proposes a comprehensive approach to stormwater management at new developments. The approach, often called the "five phase approach", sets minimum standards for treatment of water quality, groundwater recharge, protection of stream channels, and management of peak flows and volumes associated with both common storms and infrequent events. These technical criteria are implemented simultaneously through the adoption, by the municipalities, of a stormwater management ordinance that is consistent with the Plan.

Section 10 - Model Act 167 Stormwater Management Ordinance

PLEASE HAVE YOUR SOLICITOR REVIEW THE ENCLOSED ORDINANCE AND CHECK THE APPLICABILITY OF ALL SECTIONS TO YOUR MUNICIPALITY

WHITE DEER CREEK WATERSHED

STORMWATER MANAGEMENT ORDINANCE

Implementing the Requirements of the

White Deer Creek Watershed Stormwater Management Plan

ORDINANCE NO. _____ OF

_____, Union COUNTY, PENNSYLVANIA

Adopted at a Public Meeting Held on
_____, 20__

TABLE OF CONTENTS **PAGE**

ARTICLE I- GENERAL PROVISIONS 60
Section 101. Statement of Findings 60
Section 102. Purpose 60
Section 103. Statutory Authority 60
Section 104. Applicability 61
Section 105. Repealer 61
Section 106. Severability 61
Section 107. Compatibility With Other Ordinance Requirements 61

ARTICLE II-DEFINITIONS 62

ARTICLE III-STORMWATER MANAGEMENT 69
Section 301. General Requirements 69
Section 302. Water Quality Requirements 70
Section 303. Ground Water Recharge (Infiltration/Recharge/Retention) 71
Section 304. Stream Bank Protection Requirements 74
Section 305. Stormwater Management Districts 75
Section 306. Stormwater Management District Implementation Provisions (Performance Standards) 75
Section 307. Design Criteria for Stormwater Management Facilities 78
Section 308. Calculation Methodology 79
Section 309. Erosion and Sedimentation Requirements 80

ARTICLE IV-DRAINAGE PLAN REQUIREMENTS 81
Section 401. General Requirements 81
Section 402. Exemptions 81
Section 403. Drainage Plan Contents 81
Section 404. Plan Submission 84
Section 405. Drainage Plan Review 84
Section 406. Modification of Plans 86
Section 407. Resubmission of Disapproved Drainage Plans 86

ARTICLE V-INSPECTIONS 86
Section 501. Schedule of Inspections 86

ARTICLE VI-FEES AND EXPENSES 86
Section 601. General 86
Section 602. Municipality Drainage Plan Review Fee 86
Section 603. Expenses Covered by Fees 87

ARTICLE VII-MAINTENANCE RESPONSIBILITIES 87
Section 701. Performance Guarantee 87
Section 702. Maintenance Responsibilities 87
Section 703. Maintenance Agreement for Privately Owned Stormwater Facilities 88
Section 704. Municipal Stormwater Maintenance Fund 88

ARTICLE VIII-ENFORCEMENT AND PENALTIES 89
Section 801. Right-of-Entry 89
Section 802. Notification 89
Section 803. Enforcement 89
Section 804. Public Nuisance 90
Section 805. Penalties 90
Section 806. Appeals 91

Appendices

APPENDIX A - STANDARD STORMWATER FACILITIES MAINTENANCE AND MONITORING AGREEMENT 92
APPENDIX B - STORMWATER MANAGEMENT DESIGN CRITERIA 96
APPENDIX C - SAMPLE DRAINAGE PLAN APPLICATION AND FEE SCHEDULE 106
APPENDIX D - COMPUTATION OF CHANNEL PROTECTION STORAGE VOLUME 112

ARTICLE I - GENERAL PROVISIONS

Section 101. Statement of Findings

The governing body of the Municipality finds that:

A. Inadequate management of accelerated stormwater runoff resulting from development throughout a watershed increases flood flows and velocities, contributes to erosion and sedimentation, overtaxes the carrying capacity of existing streams and storm sewers, greatly increases the cost of public facilities to convey and manage stormwater, undermines floodplain management and flood reduction efforts in upstream and downstream communities, reduces groundwater recharge, and threatens public health and safety.

B. A comprehensive program of stormwater management, including reasonable regulation of development and activities causing accelerated erosion, is fundamental to the public health, safety, welfare, and the protection of the people of the Municipality and all the people of the Commonwealth, their resources, and the environment.

Section 102. Purpose

The purpose of this Ordinance is to promote health, safety, and welfare within the White Deer Creek Watershed by minimizing the damages described in Section 101.A. of this Ordinance through provisions designed to:

A. Manage accelerated runoff and erosion and sedimentation problems at their source by regulating activities that cause these problems.

B. Utilize and preserve the existing natural drainage systems.

C. Encourage recharge of groundwater where appropriate and prevent degradation of groundwater quality.

D. Maintain existing flows and quality of streams and watercourses in the Municipality and the Commonwealth.

E. Preserve and restore the flood-carrying capacity of streams.

F. Provide proper maintenance of all permanent stormwater management facilities that are constructed in the Municipality.

G. Provide performance standards and design criteria for watershed-wide stormwater management and planning.

Section 103. Statutory Authority

The Municipality is empowered to regulate land use activities that affect runoff by the authority of the Act of October 4, 1978 32 P.S., P.L. 864 (Act 167) Section 680.1 et seq., as amended, the “Stormwater Management Act”, (and the applicable Municipal Code).

Section 104. Applicability

This Ordinance shall apply to those areas of the Municipality that are located within the White Deer Creek Watershed, as identified in the White Deer Creek Act 167 Stormwater Management Plan.

This Ordinance shall only apply to permanent stormwater management facilities constructed as part of any of the Regulated Activities listed in this Section. Stormwater management and erosion and sedimentation control during construction activities are specifically not regulated by this Ordinance, but shall continue to be regulated under existing laws and ordinances.

This Ordinance contains only the stormwater management performance standards and design criteria that are necessary or desirable from a watershed-wide perspective. Local stormwater management design criteria (e.g., inlet spacing, inlet type, collection system design and details, outlet structure design, etc.) shall continue to be regulated by the applicable Municipal Ordinances or at the Municipal Engineer's discretion.

The following activities are defined as "Regulated Activities" and shall be regulated by this Ordinance:

A. Land development.

B. Subdivision.

C. Construction of new or additional impervious or semi-pervious surfaces (driveways, parking lots, etc.).

D. Construction of new buildings or additions to existing buildings.

E. Diversion or piping of any natural or man-made stream channel.

F. Installation of stormwater management facilities or appurtenances thereto.

Section 105. Repealer

Any Ordinance or ordinance provision of the Municipality inconsistent with any of the provisions of this Ordinance is hereby repealed to the extent of the inconsistency only.

Section 106. Severability

Should any section or provision of this Ordinance be declared invalid by a court of competent jurisdiction, such decision shall not affect the validity of any of the remaining provisions of this Ordinance.

Section 107. Compatibility With Other Ordinance Requirements

Approvals issued pursuant to this Ordinance do not relieve the Applicant of the responsibility to secure required permits or approvals for activities regulated by any other applicable code, rule, act, or Ordinance.

ARTICLE II-DEFINITIONS

For the purposes of this chapter, certain terms and words used herein shall be interpreted as follows:

A. Words used in the present tense include the future tense; the singular number includes the plural, and the plural number includes the singular; words of masculine gender include feminine gender; and words of feminine gender include masculine gender.

B. The word "includes" or "including" shall not limit the term to the specific example, but is intended to extend its meaning to all other instances of like kind and character.

C. The word "person" includes an individual, firm, association, organization, partnership, trust, company, corporation, or any other similar entity.

D. The words "shall" and "must" are mandatory; the words "may" and "should" are permissive.

E. The words "used or occupied" include the words "intended, designed, maintained, or arranged to be used, occupied or maintained."

Accelerated Erosion - The removal of the surface of the land through the combined action of man's activity and the natural processes of a rate greater than would occur because of the natural process alone.

Agricultural Activities - The work of producing crops and raising livestock including tillage, plowing, disking, harrowing, pasturing and installation of conservation measures. Construction of new buildings or impervious area is not considered an agricultural activity.

Alteration - As applied to land, a change in topography as a result of the moving of soil and rock from one location or position to another; also the changing of surface conditions by causing the surface to be more or less impervious; land disturbance.

Applicant - A landowner or developer who has filed an application for approval to engage in any Regulated Activities as defined in Section 104 of this Ordinance.

BMP (Best Management Practice) - Stormwater structures, facilities and techniques to control, maintain or improve the quantity and quality of surface runoff.

Channel Erosion - The widening, deepening, and headward cutting of small channels and waterways, due to erosion caused by moderate to large floods.

Cistern - An underground reservoir or tank for storing rainwater.

Conservation District - The Union County Conservation District.

Culvert - A structure with appurtenant works which carries a stream under or through an embankment or fill.

Dam - An artificial barrier, together with its appurtenant works, constructed for the purpose of impounding or storing water or another fluid or semifluid, or a refuse bank, fill or structure for highway, railroad or other purposes which does or may impound water or another fluid or semifluid.

DEP – The Pennsylvania Department of Environmental Protection

Design Storm - The magnitude and temporal distribution of precipitation from a storm event measured in probability of occurrence (e.g., a 5-year storm) and duration (e.g., 24-hours), used in the design and evaluation of stormwater management systems.

Designee - The agent of the Planning Commission and/or agent of the governing body involved with the administration, review or enforcement of any provisions of this Ordinance by contract or memorandum of understanding.

Detention Basin - An impoundment structure designed to manage stormwater runoff by temporarily storing the runoff and releasing it at a predetermined rate.

Detention District - Those subareas in which some type of detention is required to meet the Plan requirements and the goals of Act 167.

Developer - A person, partnership, association, corporation, or other entity, or any responsible person therein or agent thereof, that undertakes any Regulated Activity of this Ordinance.

Development Site - The specific tract of land for which a Regulated Activity is proposed.

Downslope Property Line - That portion of the property line of the lot, tract, or parcels of land being developed located such that all overland or pipe flow from the site would be directed towards it.

Drainage Conveyance Facility - A Stormwater Management Facility designed to transmit stormwater runoff and shall include streams, channels, swales, pipes, conduits, culverts, storm sewers, etc.

Drainage Easement - A right granted by a landowner to a grantee, allowing the use of private land for stormwater management purposes.

Drainage Permit - A permit issued by the municipal governing body after the drainage plan has been approved. Said permit is issued prior to or with the final municipal approval.

Drainage Plan - The documentation of the stormwater management system, if any, to be used for a given development site, the contents of which are established in Section 403.

Earth Disturbance - Any activity including, but not limited to, construction, mining, timber harvesting and grubbing which alters, disturbs, and exposes the existing land surface.

Erosion - The movement of soil particles by the action of water, wind, ice, or other natural forces.

Erosion and Sediment Pollution Control Plan - A plan that is designed to minimize accelerated erosion and sedimentation.

Existing Conditions - The initial condition of a project site prior to the proposed construction. If the initial condition of the site is undeveloped land, the land use shall be considered as “meadow” unless the natural land cover is proven to generate lower curve numbers or Rational “C” value, such as forested lands.

Flood - A general but temporary condition of partial or complete inundation of normally dry land areas from the overflow of streams, rivers, and other waters of this Commonwealth.

Floodplain - Any land area susceptible to inundation by water from any natural source or delineated by applicable Department of Housing and Urban Development, Federal Insurance Administration Flood Hazard Boundary mapped as being a special flood hazard area. Also included are areas that comprise Group 13 Soils, as listed in Appendix A of the Pennsylvania Department of Environmental Protection (DEP) Technical Manual for Sewage Enforcement Officers (as amended or replaced from time to time by DEP).

Floodway - The channel of the watercourse and those portions of the adjoining floodplains, which are reasonably required to carry and discharge the 100-year frequency flood. Unless otherwise specified, the boundary of the floodway is as indicated on maps and flood insurance studies provided by FEMA. In an area where no FEMA maps or studies have defined the boundary of the 100-year frequency floodway, it is assumed - absent evidence to the contrary - that the floodway extends from the stream to 50 feet from the top of the bank of the stream.

Forest Management/Timber Operations - Planning and activities necessary for the management of forest land. These include timber inventory and preparation of forest management plans, silvicultural treatment, cutting budgets, logging road design and construction, timber harvesting, site preparation and reforestation.

Freeboard - A vertical distance between the elevation of the design high-water and the top of a dam, levee, tank, basin, or diversion ridge. The space is required as a safety margin in a pond or basin.

Grade - A slope, usually of a road, channel or natural ground specified in percent and shown on plans as specified herein. (To) Grade - to finish the surface of a roadbed, top of embankment or bottom of excavation.

Grassed Waterway - A natural or constructed waterway, usually broad and shallow, covered with erosion-resistant grasses, used to conduct surface water from cropland.

Groundwater Recharge - Replenishment of existing natural underground water supplies.

HEC-HMS Model (calibrated) – (Hydrologic Engineering Center Hydrologic Modeling System) A computer-based hydrologic model technique adapted to the White Deer Creek Watershed for the Act 167 Plan. The model has been “calibrated” to reflect actual recorded flow values by adjoining key model input parameters.

Impervious Surface - A surface that prevents the percolation of water into the ground.

Impoundment - A retention or detention basin designed to retain stormwater runoff and release it at a controlled rate.

Infiltration Structures - A structure designed to direct runoff into the ground (e.g., french drains, seepage pits, seepage trench).

Inlet - A surface connection to a closed drain. A structure at the diversion end of a conduit. The upstream end of any structure through which water may flow.

Land Development - (i) the improvement of one lot or two or more contiguous lots, tracts, or parcels of land for any purpose involving (a) a group of two or more buildings, or (b) the division or allocation of land or space between or among two or more existing or prospective occupants by means of, or for the purpose of streets, common areas, leaseholds, condominiums, building groups, or other features; (ii) any subdivision of land; (iii) development in accordance with Section 503(1.1) of the PA Municipalities Planning Code.

Land Earth Disturbance - Any activity involving grading, tilling, digging, or filling of ground or stripping of vegetation or any other activity that causes an alteration to the natural condition of the land.

Main Stem (Main Channel) - Any stream segment or other runoff conveyance facility used as a reach in the White Deer Creek hydrologic model.

Manning Equation in (Manning formula) - A method for calculation of velocity of flow (e.g., feet per second) and flow rate (e.g., cubic feet per second) in open channels based upon channel shape, roughness, depth of flow and slope. "Open channels" may include closed conduits so long as the flow is not under pressure.

Municipality – (municipal name), Union County, Pennsylvania.

Nonpoint Source Pollution - Pollution that enters a watery body from diffuse origins in the watershed and does not result from discernible, confined, or discrete conveyances.

NRCS - Natural Resource Conservation Service (previously SCS).

Open Channel - A drainage element in which stormwater flows with an open surface. Open channels include, but shall not be limited to, natural and man-made drainageways, swales, streams, ditches, canals, and pipes flowing partly full.

Outfall - Point where water flows from a conduit, stream, or drain.

Outlet - Points of water disposal from a stream, river, lake, tidewater or artificial drain.

Parking Lot Storage - Involves the use of impervious parking areas as temporary impoundments with controlled release rates during rainstorms.

Peak Discharge - The maximum rate of stormwater runoff from a specific storm event.

Penn State Runoff Model (PSRM) - A computer-based hydrologic modeling technique.

Pipe - A culvert, closed conduit, or similar structure (including appurtenances) that conveys stormwater.

Planning Commission - The planning commission of [municipal name].

PMF - Probable Maximum Flood - The flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in any area. The PMF is derived from the probable maximum precipitation (PMP) as determined based on data obtained from the National Oceanographic and Atmospheric Administration (NOAA).

Pseudo-hydrograph – A hydrograph derived from an established formula without the need for rainfall-runoff data analysis.

Rational Formula - A rainfall-runoff relation used to estimate peak flow.

Regulated Activities - Actions or proposed actions that have an impact on stormwater runoff and that are specified in Section 104 of this Ordinance.

Release Rate - The percentage of pre-development peak rate of runoff from a site or subarea to which the post development peak rate of runoff must be reduced to protect downstream areas.

Retention Basin - An impoundment in which stormwater is stored and not released during the storm event. Stored water may be released from the basin at some time after the end of the storm.

Return Period - The average interval, in years, within which a storm event of a given magnitude can be expected to recur. For example, the 25-year return period rainfall would be expected to recur on the average of once every twenty- five years.

Riser - A vertical pipe extending from the bottom of a pond that is used to control the discharge rate from the pond for a specified design storm.

Rooftop Detention - Temporary ponding and gradual release of stormwater falling directly onto flat roof surfaces by incorporating controlled-flow roof drains into building designs.

Runoff - Any part of precipitation that flows over the land surface.

Sediment Basin - A barrier, dam, retention or detention basin located and designed to retain rock, sand, gravel, silt, or other material transported by water.

Sediment Pollution - The placement, discharge or any other introduction of sediment into the waters of the Commonwealth occurring from the failure to design, construct, implement or maintain control measures and control facilities in accordance with the requirements of this Ordinance.

Sedimentation - The process by which mineral or organic matter is accumulated or deposited by the movement of water.

Seepage Pit/Seepage Trench - An area of excavated earth filled with loose stone or similar coarse material, into which surface water is directed for infiltration into the ground.

Sheet Flow - Runoff that flows over the ground surface as a thin, even layer, not concentrated in a channel.

Soil-Cover Complex Method - A method of runoff computation developed by the NRCS that is based on relating soil type and land use/cover to a runoff parameter called Curve Number (CN).

Soil Group, Hydrologic - A classification of soils by the Natural Resources Conservation Service, formerly the Soil Conservation Service, into four runoff potential groups. The groups range from A soils, which are very permeable and produce little runoff, to D soils, which are not very permeable and produce much more runoff.

Spillway - A depression in the embankment of a pond or basin which is used to pass peak discharge greater than the maximum design storm controlled by the pond.

Storage Indication Method - A reservoir routing procedure based on solution of the continuity equation (inflow minus outflow equals the change in storage) with outflow defined as a function of storage volume and depth.

Storm Frequency - The number of times that a given storm "event" occurs or is exceeded on the average in a stated period of years. See "Return Period."

Storm Sewer - A system of pipes and/or open channels that convey intercepted runoff and stormwater from other sources, but excludes domestic sewage and industrial wastes.

Stormwater - The total amount of precipitation reaching the ground surface.

Stormwater Hotspot - A stormwater hotspot is defined as a land use or activity that generates higher concentrations of hydrocarbons, trace metals or toxicants than are found in typical stormwater runoff, based on monitoring studies. A list of categories of typical hotspots is contained in the White Deer Creek Act 167 Plan.

Stormwater Management Facility - Any structure, natural or man-made, that, due to its condition, design, or construction, conveys, stores, or otherwise affects stormwater runoff. Typical stormwater management facilities include, but are not limited to, detention and retention basins, open channels, storm sewers, pipes, and infiltration structures.

Stormwater Management Plan - The plan for managing stormwater runoff in the White Deer Creek Watershed adopted by Union County as required by the Act of October 4, 1978, P.L. 864, (Act 167), and known as the "White Deer Creek Watershed Act 167 Stormwater Management Plan."

Stormwater Management Site Plan - The plan prepared by the developer or his representative indicating how stormwater runoff will be managed at the particular site of interest according to this Ordinance.

Stream Enclosure - A bridge, culvert or other structure in excess of 100 feet in length upstream to downstream which encloses a regulated water of this Commonwealth.

Subarea - The smallest drainage unit of a watershed for which stormwater management criteria have been established in the Stormwater Management Plan.

Subdivision - The division or re-division of a lot, tract or parcel of land by any means into two or more lots, tracts, parcels or other divisions of land including changes in existing lot lines for the purpose, whether immediate or future, of lease, partition by the court for distribution to heirs or devisees, transfer of ownership, or building or lot development; provided, however, that the subdivision by lease of land for agricultural purposes into parcels of more than ten acres, not involving any new street or easement of access or any residential dwellings, shall be exempt.

Swale - A low lying stretch of land which gathers or carries surface water runoff.

Timber Operations - See Forest Management.

Time-of-Concentration (Tc) - The time for surface runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. This time is the combined total of overland flow time and flow time in pipes or channels, if any.

Watercourse - A stream of water, river, brook, creek, or a channel or ditch for water, whether natural or manmade.

Waters of the Commonwealth - Any and all rivers, streams, creeks, rivulets, ditches, watercourses, storm sewers, lakes, dammed water, wetlands, ponds, springs, and all other bodies or channels of conveyance of surface and underground water, or parts thereof, whether natural or artificial, within or on the boundaries of this Commonwealth.

Wetland - Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs, ferns, and similar areas.

ARTICLE III-STORMWATER MANAGEMENT

Section 301. General Requirements

A. All regulated activities in White Deer Creek Watershed which do not fall under the exemption criteria shown in Section 402 shall submit a drainage plan consistent with the White Deer Creek Watershed Stormwater Management Plan to the Municipality for review. This criteria shall apply to the total proposed development even if development is to take place in stages. Impervious cover shall include, but not be limited to, any roof, parking or driveway areas and any new streets and sidewalks. Any areas designed to initially be gravel or crushed stone shall be assumed to be impervious for the purposes of comparison to the exemption criteria.

B. Stormwater drainage systems shall be provided in order to permit unimpeded flow along natural watercourses, except as modified by stormwater management facilities or open channels consistent with this Ordinance.

C. The existing points of concentrated drainage that discharge onto adjacent property shall not be altered without permission of the affected property owner(s) and shall be subject to any applicable discharge criteria specified in this Ordinance.

D. Areas of existing diffused drainage discharge shall be subject to any applicable discharge criteria in the general direction of existing discharge, whether proposed to be concentrated or maintained as diffused drainage areas, except as otherwise provided by this Ordinance. If diffused flow is proposed to be concentrated and discharged onto adjacent property, the developer must document that adequate downstream conveyance facilities exist to safely transport the concentrated discharge, or otherwise prove that no erosion, sedimentation, flooding or other harm will result from the concentrated discharge.

E. Where a development site is traversed by watercourses, drainage easements shall be provided conforming to the line of such watercourses. The terms of the easement shall prohibit excavation, the placing of fill or structures, and any alterations that may adversely affect the flow of stormwater within any portion of the easement.

F. When it can be shown that, due to topographic conditions, natural drainageways on the site cannot adequately provide for drainage, open channels may be constructed conforming substantially to the line and grade of such natural drainageways. Work within natural drainageways shall be subject to approval by DEP through the Joint Permit Application process, or, where deemed appropriate by DEP, through the General Permit process.

G. Any stormwater management facilities regulated by this Ordinance that would be located in or adjacent to waters of the Commonwealth or wetlands shall be subject to approval by DEP through the Joint Permit Application process, or, where deemed appropriate by DEP, the General Permit process. When there is a question whether wetlands may be involved, it is the responsibility of the developer or his agent to show that the land in question cannot be classified as wetlands, otherwise approval to work in the area must be obtained from DEP.

H. Minimization of impervious surfaces and infiltration of runoff through seepage beds, infiltration trenches, etc. are encouraged, where soil conditions permit, to reduce the size or eliminate the need for detention facilities.

I. Roof drains must not be connected to streets, sanitary or storm sewers or roadside ditches.

J. Developers are encouraged to incorporate designs to take advantage of the stormwater credits presented in Appendix D of the White Deer Creek Act 167 Stormwater Management Plan.

Section 302. Water Quality Requirements

A. In addition to the performance standards and design criteria requirements of Article III of this Ordinance, the land developer SHALL comply with the following water quality requirements of this Article unless otherwise exempted by provisions of this Ordinance.

For water quality, the objective is to provide adequate storage to capture and treat the runoff from 90% of the average annual rainfall. P_{90} represents the depth of rain associated with 90% of the total rainfall events over 0.11 inches.

1. The size of the water quality facility shall be based upon the following equation:

$$WQ_v = \frac{(1.2)\,(R_v)(A)}{12} \qquad P_{90} = 1.2 \text{ inches of rainfall}$$

Where: WQ_v = water quality volume (in ac-ft)
R_v = 0.05 + 0.009(I) where I is percent impervious cover
A = area in ac*

2. Treatment of the WQ_v shall be provided at all developments where stormwater management is required. A minimum WQ_v of 0.2 inches per acre shall be met at sites or in drainage areas that have less than 15% impervious cover.

3. Drainage areas having no impervious cover and no proposed disturbance during development may be excluded from the WQ_v calculations. Designers are encouraged to use these areas as non-structural practices for WQ_v treatment.

4. The design of the facility shall consider and minimize the chances of clogging and sedimentation potential. Orifices smaller than 3 inches diameter are not recommended. However, if the Design Engineer can provide proof that the smaller orifices are protected from clogging by use of trash racks, etc., smaller orifices may be permitted.

B. To accomplish A. above, the land developer MAY submit original and innovative designs to the Municipal Engineer for review and approval. Such designs may achieve the water quality objectives through a combination of BMPs.

C. In selecting the appropriate BMPs or combinations thereof, the land developer SHALL consider the following:

1. Total contributing area.
2. Permeability and infiltration rate of the site soils.
3. Slope and depth to bedrock.
4. Seasonal high water table.
5. Proximity to building foundations and well heads.
6. Erodibility of soils.
7. Land availability and configuration of the topography.

D. The following additional factors SHOULD be considered when evaluating the suitability of BMPs used to control water quality at a given development site:

1. Peak discharge and required volume control.
2. Stream bank erosion.
3. Efficiency of the BMPs to mitigate potential water quality problems.
4. The volume of runoff that will be effectively treated.
5. The nature of the pollutant being removed.
6. Maintenance requirements.

Section 303. Ground Water Recharge (Infiltration/Recharge/Retention)

A. General

The ability to retain and maximize the ground water recharge capacity of the area being developed is encouraged. Design of the infiltration/recharge stormwater management facilities shall give consideration to providing ground water recharge to compensate for the reduction in the percolation that occurs when the ground surface is paved and roofed over. These measures are encouraged, particularly in hydrologic soil groups A and B and shall be utilized wherever feasible. Soils used for the construction of basins shall have low-erodibility factors ("K" factors).

The criteria for maintaining recharge is based on the USDA average annual recharge volume per soil type divided by the annual rainfall in Union County (40 inches per year) and multiplied by 90%. This keeps the recharge calculation consistent with the WQ_v methodology. Thus, an annual recharge volume requirement shall be specified for a site as follows:

1. Percent Volume Method

$Re_v = [(S)(R_v)(A)]/12$

where: $R_v = 0.05 + 0.009(I)$ where I is percent impervious cover
A = site area in acres

2. Percent Area Method

$Re_v = (S)(A_i)$

where: A_i = the measured impervious cover

Hydrologic Soil Group	Soil Specific Recharge Factor (S)
A	0.40
B	0.27
C	0.14
D	0.07

The recharge volume is considered part of the total WQ_v that must be provided at a site and can be achieved either by a structural practice (e.g., infiltration, bioretention), a non-structural practice (e.g., buffers, disconnection of rooftops), or a combination of both.

Drainage areas having no impervious cover and no proposed disturbance during development may be excluded from the Re_v calculations. Designers are encouraged to use these areas as non-structural practices for Re_v treatment.

Note: Re_v and WQ_v are inclusive. When treated separately, the Re_v may be subtracted from the WQ_v when sizing the water quality BMP.

B. Basis for Determining Recharge Volume

1. If more than one HSG is present at a site, a composite soil specific recharge factor shall be computed based on the proportion of total site area within each HSG. **The recharge volume provided at the site shall be directed to the most permeable HSG available.**

2. **The "percent volume" method is used to determine the Re_v treatment requirement when <u>structural practices</u> are used to provide recharge.** These practices must provide seepage into the ground and may include infiltration and exfiltration structures (e.g., infiltration, bioretention, dry swales or sand filters with storage below the under drain). Structures that require impermeable liners, intercept groundwater, or are designed for trapping sediment (e.g., forbays) may not be used. In this method, the volume of runoff treated by structural practices shall meet or exceed the computed recharge volume.

3. **The "percent area" method is used to determine the Re_v treatment requirements when <u>non-structural practices</u> are used.** Under this method, the recharge requirements are evaluated by mapping the percent of impervious area that is effectively treated by an acceptable non-structural practice and comparing it to the minimum recharge requirements.

4. Acceptable non-structural practices include filter strips that treat rooftop or parking lot runoff, sheet flow discharge to stream buffers, and grass channels that treat roadway runoff.

5. The recharge volume criterion does not apply to any portion of a site designated as a stormwater hotspot or any project considered as redevelopment. In addition, the Municipal Engineer may alter or eliminate the recharge volume requirement if the site is situated on unsuitable soils (e.g., marine clays, karst, or in an urban redevelopment area). In this situation, non-structural practices (percent area method) shall be implemented to the maximum extent practicable and the remaining or untreated Re_v included in the WQ_v treatment.

6. If Re_v is treated by structural or non-structural practices separate and upstream of the WQ_v treatment, the WQ_v is adjusted accordingly.

C. Soils Evaluation

1. **A detailed soils evaluation of the project site shall be performed to determine the suitability of recharge facilities.** The evaluation shall be performed by a qualified professional, and at a minimum, address soil permeability, depth to bedrock, susceptibility to sinkhole formation, and subgrade stability.

2. **Extreme caution shall be exercised where infiltration is proposed in geologically susceptible areas such as strip mine or limestone areas.** Extreme caution shall also be exercised where salt or chloride would be a pollutant since soils do little to filter this pollutant and it may contaminate the groundwater. It is also extremely important that the design professional evaluates the possibility of groundwater contamination from the proposed infiltration/recharge facility and recommend a hydrogeologic justification study be performed if necessary. Whenever a basin will be located in an area underlain by limestone, a geological evaluation of the proposed location shall be conducted to determine susceptibility to sinkhole formations. The design of all facilities over limestone formations shall include measures to prevent ground water contamination and, where necessary, sinkhole formation.

   A. The Municipality may require the installation of an impermeable liner in detention basins. A detailed hydrogeologic investigation may be required by the Municipality. The Municipality may require the developer to provide safeguards against groundwater contamination for uses which may cause groundwater contamination, should there be a mishap or spill.

   B. It shall be the developer's responsibility to verify if the site is underlain by limestone. The following note shall be attached to all drainage plans and signed and sealed by the developers engineer/surveyor/landscape architect/geologist:

      I, _____, certify that the proposed detention basin (circle one) is/is not underlain by limestone.

3. Where pervious pavement is permitted for parking lots, recreational facilities, non-dedicated streets, or other areas, pavement construction specifications shall be noted on the plan.

4. Recharge/infiltration facilities may be used in conjunction with other innovative or traditional BMPs, stormwater control facilities, and nonstructural stormwater management alternatives.

5. All recharge/infiltration facilities shall be designed to completely drain within 72 hours of reaching maximum capacity.

Section 304. Stream Bank Protection Requirements

A. Stream bank protection shall be considered in implementing performance standards pursuant to Section 306. If a stormwater storage facility needs to be constructed then, to protect channels from erosion, the outflow structure shall be designed to provide the **24-hour extended detention of the one-year 24-hour storm event**. The method for determining the Cp_v requirement is detailed in Appendix D of this Ordinance.

For discharges to streams having verified naturally reproducing wild trout or that is stocked with trout, only 12 hours of extended detention shall be provided. The rationale for this criterion is that runoff will be stored and released in such a gradual manner that critical erosive velocities during bankfull and near-bankfull events will seldom be exceeded in downstream channels.

B. Basis for Determining Channel Protection Storage Volume

1. The models HEC-HMS, TR-55 and TR-20 (or an equivalent approved by the Municipal Engineer) shall be used for determining peak discharge rates.

2. Rainfall depth for the one-year, 24-hour storm event in Union County is 1.2 inches.

3. Off-site areas shall be modeled as present land use in good condition for the one-year storm event.

4. The length of overland flow used in time of concentration (t_c) calculations is limited to no more than 150 feet.

5. The Cp_v storage volume shall be computed using procedures outlined in Appendix D of this Ordinance.

6. Cp_v is not required at sites where the one-year post development peak discharge (q_i) is less than or equal to 2.0 cfs. A Cp_v orifice diameter (d_o) of less than 3.0 inches is subject to approval by the Municipal Engineer and is not recommended unless an internal control for orifice protection is used.

7. Cp_v shall be addressed for the entire site. If a site consists of multiple drainage areas, Cp_v may be distributed proportionately to each drainage area.

8. Extended detention storage provided for the Cp_v does not meet the WQ_v requirement (i.e., Cp_v and WQ_v shall be treated separately).

9. The stormwater storage needed for the Cp_v may be provided above the WQ_v storage in stormwater ponds and wetlands; thereby meeting all storage criteria except Re_v in a single facility with appropriate hydraulic control structures for each storage requirement.

10. Infiltration is not recommended for Cp_v control because of large storage requirements.

Section 305. Release Rate Requirements

A. The White Deer Creek Watershed has been divided into subwatersheds (stormwater management districts) as identified in the White Deer Creek Act 167 Stormwater Management Plan.

In addition to the requirements specified below, the Erosion & Sedimentation Control Requirements (Section 309), Water Quality (Section 302), Ground Water Recharge (Section 303), and Stream Bank Protection (Section 304), shall be implemented.

All controls designed to meet the requirements of this Section shall meet a 100% release rate for the two (2) year, ten (10) year, and twenty-five (25) year return period storms.

Section 306. Stormwater Management District Implementation Provisions (Performance Standards)

A. To utilize the 100 % release rate for a particular site in the watershed the developer shall follow the following general sequence of actions:

1. Compute the pre-development and post-development runoff for the specific site using an approved method for the 2-,10-,25-,and 100-year storms, using no stormwater management techniques. If the post-development peak rate is less than or equal to the pre-development rate and time of peak of post and pre-development rates are identical, the requirements of Act 167 and this Plan have been met. If the post-development runoff rate exceeds the pre-development rate, proceed to Step 2.

2. Apply on-site stormwater management techniques to provide for WQ_v, Re_v, and Cp_v. Recompute the post-development runoff rate for the 2-, 10-, 25-, and 100-year storms; and if the resulting post-development peak runoff rate is less than or equal to the pre-development peak runoff rate, the requirements of this Plan have been met. Otherwise additional stormwater management measures, possibly detention or retention, will be required and the developer should proceed to Step 3.

3. Design the necessary facilities to meet the pre-development peak runoff rate.

   It should be noted that stormwater storage can be provided on or off site. The possibility for regional or off-site facilities is an option which can be considered as a means to more efficiently provide the needed facilities, in terms of both cost and land requirement considerations. In many areas, the best solution may be for several development sites to share a joint facility.

   Municipalities may also benefit from this approach. They may maximize development in prime development areas by providing regional or distributed storage through the use of natural or artificial lakes, floodplains and steep sloped valleys which are unsuitable for development. However, where off site storage is to be used, the developer must ensure that no flooding or harm will be caused by runoff between the new development and the off site storage area. This may require the protection of

the stream channel or the construction of a storm sewer to convey runoff to the storage site.

B. District Boundaries - The boundaries of the Stormwater Management Districts are shown on an official map that is available for inspections at the municipal office. A copy of the official map is included in the White Deer Creek Act 167 Stormwater Management Plan. The exact location of the Stormwater Management District boundaries as they apply to a given development site shall be determined by mapping the boundaries using the two-foot topographic contours (or most accurate data required) provided as part of the Drainage Plan.

C. Off-Site Areas - Off-site Areas that drain through a proposed development site are not subject to release rate criteria when determining allowable peak runoff rates. However, on-site drainage facilities shall be designed to safely convey off-site flows through the development site.

D. Site Areas - Where the site area to be impacted by a proposed development activity differs significantly from the total site area, only the proposed impact area utilizing stormwater management measures shall be subject to the Management District Criteria. In other words, unimpacted areas bypassing the stormwater management facilities would not be subject to the Management District Criteria.

E. "No Harm" Option - For any proposed development the developer has the option of using a less restrictive runoff control (including no detention) if the developer can prove that "no harm" would be caused by discharging at a higher runoff rate than that specified by the Plan. The "no harm" option is used when a developer can prove that the post-development hydrographs can match pre-development hydrographs, or if it can be proved that the post-development conditions will not cause increases in peaks at all points downstream. Proof of "no harm" would have to be shown based upon the following "Downstream Impact Evaluation" which shall include a "downstream hydraulic capacity analysis" consistent with Section 306.F. to determine if adequate hydraulic capacity exists. The land developer shall submit to the Municipality this evaluation of the impacts due to increased downstream stormwater flows in the watershed.

1. The "Downstream Impact Evaluation" shall include hydrologic and hydraulic calculations necessary to determine the impact of hydrograph timing modifications due to the proposed development upon a dam, highway, structure, natural point of restricted streamflow or any stream channel section, established with the concurrence of the Municipality.

2. The evaluation shall continue downstream until the increase in flow diminishes due to additional flow from tributaries and/or stream attenuation.

3. The peak flow values to be used for downstream areas for the design return period storms (1-, 2-, 5-, 10-, 25-, 50-, and 100-year) shall be the values from the calibrated model for the White Deer Creek Watershed. These flow values can be obtained from the watershed plan.

4. Developer-proposed runoff controls which would generate increased peak flow rates at storm drainage problem areas would, by definition, be precluded from successful

attempts to prove "no-harm," except in conjunction with proposed capacity improvements for the problem areas consistent with Section 306.F.

5. A financial distress shall not constitute grounds for granting a "no-harm" exemption.

6. Capacity improvements may be provided as necessary to implement the "no harm" option which proposes specific capacity improvements to provide that a less stringent discharge control would not create any harm downstream.

7. Any "no harm" justifications shall be submitted by the developer as part of the Drainage Plan submission per Article IV.

F. "Downstream Hydraulic Capacity Analysis" - Any downstream capacity hydraulic analysis conducted in accordance with this Ordinance shall use the following criteria for determining adequacy for accepting increased peak flow rates:

1. Natural or man-made channels or swales must be able to convey the increased runoff associated with a 2-year return period event within their banks at velocities consistent with protection of the channels from erosion. Acceptable velocities shall be based upon criteria included in the DEP *Erosion and Sediment Pollution Control Program Manual*.

2. Natural or man-made channels or swales must be able to convey increased 25-year return period runoff without creating any hazard to persons or property.

3. Culverts, bridges, storm sewers or any other facilities which must pass or convey flows from the tributary area must be designed in accordance with DEP Chapter 105 regulations (if applicable) and, at minimum, pass the increased 25-year return period runoff.

G. Regional Detention Alternatives - For certain areas within the study area, it may be more cost-effective to provide one control facility for more than one development site than to provide an individual control facility for each development site. The initiative and funding for any regional runoff control alternatives are the responsibility of prospective developers. The design of any regional control basins must incorporate reasonable development of the entire upstream watershed. The peak outflow of a regional basin would be determined on a case-by-case basis using the hydrologic model of the watershed consistent with protection of the downstream watershed areas. "Hydrologic model" refers to the calibrated model as developed for the Stormwater Management Plan.

H. Hardship Option - The development of the plan and its standards and criteria was designed to maintain existing peak flows throughout the White Deer Creek Watershed as the watershed becomes developed. There may be certain instances, however, where the standards and criteria established are too restrictive for a particular landowner or developer. The existing drainage network in some areas may be capable of safely transporting slight increases in flows without causing a problem or increasing flows elsewhere. If a developer or homeowner may not be able to possibly meet the stormwater standards due to lot conditions or if conformance would become a hardship to an owner, the hardship option may be applied. The landowner would have to plead his/her case to the Township/Borough Supervisors with the final determination made by the

Township/Borough. Any landowners pleading the "hardship option" will assume all liabilities that may arise due to exercising this option.

Section 307. Design Criteria for Stormwater Management Facilities

A. Any stormwater facility located on State highway rights-of-way shall be subject to approval by the Pennsylvania Department of Transportation (PENNDOT).

B. Any stormwater management facility (i.e., detention basin) designed to store runoff and requiring a berm or earthen embankment required or regulated by this Ordinance shall be designed to provide an emergency spillway to handle flow up to and including the 100-year post-development conditions. The height of embankment must be set as to provide a minimum 1.0 foot of freeboard above the maximum pool elevation computed when the facility functions for the 100-year post-development inflow. Should any storm-water management facility require a dam safety permit under DEP Chapter 105, the facility shall be designed in accordance with Chapter 105 and meet the regulations of Chapter 105 concerning dam safety which may be required to pass storms larger than 100-year event.

C. Any facilities that constitute water obstructions (e.g., culverts, bridges, outfalls, or stream enclosures), and any work involving wetlands as directed in DEP Chapter 105 regulations (as amended or replaced from time to time by DEP), shall be designed in accordance with Chapter 105 and will require a permit from DEP. Any other drainage conveyance facility that does not fall under Chapter 105 regulations must be able to convey, without damage to the drainage structure or roadway, runoff from the 25-year design storm with a minimum 1.0 foot of freeboard measured below the lowest point along the top of the roadway. Any facility that constitutes a dam as defined in DEP chapter 105 regulations may require a permit under dam safety regulations. Any facility located within a PENNDOT right of way must meet PENNDOT minimum design standards and permit submission requirements.

D. Any drainage conveyance facility and/or channel that does not fall under Chapter 105 Regulations, must be able to convey, without damage to the drainage structure or roadway, runoff from the 10-year design storm. Conveyance facilities to or exiting from stormwater management facilities (i.e., detention basins) shall be designed to convey the design flow to or from that structure. Roadway crossings located within designated floodplain areas must be able to convey runoff from a 100-year design storm. Any facility located within a PENNDOT right-of-way must meet PENNDOT minimum design standards and permit submission requirements.

E. Storm sewers must be able to convey post-development runoff from a 10-year design storm without surcharging inlets, where appropriate.

F. Adequate erosion protection shall be provided along all open channels, and at all points of discharge.

G. The design of all stormwater management facilities shall incorporate sound engineering principles and practices. The Municipality shall reserve the right to disapprove any design that would result in the occupancy or continuation of an adverse hydrologic or hydraulic condition within the watershed.

Section 308. Calculation Methodology

Stormwater runoff from all development sites shall be calculated using either the rational method or a soil-cover-complex methodology.

A. Any stormwater runoff calculations shall use a generally accepted calculation technique that is based on the NRCS soil cover complex method. Table 308-1 summarizes acceptable computation methods. It is assumed that all methods will be selected by the design professional based on the individual limitations and suitability of each method for a particular site. The Municipality may allow the use of the Rational Method to estimate **peak discharges** from drainage areas that contain 200 acres or less. However, the rational method should not be used to generate **pseudo-hydrographs** for drainage areas greater then 10 acres.

B. All calculations consistent with this Ordinance using the soil cover complex method shall use the appropriate design rainfall depths for the various return period storms according to the region for which they are located as presented in Table B-1 in Appendix B of this Ordinance. If a hydrologic computer model such as PSRM or HEC-HMS is used for stormwater runoff calculations, then the duration of rainfall shall be 24 hours. The SCS 'S' curve shown in Figure B-1, Appendix B of this Ordinance shall be used for the rainfall distribution.

C. For the purposes of pre-development flow rate determination, undeveloped land shall be considered as "meadow" in good condition, unless the natural ground cover generates a lower curve number or Rational 'C' value (i.e., forest), as listed in Table B-2 or B-3 in Appendix B of this document.

D. All calculations using the Rational Method shall use rainfall intensities consistent with appropriate times-of-concentration for overland flow and return periods from the Design Storm Curves from Department of Transportation Design Rainfall Curves (1986) (Figure B-2). Times-of-concentration for overland flow shall be calculated using the methodology presented in Chapter 3 of Urban Hydrology for Small Watersheds, NRCS, TR-55 (as amended or replaced from time to time by NRCS). Times of concentration for channel and pipe flow shall be computed using Manning's equation.

E. Runoff Curve Numbers (CN) for both existing and proposed conditions to be used in the soil cover complex method shall be obtained from Table B-2 in Appendix B of this Ordinance.

F. Runoff coefficients (c) for both existing and proposed conditions for use in the Rational method shall be obtained from Table B-3 in Appendix B of this Ordinance.

G. Where uniform flow is anticipated, the Manning equation shall be used for hydraulic computations, and to determine the capacity of open channels, pipes, and storm sewers. Values for Manning's roughness coefficient (n) shall be consistent with Table B-4 in Appendix B of the Ordinance.

Outlet structures for stormwater management facilities shall be designed to meet the performance standards of this Ordinance using any generally accepted hydraulic analysis technique or method.

H. The design of any stormwater detention facilities intended to meet the performance standards of this Ordinance shall be verified by routing the design storm hydrograph through these facilities using the Storage-Indication Method. For drainage areas greater than 200 acres in size, the design storm hydrograph shall be computed using a calculation method that produces a full hydrograph. The Municipality may approve the use of any generally accepted full hydrograph approximation technique that shall use a total runoff volume that is consistent with the volume from a method that produces a full hydrograph.

TABLE 308-1: Acceptable Computation Methodologies For Stormwater Management Plans

METHOD	METHOD DEVELOPED BY	APPLICABILITY
TR-20 (or commercial computer package based on TR-20)	USDA NRCS	Applicable where use of full hydrology computer model is desirable or necessary
TR-55 (or commercial computer package based in TR-55	USDA NRCS	Applicable for land development plans within limitations described in TR-55
HEC-1, HEC-HMS	US Army Corps of Engineers	Applicable where use of full hydrologic computer model is desirable or necessary
PSRM	Penn State University	Applicable where use of a hydrologic computer model is desirable or necessary
Rational Method (or commercial computer package based on Rational Method)	Emil Kuichling (1889)	For sites less than 10 acres, or as approved by the Municipality and/or Municipal Engineer
Other Methods	Varies	Other computation methodologies approved by the Municipality and/or Municipal Engineer

Section 309. Erosion and Sedimentation Requirements

A. Whenever the vegetation and topography are to be disturbed, such activity must be in conformance with Chapter 102, Title 25, Rules and Regulations, Part I, Commonwealth of Pennsylvania, Department of Environmental Protection, Subpart C, Protection of Natural Resources, Article II, Water Resources, Chapter 102, "Erosion Control," and in accordance with the Union County Conservation District.

B. Additional erosion and sedimentation control design standards and criteria that must be or are recommended to be applied where infiltration BMPs are proposed shall include the following:

1. Areas proposed for infiltration BMPs shall be protected from sedimentation and compaction during the construction phase, so as to maintain their maximum infiltration capacity.

2. Infiltration BMPs shall not be constructed nor receive runoff until the entire contributory drainage area to the infiltration BMP has received final stabilization.

ARTICLE IV-DRAINAGE PLAN REQUIREMENTS

Section 401. General Requirements

For any of the activities regulated by this Ordinance, the preliminary or final approval of subdivision and/or land development plans, the issuance of any building or occupancy permit, or the commencement of any land disturbance activity may not proceed until the property owner or developer or his/her agent has received written approval of a Drainage Plan from the Municipality.

Section 402. Exemptions

A. Any Regulated Activity on parcels generating less than 5,000 square feet of total impervious area may be granted a waiver from the provisions of this Ordinance. This criterion shall apply to the total development even if development is to take place in phases. The date of the Municipal Ordinance adoption shall be the starting point from which to consider tracts as "parent tracts" in which future subdivisions and respective impervious area computations shall be cumulatively considered. Exemptions shall be at discretion of Municipal Engineer upon review of site conditions, topography, soils and other factors as deemed appropriate.

B. Prior to the granting of a waiver, the Applicant must provide documentation that the increased flows from the site leaves the site in the same manner as the pre-development condition, and that there will be no adverse affects to properties along the path of flow(s), or that the increased flow(s) will reach a natural watercourse or an existing stormwater management structure before adversely affecting any property along the path of the flow(s). This documentation must include a signed statement by the landowner indicating the total impervious area constructed since the date of adoption of this Ordinance.

C. No waiver shall be provided for Regulated Activities as defined in Section 104.E. and 104.F. of this Ordinance.

Section 403. Drainage Plan Contents

The Drainage Plan shall consist of all applicable calculations, maps, and plans. A note on the maps shall refer to the associated computations and erosion and sedimentation control plan by title and date. The cover sheet of the computations and erosion and sedimentation control plan shall refer to the associated maps by title and date. All Drainage Plan materials shall be submitted to the Municipality in a format that is clear, concise, legible, neat, and well organized; otherwise, the Drainage Plan shall be disapproved and returned to the Applicant. The following items shall be included in the Drainage Plan:

A. General

1. General description of project.

2. General description of permanent stormwater management techniques, including construction specifications of the materials to be used for stormwater management facilities.

3. Complete hydrologic, hydraulic, and structural computations for all stormwater management facilities.

B. Map(s) of the project area shall be submitted on 24-inch x 36-inch sheets and shall be prepared in a form that meets the requirements for recording at the offices of the Recorder of Deeds of Union County. The contents of the maps(s) shall include, but not be limited to:

1. The location of the project relative to highways, municipalities or other identifiable landmarks.

2. Existing contours at intervals of one foot. In areas of steep slopes (greater than 15 percent), five-foot contour intervals may be used.

3. Existing streams, lakes, ponds, field delineated wetlands, or other bodies of water within the project area.

4. Other physical features including flood hazard boundaries, sinkholes, streams, existing drainage courses, areas of natural vegetation to be preserved, and the total extent of the upstream area draining through the site.

5. The locations of all existing and proposed utilities, sanitary sewers, and water lines within 50 feet of property lines.

6. An overlay showing soil names and boundaries.

7. Proposed changes to the land surface and vegetative cover, including the type and amount of impervious area that would be added.

8. Proposed structures, roads, paved areas, and buildings.

9. Final contours at intervals of one foot. In areas of steep slopes (greater than 15 percent), five- feet contour intervals may be used.

10. The name of the development, the name and address of the owner of the property, and the name of the individual or firm preparing the plan.

11. The date of submission.

12. A graphic and written scale of one (1) inch equals no more than fifty (50) feet; for tracts of twenty (20) acres or more, the scale shall be one (1) inch equals no more than one hundred (100) feet.

13. A North arrow.

14. The total tract boundary and size with distances marked to the nearest foot and bearings to the nearest degree.

15. Existing and proposed land use(s).

16. A key map showing all existing man-made features beyond the property boundary that would be affected by the project.

17. Horizontal and vertical profiles of all open channels, including hydraulic capacity.

18. Overland drainage paths.

19. A minimum fifteen-foot wide access easement around all stormwater management facilities that would provide ingress to and egress from a public right-of-way.

20. A note on the plan indicating the location and responsibility for maintenance of stormwater management facilities that would be located off-site. All off-site facilities shall meet the performance standards and design criteria specified in this Ordinance.

21. A construction detail of any improvements made to sinkholes.

22. A statement, signed by the landowner, acknowledging the stormwater management system to be a permanent fixture that can be altered or removed only after municipal approval of a revised plan.

23. The location of all erosion and sedimentation control facilities.

C. Supplemental Information

1. A written description of the following information shall be submitted.

    a. The overall stormwater management concept for the project.
    b. Stormwater runoff computations as specified in this Ordinance.
    c. Stormwater management techniques to be applied both during and after development.
    d. Expected project time schedule.

2. A soil erosion and sedimentation control plan, where applicable, including all reviews and approvals, as required by DEP.

3. A geologic assessment of the effects of runoff on sinkholes as specified in this Ordinance.

4. The effect of the project (in terms of runoff volumes and peak flows) on adjacent properties and on any existing municipal stormwater collection system that may receive runoff from the project site.

5. A Declaration of Adequacy and Highway Occupancy Permit from the PENNDOT District Office when utilization of a PENNDOT storm drainage system is proposed.

D. Stormwater Management Facilities

1. All stormwater management facilities must be located on a plan and described in detail.

2. When groundwater recharge methods such as seepage pits, beds or trenches are used, the locations of existing and proposed septic tank infiltration areas and wells must be shown.

3. All calculations, assumptions, and criteria used in the design of the stormwater management facilities must be shown.

Section 404. Plan Submission

For all activities regulated by this Ordinance, the steps below shall be followed for submission. For any activities that require a DEP Joint Permit Application and regulated under Chapter 105 (Dam Safety and Waterway Management) or Chapter 106 (Floodplain Management) of DEP's Rules and Regulations, require a PENNDOT Highway Occupancy Permit, or require any other permit under applicable state or federal regulations, the proof of application for said permit(s) shall be part of the plan. The plan shall be coordinated with the state and federal permit process.

A. The Drainage Plan shall be submitted by the developer as part of the Preliminary and Final Plan submission for the Regulated Activity.

B. Four (4) copies of the Drainage Plan shall be submitted to the Municipality.

C. Distribution of the Drainage Plan will be as follows:

1. Two (2) copies for the Municipality accompanied by the requisite Municipal Review Fee, as specified in this Ordinance.

2. One (1) copy for the Municipal Engineer.

3. One (1) copy for the County Planning Commission.

Section 405. Drainage Plan Review

A. The Municipal Engineer shall review the Drainage Plan for consistency with the adopted White Deer Creek Watershed Act 167 Stormwater Management Plan. The Municipality shall require receipt of a complete plan, as specified in this Ordinance.

B. For activities regulated by this Ordinance, the Municipal Engineer shall notify the Municipality in writing, within 15 calendar days, whether the Drainage Plan is consistent with the Stormwater Management Plan. Should the Drainage Plan be determined to be consistent with the Stormwater Management Plan, the Municipal Engineer will forward an approval letter to the Municipal Secretary.

C. Should the Drainage Plan be determined to be inconsistent with the Stormwater Management Plan, the Municipal Engineer will forward a disapproval letter to the Municipal Secretary citing the reason(s) for the disapproval.

D. For Regulated Activities specified in Sections 104.C and 104.D of this Ordinance, the Municipal Secretary shall notify the Municipal Building and Zoning Permit Officers in writing, within a time frame consistent with the Municipal Building and Zoning Codes and/or Municipal Subdivision Ordinance, whether the Drainage Plan is consistent with the Stormwater Management Plan and forward a copy of the approval/disapproval letter to the developer.

E. For Regulated Activities requiring a DEP Joint Permit Application, the Municipal Engineer shall notify DEP whether the Drainage Plan is consistent with the Stormwater Management Plan and forward a copy of the review letter to the Municipality and the developer. DEP may consider the Municipal Engineer's review comments in determining whether to issue a permit.

F. The Municipality shall not approve any subdivision or land development for Regulated Activities specified in Section 104 of this Ordinance if the Drainage Plan has been found to be inconsistent with the Stormwater Management Plan, as determined by the Municipal Engineer. All required permits from DEP must be obtained prior to approval of any subdivision or land development.

G. The Municipal Building and Zoning Permit Officers shall not issue building and/or zoning permits for any Regulated Activity specified in Section 104 of this Ordinance if the Drainage Plan has been found to be inconsistent with the Stormwater Management Plan, as determined by the Municipal Engineer. All required permits from DEP must be obtained prior to issuance of a building permit.

H. The developer shall be responsible for completing record drawings of all stormwater management facilities included in the approved Drainage Plan. The record drawings and an explanation of any discrepancies with the design plans shall be submitted to the Municipal Engineer for final approval. In no case shall the Municipality approve the record drawings until the Municipality receives a copy of an approved Declaration of Adequacy, Highway Occupancy Permit from the PENNDOT District Office, and any applicable permits from DEP.

I. The Municipality's approval of a Drainage Plan shall be valid for a period not to exceed five (5) years. This 5-year time period shall commence on the date that the Municipality signs the approved Drainage Plan. If stormwater management facilities included in the approved Drainage Plan have not been constructed, or if constructed, and record drawings of these facilities have not been approved within this 5-year time period, then the Municipality may consider the Drainage plan disapproved and may revoke any and all permits. Drainage Plans that are considered disapproved by the Municipality shall be resubmitted in accordance with Section 407 of this Ordinance.

Section 406. Modification of Plans

A modification to a submitted Drainage Plan for a development site that involves a change in stormwater management facilities or techniques, or that involves the relocation or re-design of stormwater management facilities, or that is necessary because soil or other conditions are not as stated on the Drainage Plan as determined by the Municipal Engineer, shall require a resubmission of the modified Drainage Plan consistent with Section 404 of this Ordinance and be subject to review as specified in Section 405 of this Ordinance.

A modification to an already approved or disapproved Drainage Plan shall be submitted to the Municipality, accompanied by the applicable review fee. A modification to a Drainage Plan for which a formal action has not been taken by the Municipality shall be submitted to the Municipality, accompanied by the applicable Municipality Review Fee.

Section 407. Resubmission of Disapproved Drainage Plans

A disapproved Drainage Plan may be resubmitted, with the revisions addressing the Municipal Engineer's concerns documented in writing, to the Municipal Secretary in accordance with Section 404 of this Ordinance and distributed accordingly and be subject to review as specified in Section 405 of this Ordinance. The applicable Municipality Review Fee must accompany a resubmission of a disapproved Drainage Plan.

ARTICLE V-INSPECTIONS

Section 501. Schedule of Inspections

A. The Municipal Engineer or his municipal assignee shall inspect all phases of the installation of the permanent stormwater management facilities as deemed appropriate by the Municipal Engineer.

B. During any stage of the work, if the Municipal Engineer determines that the permanent stormwater management facilities are not being installed in accordance with the approved Drainage Plan, the Municipality shall revoke any existing permits and issue a cease and desist stop work order until a revised Drainage Plan is submitted and approved, as specified in this Ordinance.

ARTICLE VI-FEES AND EXPENSES

Section 601. General

The fee required by this Ordinance is the Municipal Review Fee. The Municipal Review fee shall be established by the Municipality to defray review costs incurred by the Municipality and the Municipal Engineer. All fees shall be paid by the Applicant.

Section 602. Municipality Drainage Plan Review Fee

The Municipality shall establish a Review Fee Schedule by resolution of the municipal governing body based on the size of the Regulated Activity and based on the Municipality's costs for reviewing Drainage

Plans. The Municipality shall periodically update the Review Fee Schedule to ensure that review costs are adequately reimbursed.

Section 603. Expenses Covered by Fees

The fees required by this Ordinance shall at a minimum cover:

A. Administrative costs.

B. The review of the Drainage Plan by the Municipality and the Municipal Engineer.

C. The site inspections.

D. The inspection of stormwater management facilities and drainage improvements during construction.

E. The final inspection upon completion of the stormwater management facilities and drainage improvements presented in the Drainage Plan.

F. Any additional work required to enforce any permit provisions regulated by this Ordinance, correct violations, and assure proper completion of stipulated remedial actions.

ARTICLE VII-MAINTENANCE RESPONSIBILITIES

Section 701. Performance Guarantee

The Applicant shall provide a financial guarantee to the Municipality for the timely installation and proper construction of all stormwater management controls as required by the approved stormwater plan and this Ordinance equal to the 110% of the construction cost of the required controls in accordance with the municipal subdivision and land development Ordinance.

Section 702. Maintenance Responsibilities

A. The Drainage Plan for the development site shall contain an operation and maintenance plan prepared by the developer and approved by the Municipal Engineer. The operation and maintenance plan shall outline required routine maintenance actions and schedules necessary to insure proper operation of the facility(ies).

B. The Drainage Plan for the development site shall establish responsibilities for the continuing operating and maintenance of all proposed stormwater control facilities, consistent with the following principals:

1. If a development consists of structures or lots which are to be separately owned and in which streets, sewers and other public improvements are to be dedicated to the Municipality, stormwater control facilities may also be offered for dedication to the Municipality (the Municipality is not obligated to accept ownership).

2. If a development site is to be maintained in a single ownership or if sewers and other public improvements are to be privately owned and maintained, then the ownership

and maintenance of stormwater control facilities shall be the responsibility of the owner or private management entity.

C. The governing body, upon recommendation of the Municipal Engineer, shall make the final determination on the continuing maintenance responsibilities prior to final approval of the drainage plan. The governing body reserves the right to accept or reject the ownership and operating responsibility for any or all of the stormwater management controls.

Section 703. Maintenance Agreement for Privately Owned Stormwater Facilities

A. Prior to final approval of the site's drainage plan, the property owner shall sign and record the maintenance agreement contained in Appendix A which is attached and made part hereof, covering all stormwater control facilities that are to be privately owned.

B. Other items may be included in the agreement where determined necessary to guarantee the satisfactory maintenance of all facilities. The maintenance agreement shall be subject to the review and approval of the municipal solicitor and governing body.

Section 704. Municipal Stormwater Maintenance Fund

A. Persons installing stormwater storage facilities shall be required to pay a specified amount to the Municipal Stormwater Maintenance Fund to help defray costs of periodic inspections and maintenance expenses. The amount of the deposit shall be determined as follows:

1. If the storage facility is to be privately owned and maintained, the deposit shall cover the cost of periodic inspections performed by the Municipality for a period of ten (10) years, as estimated by the Municipal Engineer. After that period of time, inspections will be performed at the expense of the Municipality.

2. If the storage facility is to be owned and maintained by the Municipality, the deposit shall cover the estimated costs for maintenance and inspections for ten (10) years. The Municipal Engineer will establish the estimated costs utilizing information submitted by the Applicant.

B. If a storage facility is proposed that also serves as a recreation facility (e.g., ballfield, lake), the Municipality may reduce or waive the amount of the maintenance fund deposit based upon the value of the land for public recreation purpose.

C. If at some future time a storage facility (whether publicly or privately owned) is eliminated due to the installation of storm sewers or other storage facility, the unused portion of the maintenance fund deposit will be applied to the cost of abandoning the facility and connecting to the storm sewer system or other facility. Any amount of the deposit remaining after the costs of abandonment are paid will be returned to the depositor.

ARTICLE VIII-ENFORCEMENT AND PENALTIES

Section 801. Right-of-Entry

Upon presentation of proper credentials, duly authorized representatives of the Municipality may enter at reasonable times upon any property within the Municipality to inspect the condition of the stormwater structures and facilities in regard to any aspect regulated by this Ordinance.

Section 802. Notification

In the event that a person fails to comply with the requirements of this Ordinance, or fails to conform to the requirements of any permit issued hereunder, the Municipality shall provide written notification of the violation. Such notification shall set forth the nature of the violation(s) and establish a time limit for correction of these violation(s). Failure to comply within the time specified shall subject such person to the penalty provisions of this Ordinance. All such penalties shall be deemed cumulative and resort by the Municipality from pursuing any and all remedies. It shall be the responsibility of the Owner of the real property on which any Regulated Activity is proposed to occur, is occurring, or has occurred, to comply with the terms and conditions of this Ordinance.

Section 803. Enforcement

The municipal governing body is hereby authorized and directed to enforce all of the provisions of this Ordinance. All inspections regarding compliance with the drainage plan shall be the responsibility of the Municipal Engineer or other qualified persons designated by the Municipality.

A. A set of design plans approved by the Municipality shall be on file at the site throughout the duration of the construction activity. Periodic inspections may be made by the Municipality or designee during construction.

B. It shall be unlawful for any person, firm or corporation to undertake any regulated activity under Section 104 on any property except as provided for in the approved Drainage Plan and pursuant to the requirements of this Ordinance. It shall be unlawful to alter or remove any control structure required by the Drainage Plan pursuant to this Ordinance or to allow the property to remain in a condition which does not conform to the approved Drainage Plan.

C. At the completion of the project, and as a prerequisite for the release of the performance guarantee, the owner or his representatives shall:

    1. Provide a certification of completion from an engineer, architect, surveyor or other qualified person verifying that all permanent facilities have been constructed according to the plans and specifications and approved revisions thereto.

    2. Provide a set of as-built (record) drawings.

D. After receipt of the certification by the Municipality, a final inspection shall be conducted by the Municipal Engineer or designated representative to certify compliance with this Ordinance.

E. Suspension and Revocation of Permits

1. Any permit issued under this Ordinance may be suspended or revoked by the governing body for:

   a. Non-compliance with or failure to implement any provision of the permit.
   b. A violation of any provision of this Ordinance or any other applicable law, ordinance, rule or regulation relating to the project.
   c. The creation of any condition or the commission of any act during construction or development which constitutes or creates a hazard or nuisance, pollution or which endangers the life or property of others.

2. A suspended permit shall be reinstated by the governing body when:

   a. The Municipal Engineer or his designee has inspected and approved the corrections to the stormwater management and erosion and sediment pollution control measure(s), or the elimination of the hazard or nuisance, and/or;
   b. The governing body is satisfied that the violation of the Ordinance, law, or rule and regulation has been corrected.

3. A permit that has been revoked by the governing body cannot be reinstated. The Applicant may apply for a new permit under the procedures outlined in this Ordinance.

F. Occupancy Permit

An occupancy permit shall not be issued unless the certification of completion pursuant to Section 803.C. has been secured. The occupancy permit shall be required for each lot owner and/or developer for all subdivisions and land development in the Municipality.

Section 804. Public Nuisance

A. The violation of any provision of this Ordinance is hereby deemed a Public Nuisance.

B. Each day that a violation continues shall constitute a separate violation.

Section 805. Penalties

A. Anyone violating the provisions of this Ordinance shall be subject to a fine of not more than $ _____ for each violation, recoverable with costs. Each day that the violation continues shall be a separate offense and the penalties shall be cumulative.

B. In addition, the Municipality, through its solicitor may institute injunctive, mandamus or any other appropriate action or proceeding at law or in equity for the enforcement of this Ordinance. Any court of competent jurisdiction shall have the right to issue restraining orders, temporary or permanent injunctions, mandamus or other appropriate forms of remedy or relief.

Section 806. Appeals

A. Any person aggrieved by any action of the Municipality or its designee may appeal to the Municipality's governing body or Zoning Hearing Board within thirty (30) days of that action.

B. Any person aggrieved by any decision of the Municipality's governing body may appeal to the County Court of Common Pleas in the County where the activity has taken place within thirty (30) days of the municipal decision.

ORDINANCE APPENDIX A
STANDARD STORMWATER FACILITIES MAINTENANCE AND MONITORING AGREEMENT

THIS AGREEMENT, made and entered into this _____ day of _____, 20__, by and between _____, (hereinafter the "Landowner"), and _____, _____ County; Pennsylvania, (hereinafter "Municipality");

WITNESSETH

WHEREAS, the Landowner is the owner of certain real property as recorded by deed in the land records of _____ County, Pennsylvania, Deed Book _____ at Page _____, (hereinafter "Property").

WHEREAS, the Landowner is proceeding to build and develop the Property; and

WHEREAS, the Subdivision/Land Management Plan (hereinafter "Plan") for the _____ Subdivision which is expressly made a part hereof, as approved or to be approved by the Municipality, provides for detention or retention of stormwater within the confines of the Property; and

WHEREAS, the Municipality and the Landowner, his successors and assigns agree that the health, safety, and welfare of the residents of the Municipality require that on-site stormwater management facilities be constructed and maintained on the Property: and

WHEREAS, the Municipality requires, through the implementation of the _____ Watershed Stormwater Management Plan, that stormwater management facilities as shown on the Plan be constructed and adequately maintained by the Landowner, his successors and assigns.

NOW, THEREFORE, in consideration of the foregoing premises, the mutual covenants contained herein, and the following terms and conditions, the parties hereto agree as follows:

1. The on-site stormwater management facilities shall be constructed by the Landowner, his successors and assigns, in accordance with the terms, conditions and specifications identified in the Plan.

2. The Landowner, his successors and assigns, shall maintain the stormwater management facilities in good working condition, acceptable to the Municipality so that they are performing their design functions.

3. The Landowner, his successors and assigns, hereby grants permission to the Municipality, his authorized agents and employees, upon presentation of proper identification, to enter upon the Property at reasonable times, and to inspect the stormwater management facilities whenever the Municipality deems necessary. The purpose of the inspection is to assure safe and proper functioning of the facilities. The inspection shall cover the entire facilities, berms, outlet structures, pond areas, access roads, etc. When inspections are conducted, the Municipality shall give the Landowner, his successors and assigns, copies of the inspection

report with findings and evaluations. At a minimum, maintenance inspections shall be performed in accordance with the following schedule:

- Annually for the first 5 years after the construction of the stormwater facilities,
- Once every 2 years thereafter, or
- During or immediately upon the cessation of a 100-year or greater precipitation event.

4. All reasonable costs for said inspections shall be born by the Landowner and payable to the Municipality.

5. The owner shall convey to the Municipality easements and/or rights-of-way to assure access for periodic inspections by the Municipality and maintenance, if required.

6. In the event the Landowner, his successors and assigns, fails to maintain the stormwater management facilities in good working condition acceptable to the Municipality, the Municipality may enter upon the Property and take such necessary and prudent action to maintain said stormwater management facilities and to charge the costs of the maintenance and/or repairs to the Landowner, his successors and assigns. This provision shall not be construed as to allow the Municipality to erect any structure of a permanent nature on the land of the Landowner, outside of any easement belonging to the Municipality. It is expressly understood and agreed that the Municipality is under no obligation to maintain or repair said facilities, and in no event shall this Agreement be construed to impose any such obligation on the Municipality.

7. The Landowner, his successors and assigns, will perform maintenance in accordance with the maintenance schedule for the stormwater management facilities including sediment removal as outlined on the approved schedule and/or Subdivision/Land Management Plan.

8. In the event the Municipality, pursuant to this Agreement, performs work of any nature, or expends any funds in performance of said work for labor, use of equipment, supplies, materials, and the like on account of the Landowner's or his successors' and assigns' failure to perform such work, the Landowner, his successors and assigns, shall reimburse the Municipality upon demand, within 30 days of receipt of invoice thereof, for all costs incurred by the Municipality hereunder. If not paid within said 30-day period, the Municipality may enter a lien against the property in the amount of such costs, or may proceed to recover his costs through proceedings in equity or at law as authorized under the provisions of the _____ Code.

9. The Landowner, his successors and assigns, shall indemnify the Municipality and his agents and employees against any and all damages, accidents, casualties, occurrences or claims which might arise or be asserted against the Municipality for the construction, presence, existence or maintenance of the stormwater management facilities by the Landowner, his successors and assigns.

10. In the event a claim is asserted against the Municipality, his agents or employees, the Municipality shall promptly notify the Landowner, his successors and assigns, and they shall defend, at their own expense, any suit based on such claim. If any judgment or claims against the Municipality, his agents or employees shall be allowed, the Landowner, his successors and assigns shall pay all costs and expenses in connection therewith.

11. In the advent of an emergency or the occurrence of special or unusual circumstances or situations, the Municipality may enter the Property, if the Landowner is not immediately available, without notification or identification, to inspect and perform necessary maintenance and repairs, if needed, when the health, safety or welfare of the citizens is at jeopardy. However, the Municipality shall notify the Landowner of any inspection, maintenance, or repair undertaken within 5 days of the activity. The Landowner shall reimburse the Municipality for his costs.

This Agreement shall be recorded among the land records of _____ County, Pennsylvania and shall constitute a covenant running with the Property and/or equitable servitude, and shall be binding on the Landowner, his administrators, executors, assigns, heirs and any other successors in interests, in perpetuity.

ATTEST:

WITNESS the following signatures and seals:

(SEAL) For the Municipality:

_____

(SEAL) For the Landowner:

_____

ATTEST:

_____ (City, Borough, Township/Borough)

County of _____, Pennsylvania

I, _____, a Notary Public in and for the County and State aforesaid, whose commission expires on the _____ day of _____, 20__, do hereby certify that _____ whose name(s) is/are signed to the foregoing Agreement bearing date of the _____ day of _____, 20__, has acknowledged the same before me in my said County and State.

GIVEN UNDER MY HAND THIS _____ day of _____, 20___.

_____
NOTARY PUBLIC

(SEAL)

ORDINANCE APPENDIX B
STORMWATER MANAGEMENT DESIGN CRITERIA

TABLE B-1
DESIGN STORM RAINFALL AMOUNT (INCHES)
Source: PENNDOT Intensity Duration Frequency (IDF)

FIGURE B-1
NRCS (SCS) TYPE II RAINFALL DISTRIBUTION

FIGURE B-2
PENNDOT STORM INTENSITY-DURATION-FREQUENCY CURVE
REGION 3
Source: "Field Manual of Pennsylvania Department of Transportation"
STORM INTENSITY-DURATION-FREQUENCY CHARTS
P D T - I D F" May 1986.

TABLE B-2
RUNOFF CURVE NUMBERS
Source: NRCS (SCS) TR-55

TABLE B-3
RUNOFF COEFFICIENTS FOR THE RATIONAL METHOD
Source: Rawls, W.J., S.L. Long, and R.H. McCuen, 1981. Comparison of Urban Flood Frequency Procedures. Preliminary Draft Report prepared for the Soil Conservation Service, Beltsville, Maryland.

TABLE B-4
MANNING ROUGHNESS COEFFICIENTS
Roughness Coefficients (Manning's "n") For Overland / Sheet Flow
(From U.S. Army Corps of Engineers & NRCS TR-55)

TABLE B-1
DESIGN STORM RAINFALL AMOUNT (INCHES)

The design storm rainfall amount chosen for design shall be obtained from the PENNDOT region for which the site is located according to Figure B-2.

Source: PENNDOT Intensity Duration Frequency (IDF)

Design Storm Frequency (years)	24 Hours Rainfall Amount (inches)
1	1.2
2	2.6
5	3.1
10	3.8
25	4.6
50	5.3
100	6.0

FIGURE B-1
NRCS (SCS) TYPE II RAINFALL DISTRIBUTION

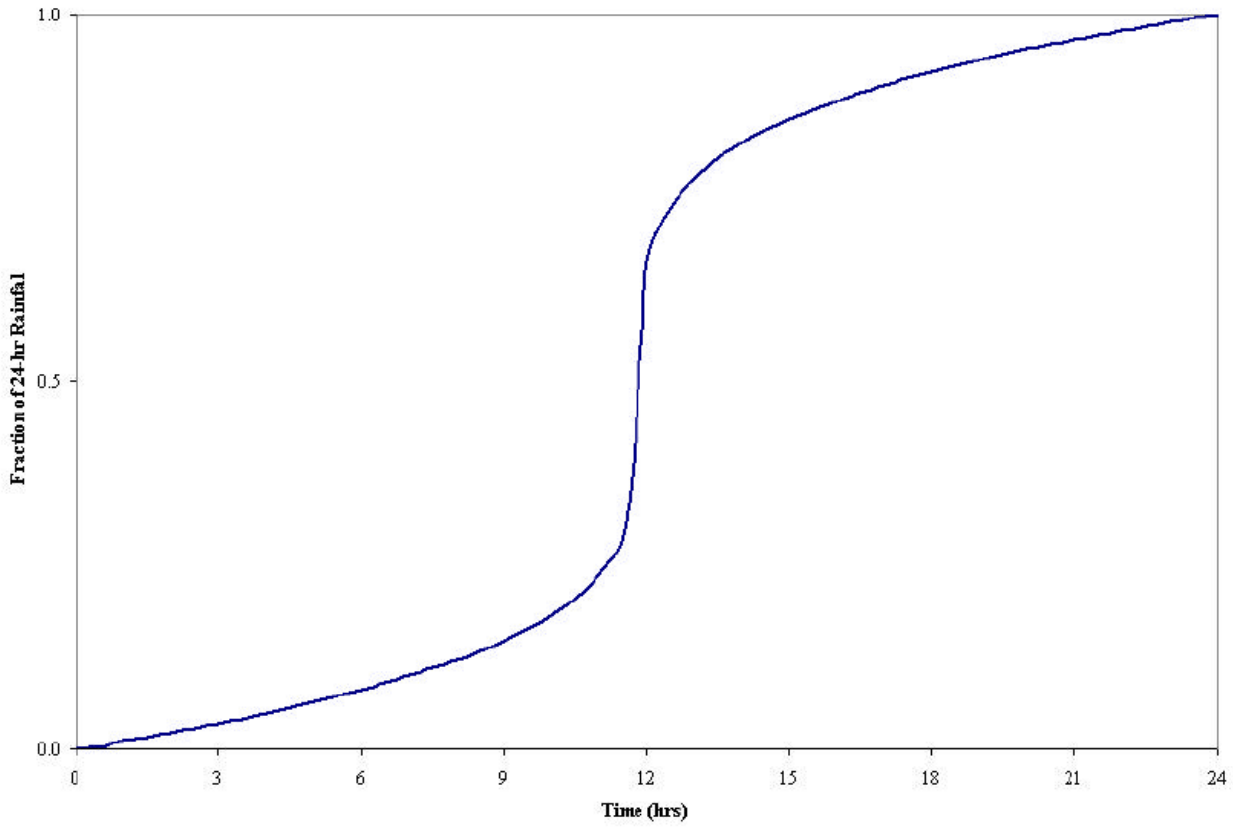


FIGURE B-2
PENNDOT STORM INTENSITY-DURATION-FREQUENCY CURVE
REGION 3
Source: "Field Manual of Pennsylvania Department of Transportation"
STORM INTENSITY-DURATION-FREQUENCY CHARTS
P D T - I D F" May 1986

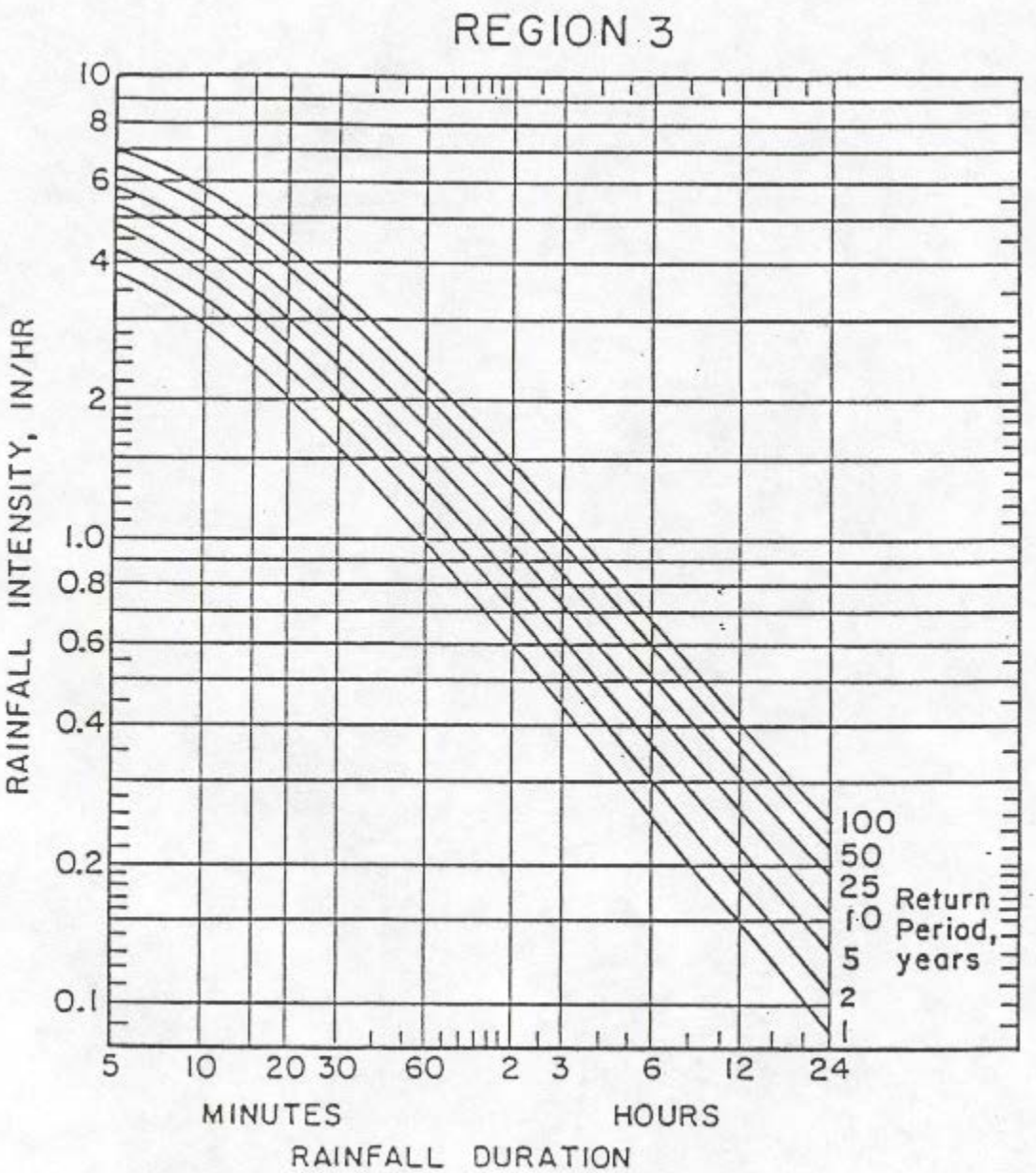


Figure 4. Storm intensity-duration-frequency curves for Region 3.

TABLE B-2
RUNOFF CURVE NUMBERS
Source: NRCS (SCS) TR-55

Runoff Curve Numbers for Urban Areas					
Cover Description		**Curve Numbers for Hydrologic Soil Groups**			
Cover Type and Hydrologic Condition	***Average % Impervious Area***	***A***	***B***	***C***	***D***
Fully Developed Urban Areas (Vegetation Established)					
Open Space (lawns, parks, golf courses, etc)					
Poor Condition (grass cover < 50%)		68	79	86	89
Fair Condition (grass cover 50% to 75%)		49	69	79	84
Good Condition (grass cover > 75%)		39	61	74	80
Impervious Areas					
Paved Parking Lots, Roofs, Driveways, etc.		98	98	98	98
Streets and Roads					
Paved: Curbed and Storm Sewers		98	98	98	98
Paved: Open Ditches		83	89	92	93
Gravel		76	85	89	91
Dirt		72	82	87	89
Western Desert Urban Areas					
Natural Desert Landscaping (pervious area only)		63	77	85	88
Artificial Desert Landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban Districts					
Commercial and Business	85%	89	92	94	95
Industrial	72%	81	88	91	93
Residential Districts by Average Lot Size					
1/8 Acre	65%	77	85	90	92
1/4 Acre	38%	61	75	83	87
1/3 Acre	30%	57	72	81	86
1/2 Acre	25%	54	70	80	85
1 Acre	20%	51	68	79	84
2 Acres	12%	46	65	77	82

TABLE B-2 (Cont'd.)
RUNOFF CURVE NUMBERS
Source: NRCS (SCS) TR-55

Runoff Curve Numbers for Cultivated Agricultural Lands						
Cover Description			**Curve Numbers for Hydrologic Soil Groups**			
Cover Type	***Treatment***	***Hydrologic Condition***	***A***	***B***	***C***	***D***
Fallow	Bare Soil	--	77	86	91	94
	Crop Residue Cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row Crops	Straight Row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & Terraced (C & T)	Poor	66	74	80	82
		Good	62	71	78	81
	C & T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small Grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C & T	Poor	61	72	79	82
		Good	59	70	78	81
	C & T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close Seeded or Broadcast Legumes Or Rotation Meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C & T	Poor	63	73	80	83
		Good	51	67	76	80

TABLE B-2 (Cont'd.)
RUNOFF CURVE NUMBERS
Source: NRCS (SCS) TR-55

Runoff Curve Numbers for Other Agricultural Lands					
Cover Description		**Curve Numbers for Hydrologic Soil Groups**			
Cover Type	***Hydrologic Condition***	***A***	***B***	***C***	***D***
Pasture, Grassland, or Range - Continuous Forage for Grazing	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow - Continuous Grass, Protected from Grazing and Generally Mowed for Hay	--	30	58	71	78
Brush - Brush, Weed, Grass Mixture with Brush the Major Element	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30	48	65	73
Woods - Grass Combination (Orchard or Tree Farm)	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30	55	70	77
Farmsteads - Buildings, Lanes, Driveways, and Surrounding Lots	--	59	74	82	86

TABLE B-2 (Cont'd.)
RUNOFF CURVE NUMBERS
Source: NRCS (SCS) TR-55

Runoff Curve Numbers For Cultivated Agricultural Lands					
Cover Description		**Curve Numbers for Hydrologic Soil Groups**			
Cover Type	***Hydrologic Condition***	***A***	***B***	***C***	***D***
Herbaceous - Mixture of Grass, Weeds, and Low-Growing Brush, With Brush the Minor Element	Poor	--	80	87	93
	Fair	--	71	81	89
	Good	--	62	74	85
Oak-Aspen - Mountain Brush Mixture of Oak Brush, Aspen, Mountain Mahogany, Bitter Brush, Maple, and Other Brush	Poor	--	66	74	79
	Fair	--	48	57	63
	Good	--	30	41	48
Pinyon-Juniper - Pinyon, Juniper, or Both; Grass Understory	Poor	--	75	85	89
	Fair	--	58	73	80
	Good	--	41	61	71
Sagebrush With Grass Understory	Poor	--	67	80	85
	Fair	--	51	63	70
	Good	--	35	47	55
Desert Shrub - Major Plants Include Saltbrush, Greasewood, Creosotebush, Blackbrush, Bursage, Palo Verde, Mesquite, and Cactus	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

TABLE B-3
RUNOFF COEFFICIENTS FOR THE RATIONAL METHOD

Source: Rawls, W.J., S.L. Long, and R.H. McCuen, 1981. Comparison of Urban Flood Frequency Procedures. Preliminary Draft Report prepared for the Soil Conservation Service, Beltsville, Maryland.

	A			B			C			D		
Land Use	0-2%	2-6%	6+%	0-2%	2-6%	6+%	0-2%	2-6%	6+%	0-2%	2-6%	6+%
Cultivated	0.08[a]	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
Land	0.14[b]	0.08	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Pasture	0.12	0.20	0.30	0.18	0.28	0.37	0.24	0.34	0.44	0.30	0.40	0.50
	0.15	0.25	0.37	0.23	0.34	0.45	0.30	0.42	0.52	0.37	0.50	0.62
Meadow	0.10	0.16	0.25	0.14	0.22	0.30	0.20	0.28	0.36	0.24	0.30	0.40
	0.14	0.22	0.30	0.20	0.28	0.37	0.26	0.35	0.44	0.30	0.40	0.50
Forest	0.05	0.08	0.11	0.08	0.11	0.14	0.10	0.13	0.16	0.12	0.16	0.20
	0.08	0.11	0.14	0.10	0.14	0.18	0.12	0.16	0.20	0.15	0.20	0.25
Residential	0.25	0.28	0.31	0.27	0.30	0.35	0.30	0.33	0.38	0.33	0.36	0.42
1/8 Acre	0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
1/4 Acre	0.22	0.26	0.29	0.24	0.29	0.33	0.27	0.31	0.36	0.30	0.34	0.40
	0.30	0.34	0.37	0.33	0.37	0.42	0.36	0.40	0.47	0.38	0.42	0.52
1/3 Acre	0.19	0.23	0.26	0.22	0.26	0.30	0.25	0.29	0.34	0.28	0.32	0.39
	0.28	0.32	0.35	0.30	0.35	0.39	0.33	0.38	0.45	0.36	0.40	0.50
1/2 Acre	0.16	0.20	0.24	0.19	0.23	0.28	0.22	0.27	0.32	0.26	0.30	0.37
	0.25	0.29	0.32	0.28	0.32	0.36	0.31	0.35	0.42	0.34	0.38	0.48
1 Acre	0.14	0.19	0.22	0.17	0.21	0.26	0.20	0.25	0.31	0.24	0.29	0.35
	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Industrial	0.67	0.68	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.70
	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
	0.88	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.90	0.89	0.89	0.90
Streets	0.70	0.71	0.72	0.71	0.72	0.74	0.72	0.73	0.76	0.73	0.75	0.78
	0.76	0.77	0.79	0.80	0.82	0.84	0.84	0.85	0.89	0.89	0.91	0.95
Open Space	0.05	0.10	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.16	0.21	0.28
	0.11	0.16	0.20	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Parking or	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87
Impervious	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97

a = Runoff coefficients for storm recurrence intervals less than 25 years
b = Runoff coefficients for storm recurrence intervals of 25 years or more

TABLE B-4
MANNING ROUGHNESS COEFFICIENTS
Roughness Coefficients (Manning's "n") For Overland/Sheet Flow
(From U.S. Army Corps of Engineers & NRCS TR-55)

Surface Description	**n**
Dense Growth	0.4 - 0.5
Pasture	0.3 - 0.4
Lawns	0.2 - 0.3
Bluegrass Sod	0.2 - 0.5
Short Grass Prairie	0.1 - 0.2
Sparse Vegetation	0.05 - 0.13
Bare Clay - Loam Soil (eroded)	0.01 - 0.03
Concrete/Asphalt - very shallow depths	
(less than 1/4 inch)	0.10 - 0.15
- small depths	
(1/4 inch to several inches)	0.05 - 0.10
Fallow (no residue)	0.05
Cultivated Soils	
Residue Cover Less Than or = 20%	0.06
Residue Cover Greater Than 20%	0.17
Grass	
Dense Grasses	0.24
Bermuda Grass	0.41
Range (natural)	0.13
Woods (light underbrush)	0.40

ORDINANCE APPENDIX C
SAMPLE DRAINAGE PLAN APPLICATION AND FEE SCHEDULE

DRAINAGE PLAN APPLICATION

(To be attached to the "Land Subdivision Plan or Development Plan Review Application or Minor Land Subdivision Plan Review Application")

Application is hereby made for review of the Stormwater Management and Erosion and Sedimentation Control Plan and related data as submitted herewith in accordance with The _____ Township/Borough stormwater management and earth disturbance Ordinance.

_____ Final Plan _____ Preliminary Plan _____ Sketch Plan

Date of Submission: _____ Submission No:._____

1. Name of Subdivision or Development_____

2. Name of Applicant _____ Telephone No._____

   (if corporation, list the corporation's name and the names of two officers of the corporation)

   Address_____

   City _____ Zip Code_____

   Applicant's Interest in Subdivision or Development_____
   (if other than property owner give owners name and address)

3. Name of Property Owner _____ Telephone No._____
   Address_____ City_____
   Zip Code _____

4. Name of Design Professional _____

   Telephone No. _____ Address _____

   City _____ Zip Code _____

5. Type of subdivision or development proposed:

   ____ Single Family Lots
   ____ Two Family Lots
   ____ Cluster Lots
   ____ Planned Residential
   _____ Townhouses
   _____ Garden Apartments
   _____ Campground
   _____ Other
   ____ Commercial (multi lot)
   ____ Commercial (one lot)
   ____ Industrial (one lot)

   If other, describe type of development _____

6. Lineal feet of new road proposed? _____l.f.

7. Area of proposed and existing impervious area on entire tract.

   a. Existing (to remain) _____ s.f. _____% of property
   b. Proposed _____ s.f. _____% of property

8. Stormwater

   a. Does the peak rate of runoff from proposed conditions exceed that flow which occurred for predevelopment conditions for the designated design storm?
   _____

   b. Design storm utilized (on-site conveyance systems) (24 hr.)

   - No. of subarea_____
   - Watershed name_____
   - If other, explain: _____
   _____

   c. Does the submission meet the release rate and/or district criteria for the applicable subarea?
   _____

   d. Type of proposed runoff control _____

   e. Does the proposed stormwater control criteria meet the requirement/guidelines of the Stormwater Ordinance?
   _____

   f. Does the plan meet the requirements of Article III of the Stormwater Ordinance? _____

   If not, what variances/waivers are requested?
   _____

   Reasons for request _____

   g. Was TR-55, June 1986 utilized in determining the time of concentration?
   _____

   h. What hydrologic method was used in the stormwater computations?
   _____

   i. Is a hydraulic routing through the stormwater control structure submitted?
   _____

   j. Is a construction schedule or staging attached? _____

   k. Is a recommended maintenance program attached? _____

9. Erosion and Sedimentation Pollution Control (E&S):

a. Has an erosion and sedimentation control plan been submitted to the Union County Conservation District?

_____

b. Total area of earth disturbance _____ s.f.

10. Wetlands

a. Have the wetlands been delineated by someone trained in wetland delineation?

_____

b. Have the wetland lines been verified by a state or federal permitting authority?

_____

c. Have the wetland lines been surveyed? _____

d. Total acreage of wetland within the property _____

e. Total acreage of wetland disturbed _____

f. Supporting documentation _____

11. Filing

a. Has the required fee been submitted? _____

Amount $_____

b. Has the proposed schedule of construction inspection to be performed by the Applicant's engineer been submitted?_____

c. Name of individual who will be making the inspections_____

_____

d. General comments about stormwater management at development site

_____

_____

_____

_____

_____

[1]CERTIFICATE OF OWNERSHIP AND ACKNOWLEDGMENT OF APPLICATION: COMMONWEALTH OF PENNSYLVANIA COUNTY OF _____

On this the _____ day of _____, 20_____, before me, the undersigned officer, personally appeared _____ who being duly sworn, according to law, deposes and says that _____ owners of the property described in this application and that the application was made with_____ knowledge and/or direction and does hereby agree with the said application and to the submission of the same.

Property Owner(s) _____

My Commission Expires _____, 20_____

_____Notary Public

THE UNDERSIGNED HEREBY CERTIFIES THAT TO THE BEST OF HIS KNOWLEDGE AND BELIEF THE INFORMATION AND STATEMENTS GIVEN ABOVE ARE TRUE AND CORRECT.

SIGNATURE OF APPLICANT_____

This Information To Be Completed By The Municipality

_____ Township/Borough Official Submission Receipt

Date Complete Application Received _____ Plan Number_____

Fees _____ Date Fees Paid _____ Received By _____

Official Submission Receipt Date _____

Received By _____

[1] Notarization is not required if Drainage Plan application is part of an official Land Development Plan to be recorded in the Union County Recorder of Deeds Office.

FEE SCHEDULE

_____ Township/Borough

Drainage Plan
Schedule of Fees

Subdivision Name _____ Submittal No._____

Owner _____ Date _____

Design Professional _____

1. Filing fee	$ _____
2. Land use	
2a. Subdivision, campgrounds, mobile home parks, and multi-family dwelling where the units are located in the same local watershed	$ _____
2b. Multi-family dwelling where the designated open space is located in a different local watershed from the proposed units	$ _____
2c. Commercial/industrial	$ _____
3. Relative amount of earth disturbance	
3a. Residential	
road <500 l.f.	$ _____
road 500-2,640 l.f.	$ _____
road >2,640 l.f.	$ _____
3b. Commercial/industrial and other	
impervious area <3,500 s.f.	$ _____
impervious area 3,500-43,460 s.f.	$ _____
impervious area >43,560 s.f.	$ _____
4. Relative size of project	
4a. Total tract area <1 ac	$ _____
1≤ x <5 ac	$ _____
5≤ x <25 ac	$ _____
25≤ x <100 ac	$ _____
100≤ x <200 ac	$ _____
x >200 ac	$ _____
5. Stormwater control measures	
5a. Detention basins & other controls which require a review of hydraulic routings ($ per control)	$ _____
5b. Other control facilities which require storage volume calculations but no hydraulic routings ($ per control)	$ _____
6. Site inspection ($ per inspection)	$ _____
Total	$ _____

All subsequent reviews shall be 1/4 the amount of the initial review fee unless a new application is required as per Section 406 of the Stormwater Ordinance. A new fee shall be submitted with each revision in accordance with this schedule.

ORDINANCE APPENDIX D
COMPUTATION OF THE CHANNEL PROTECTION STORAGE VOLUME (Cp_v)

The following procedure shall be used to design the channel protection storage volume (Cp_v). The method is based on the Design Procedures for Stormwater Management Extended Detention Structures (MDE, 1987) and utilizes the NRCS, TR-55 Graphical Peak Discharge Method (USDA, 1986).

- Compute the time of concentration (*tc*) and the one-year post-development runoff depth (*Qa*) in inches.

  $$Qa = \frac{(1.2 - Ia)^2}{(1.2 - Ia) + S}$$ where S = (1000/CN) - 10, Ia = (200/CN)-2

- Compute the ratio *Ia/1.2* where 1.2 is the one-year rainfall depth (Source: PENNDOT IDF).

- With *tc* and *Ia/P*, find the unit peak factor (*qu*) from Figure D.1 and compute the one year post-development peak discharge *qi = quAQa* where A is the drainage in square miles.

- **If *qi* $\leq$ 2.0 cfs, Cp_v is not required**. Provide for water quality (WQv) and groundwater recharge (Re_v) as necessary.

- With *qu*, find the ratio of outflow to inflow (*qo/qi*) for T = 12 or 24 hours from Figure D.2.

- Compute the peak outflow discharge *qo = (qo/qi)xqi*

- With *qo/qi*, compute the ratio of storage to runoff volume (V_s/V_r).

  - $V_s/V_r = 0.683 - 1.43(qo/qi) + 1.64(qo/qi)^2 - 0.804(qo/qi)^3$

- Compute the extended detention storage volume $V_s = (V_s/V_r)xV_r$ (note: V_r = Qa);

- Convert Vs to acre-feet by $(V_s/12)xA$, where V_s is in inches and A is in acres.

- Compute the required orifice area (*Ao*) for extended detention design:

  - $$Ao = \frac{qo}{C(2gho)^{0.5}} = \frac{qo}{4.18(ho)^{0.5}}$$

- Where ho is the maximum storage depth associated with V_s.

- Determine the required maximum orifice diameter (*do*) $do = (4Ao/\pi)^{0.5}$

- A *do* of less than 3.0 inches is subject to local jurisdictional approval, and is not recommended unless an internal control for orifice protection is used.

Figure D.1 SCS Graphical Method of Determining Peak Discharge (qu) in csm/in
For 24-Hour Type II Storm Distribution

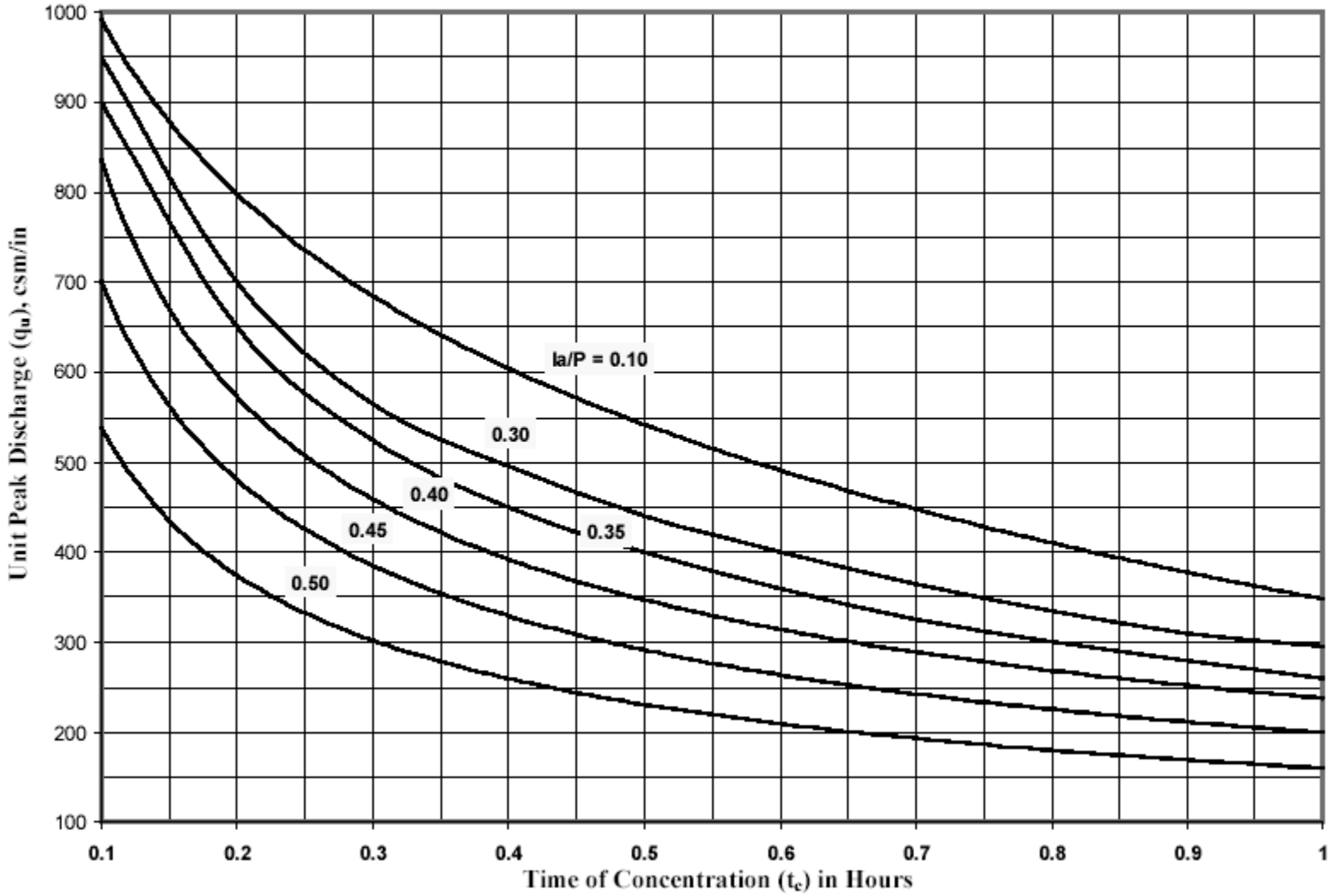


Figure D.2 Detention Time Versus Discharge Ratios (qo/qi)

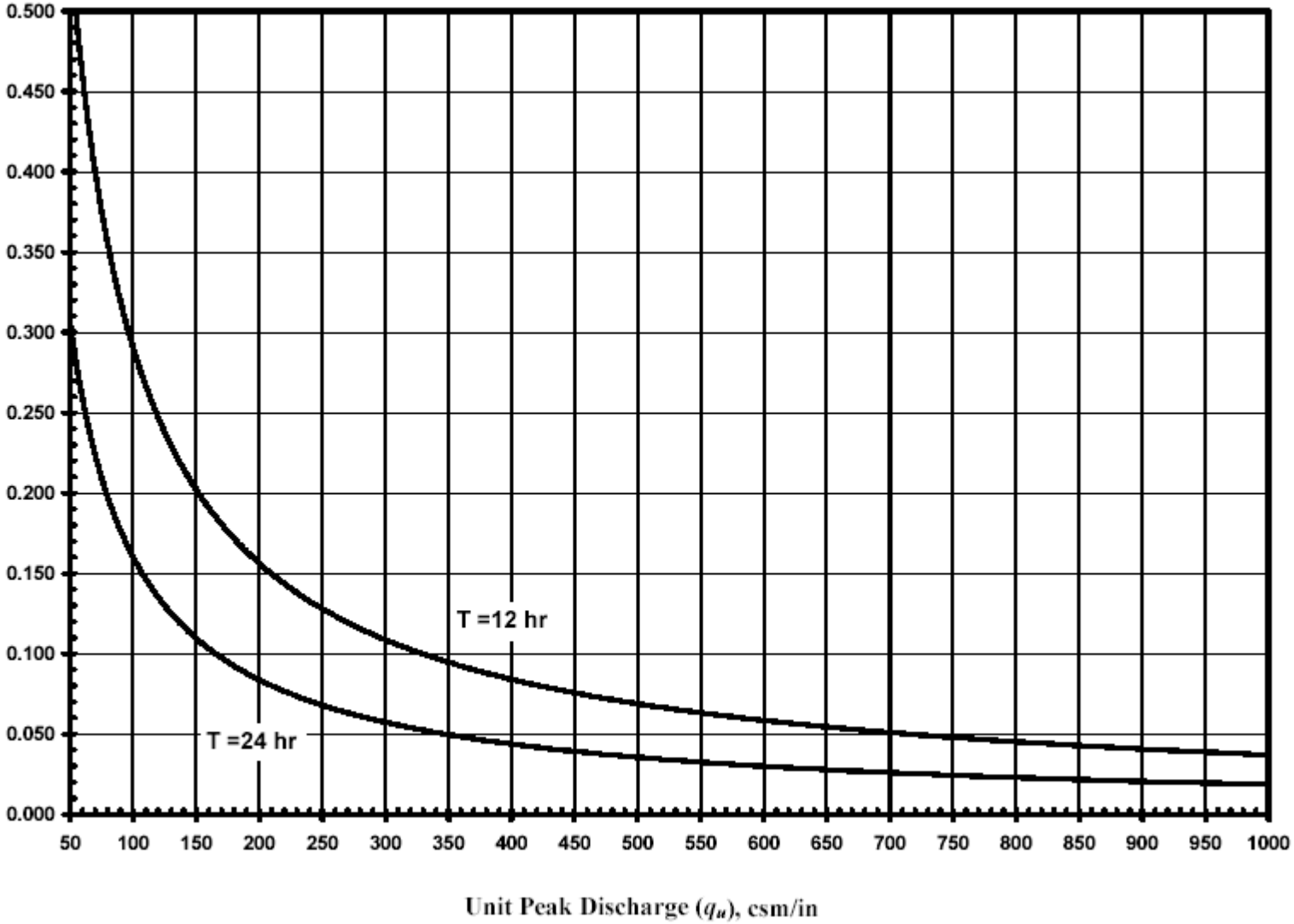
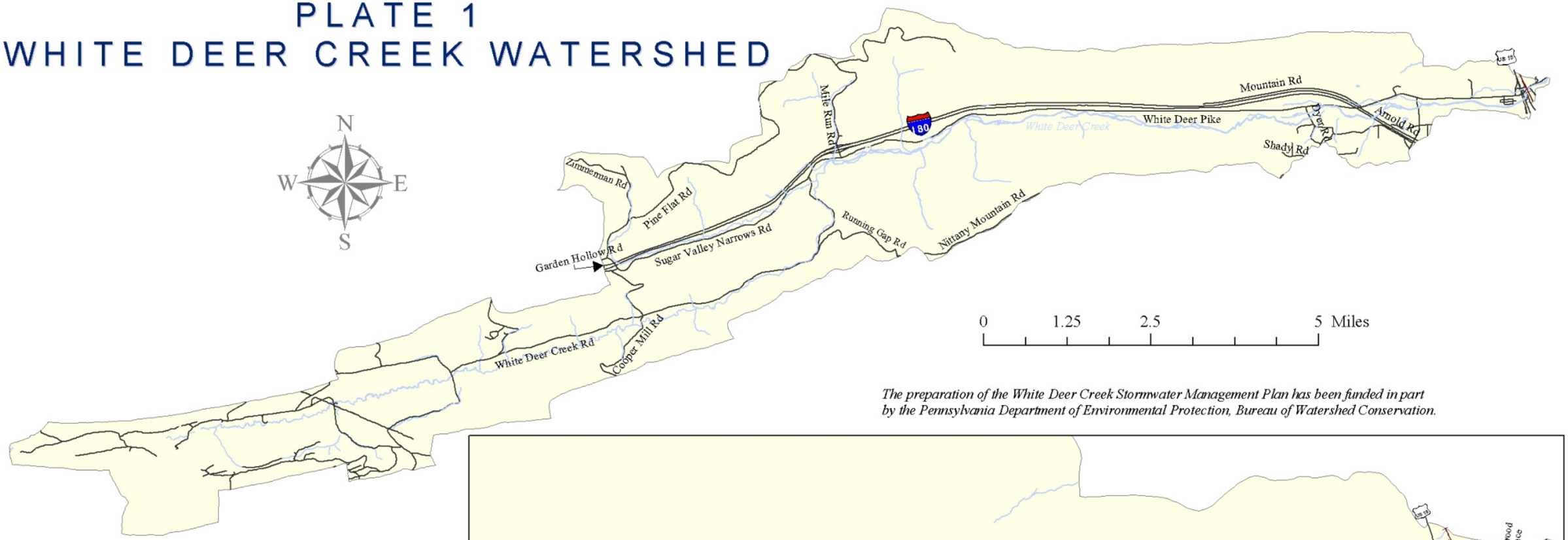
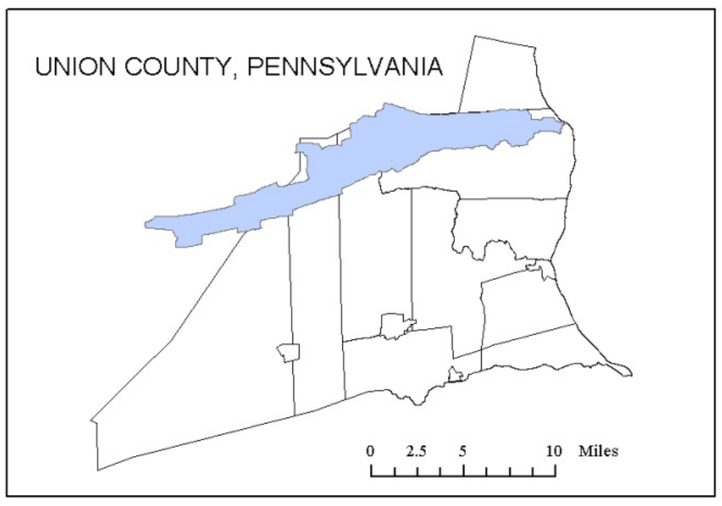


PLATE 1
WHITE DEER CREEK WATERSHED



The preparation of the White Deer Creek Stormwater Management Plan has been funded in part by the Pennsylvania Department of Environmental Protection, Bureau of Watershed Conservation.

Source: Union County GIS Department, March 2003
State Plane Coordinates, North Zone, NAD 83



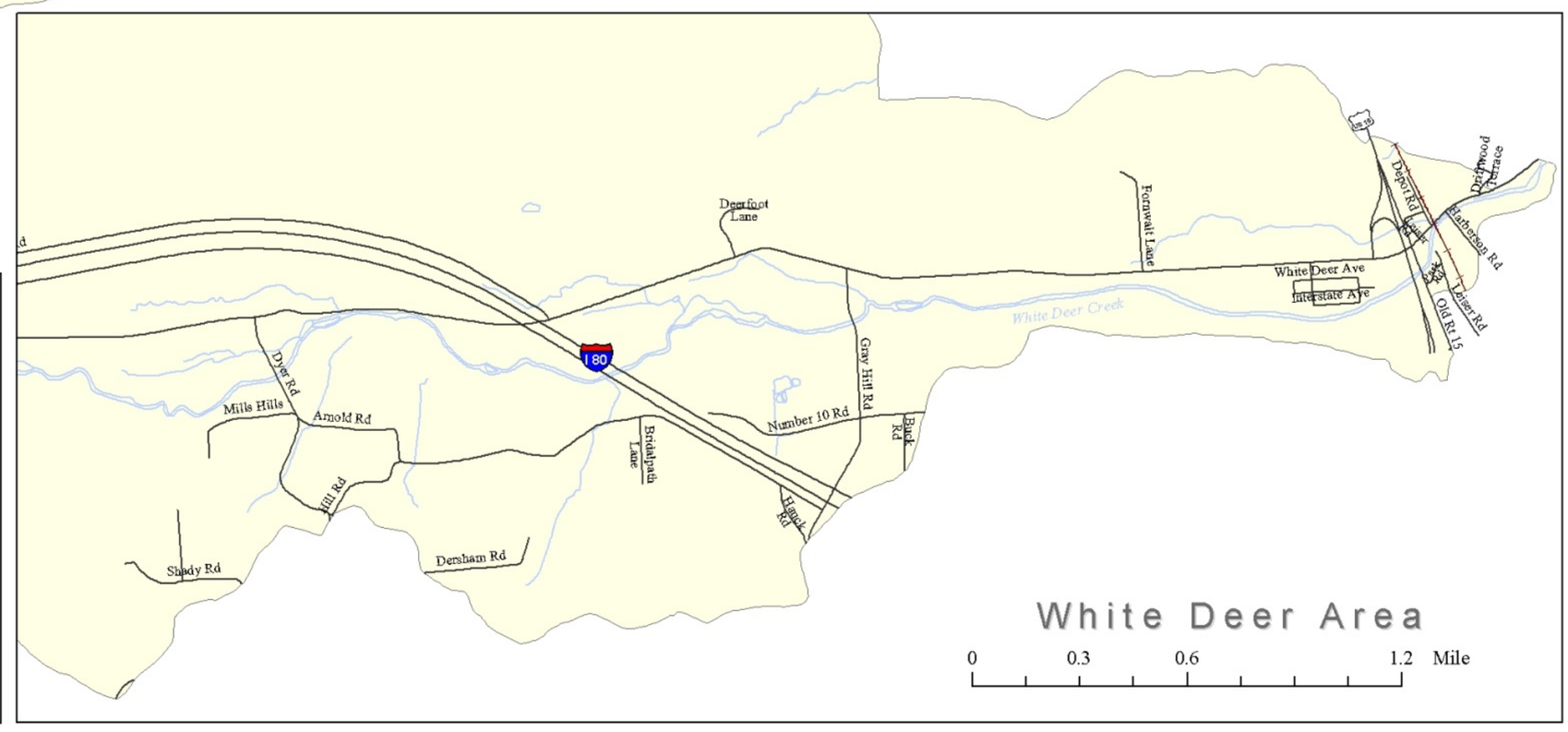
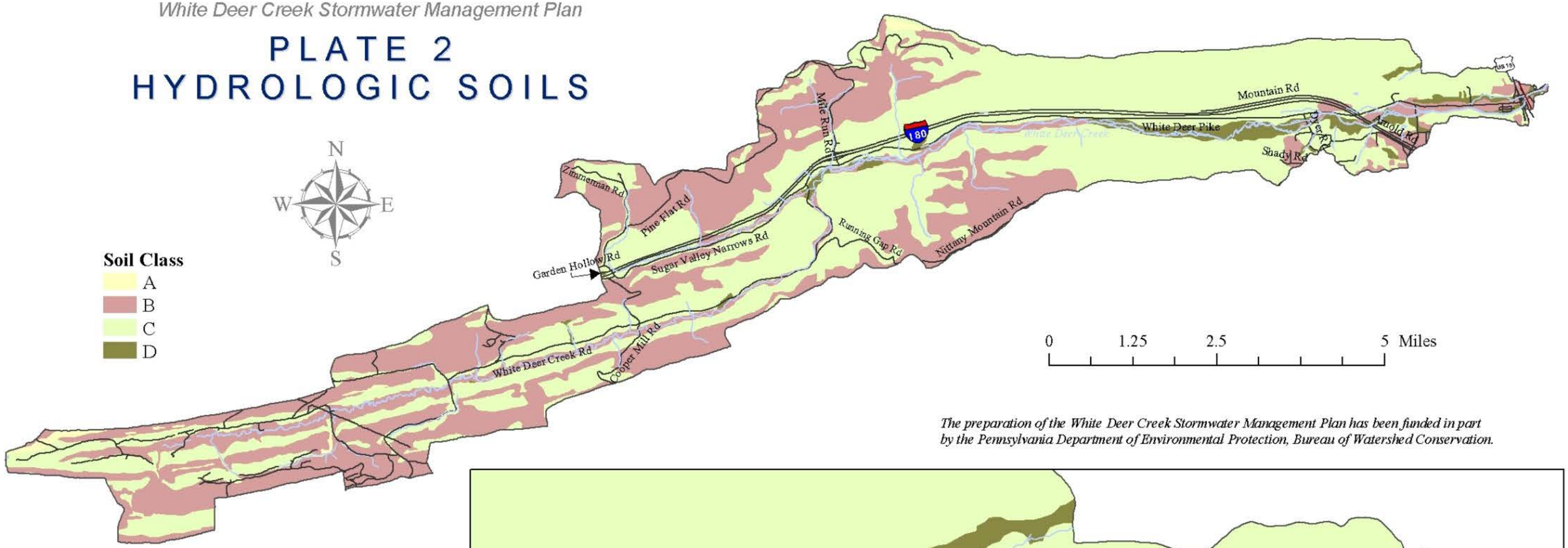
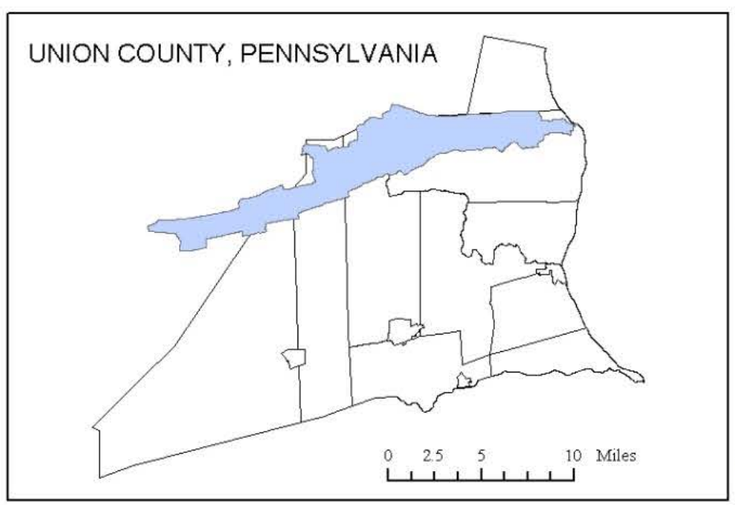


PLATE 2
HYDROLOGIC SOILS



The preparation of the White Deer Creek Stormwater Management Plan has been funded in part by the Pennsylvania Department of Environmental Protection, Bureau of Watershed Conservation.

Source: Union County GIS Department, March 2003
SSURGO Soils Data
State Plane Coordinates, North Zone, NAD 83



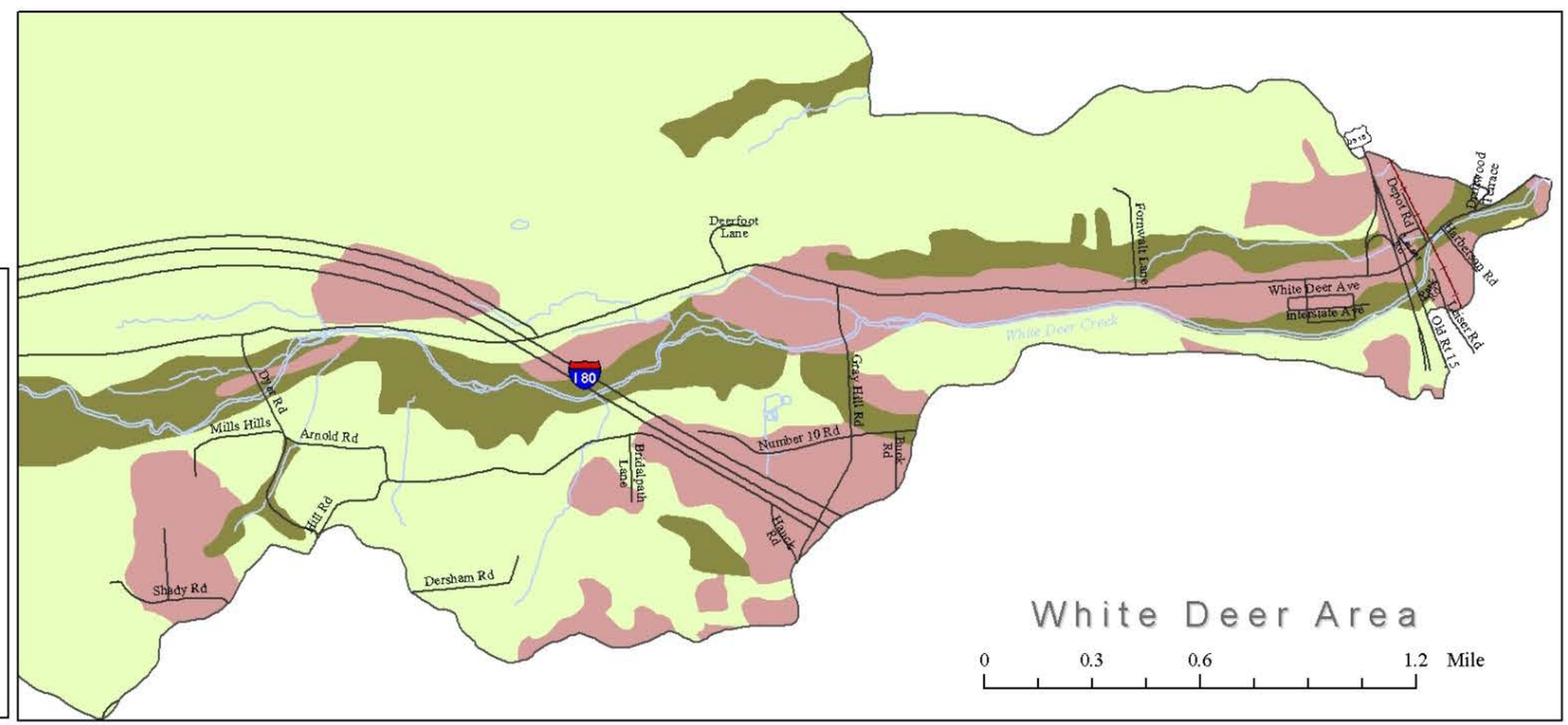


PLATE 3
STORMWATER PROBLEM AREAS

The preparation of the White Deer Creek Stormwater Management Plan has been funded in part by the Pennsylvania Department of Environmental Protection, Bureau of Watershed Conservation.

Source: Union County GIS Department, March 2003
State Plane Coordinates, North Zone, NAD 83

White Deer Creek ACT 167 Problem Areas Identified Through Questionnaires

Location	Problems Noted	Causes	Notes
1	FL, AE, SED	VOL, VEL, DIR, OBS	R.R. bridge and roadway bridge are acting as obstructions
2	FL	VOL, DIR	Debris in creek causes creek to flood road
3	FL	VOL, VEL, DIR, OBS	Ice jam reportedly caused flooding from Park Road to Carwash
4	FL, AE	VOL, DIR	Pipe under T-520 diverts runoff from west side of road toward residences
5	---	---	S.R. 1011 Bridge
6	AE	OBS	A dike was installed many years ago, confines stream flow
7	see notes	OBS	Old culvert was recently replaced. The old culvert caused backwater
8	FL, AE, SED, GW, WP	VOL, VEL, DIR	no additional data given
9	FL	VOL, OBS	Covered bridge and many curves in stream at this location
10	FL	VOL, VEL, OBS	Small bridge causes backwater to flood property
11	FL, AE, SED, GW, WP	VOL, VEL, DIR, OBS	Debris is causing stream to back up and flood
12	AE, SED, GW, WP	VOL, VEL, DIR	Infiltration sewer lines along north berm of W. Deer Pike
13	FL, AE, SED	VOL, OBS	I-80 underpass
14	---	---	Stormwater from private drives are impacting Twp. roads
15	FL	VOL, VEL	Roadway is at an elevation even with stream bank
16	FL, AE, SED, WP	VOL, VEL, OBS	Obstructions from Susquehanna River

KEY: FL - Flooding, AE - Accelerated Erosion, SED - Sedimentation, LS - Land Slide, GW - Groundwater, WP - Water Pollution
VOL - Stormwater Volume, VEL - Stormwater Velocity, DIR - Stormwater Direction, OBS - Water Obstruction

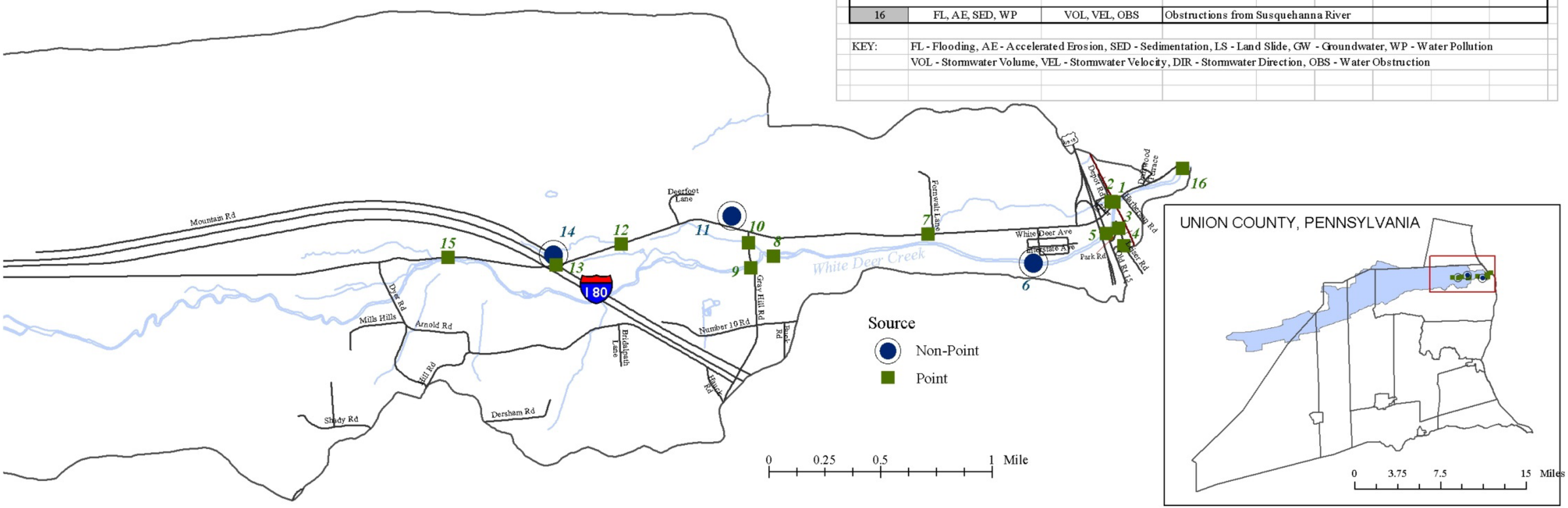
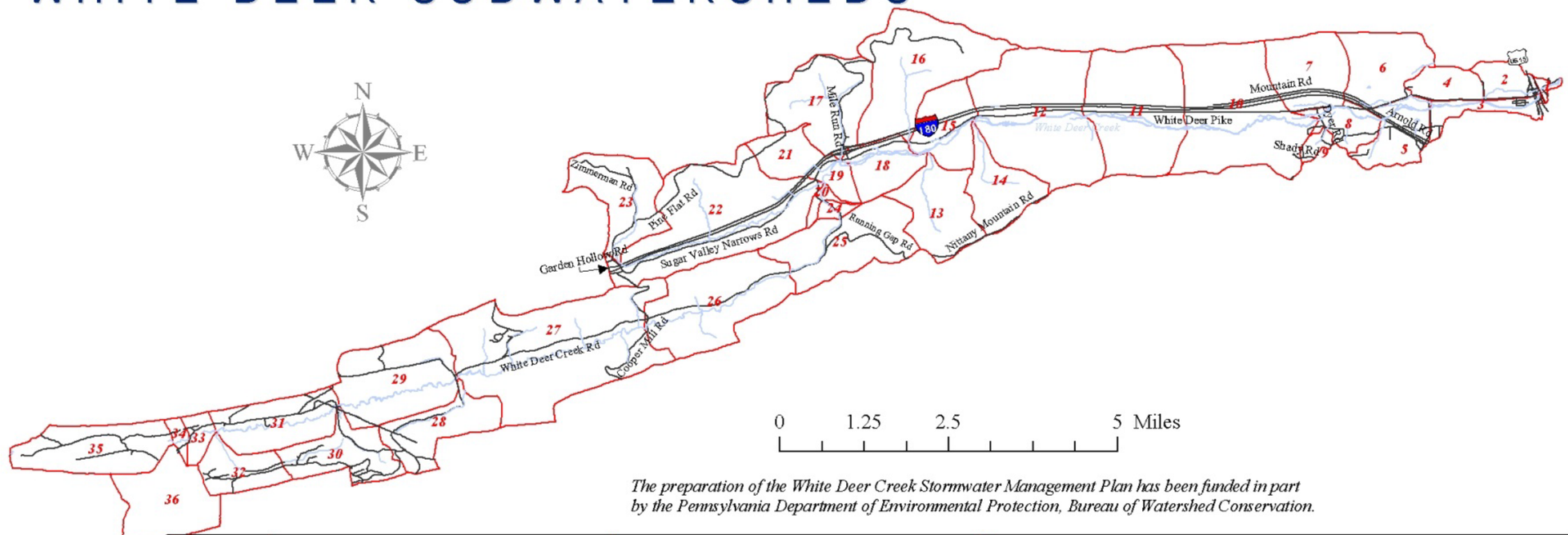


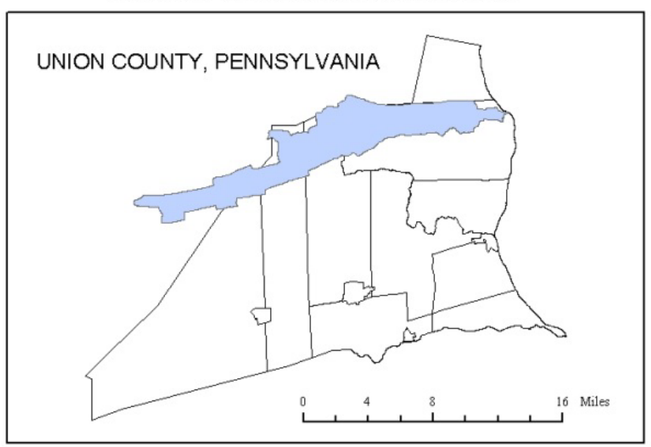
PLATE 4
WHITE DEER SUBWATERSHEDS

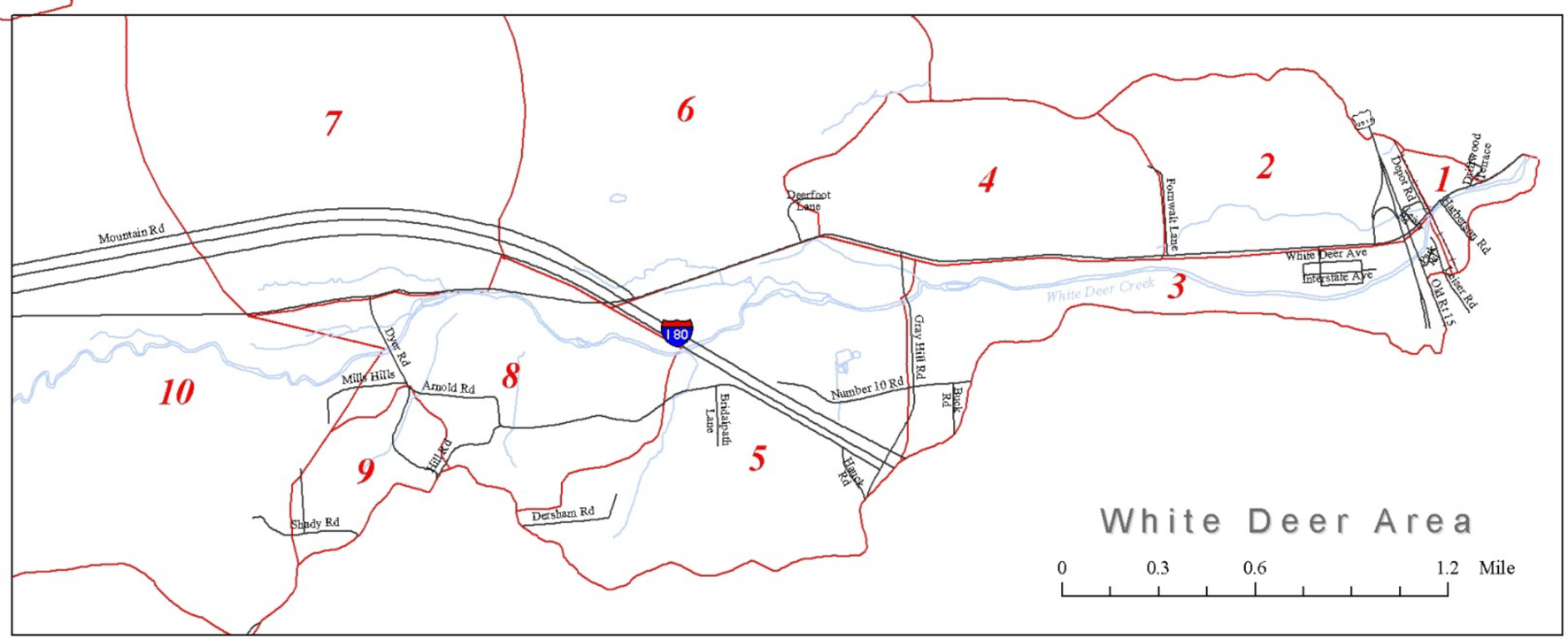
SUBSHED	ACRES	WEIGHTED	FUTURE
1	42.4598	76.9278	75.9810
2	268.3339	73.8256	73.3020
3	275.4617	76.4016	74.7239
4	307.4527	73.0460	72.4493
5	528.3750	72.6991	72.4497
6	745.5137	70.8920	70.7389
7	764.8194	70.9648	70.9714
8	324.7305	77.0275	77.0613
9	90.9904	68.6202	69.6209
10	1917.1360	71.8019	71.8609
11	1568.1577	71.0673	71.0759
12	1979.3404	67.9005	67.8854
13	810.9246	62.6129	62.6130
14	607.6009	57.0755	57.0756
15	629.3283	68.5364	68.5363
16	1515.9788	63.4332	63.4360
17	1088.0656	60.2638	60.4028
18	481.1160	70.2010	68.8263
19	193.8496	71.9912	71.1830
20	74.2815	68.6520	68.6524
21	365.7337	61.9960	61.9979
22	2102.9259	63.9074	63.8475
23	856.5106	69.2303	62.5170
24	75.9906	68.9462	68.9460
25	1114.5294	66.5674	66.5673
26	1415.7015	63.7025	63.7026
27	2763.5811	61.8037	61.8029
28	708.7520	59.9140	59.9137
29	1238.2365	59.9532	59.9512
30	687.5287	57.0151	57.0143
31	793.5831	61.0896	61.0897
32	475.2174	60.3899	60.3901
33	159.8239	61.4690	61.4684
34	80.9004	61.2742	61.2740
35	954.6011	60.6557	60.6478
36	919.0242	61.3250	61.3226

Source: Union County GIS Department, March 2003
State Plane Coordinates, North Zone, NAD 83



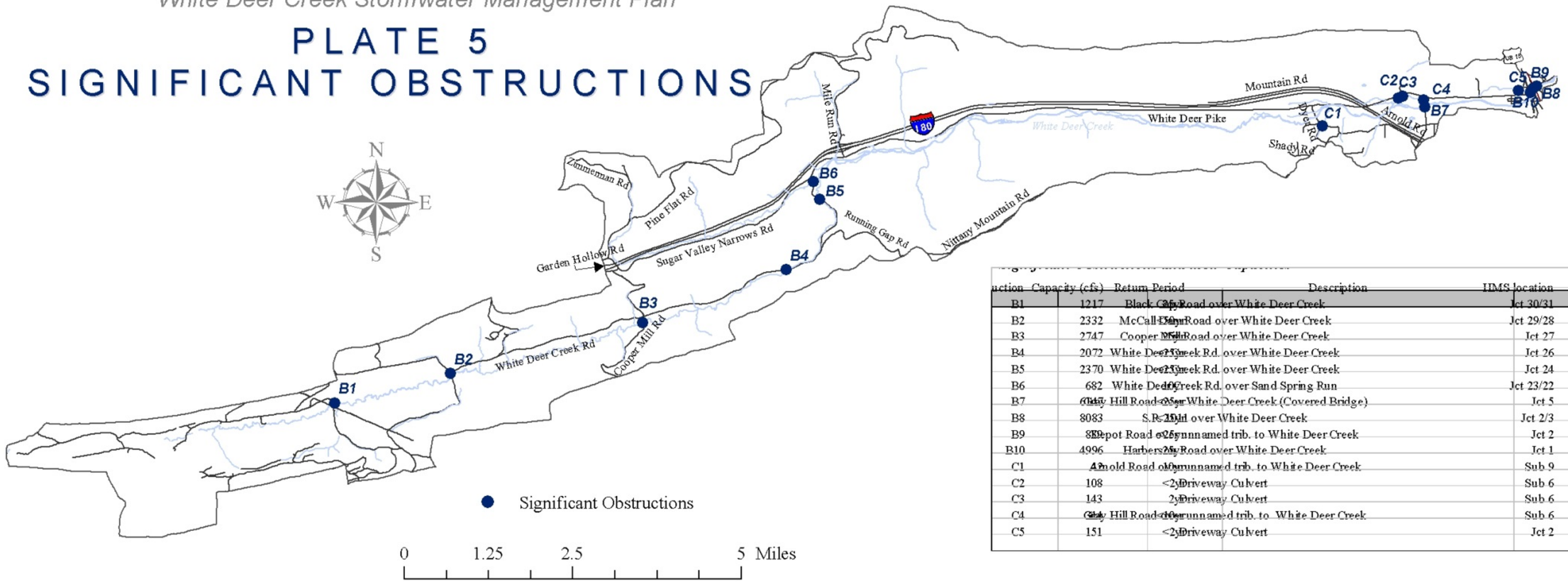
The preparation of the White Deer Creek Stormwater Management Plan has been funded in part by the Pennsylvania Department of Environmental Protection, Bureau of Watershed Conservation.





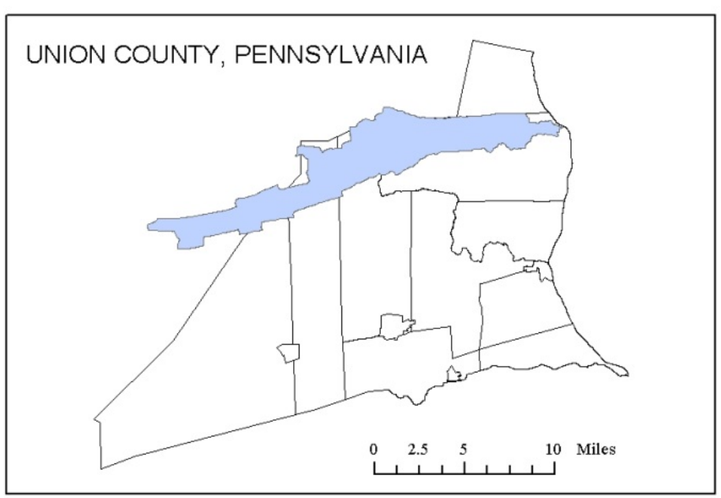
White Deer Creek Stormwater Management Plan

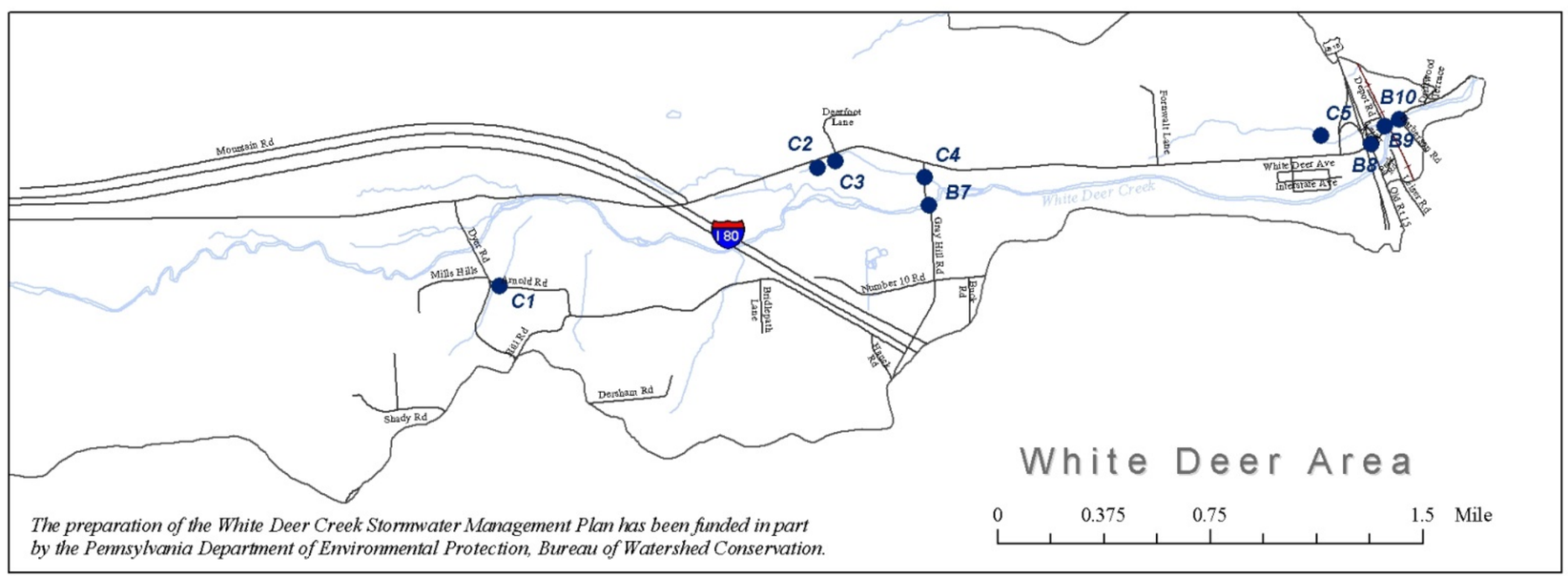
PLATE 5
SIGNIFICANT OBSTRUCTIONS



uction	Capacity (cfs)	Return Period	Description	HMS location
B1	1217	25yr	Black Gap Road over White Deer Creek	Jct 30/31
B2	2332	50yr	McCall Mill Road over White Deer Creek	Jct 29/28
B3	2747	50yr	Cooper Mill Road over White Deer Creek	Jct 27
B4	2072	25yr	White Deer Creek Rd. over White Deer Creek	Jct 26
B5	2370	25yr	White Deer Creek Rd. over White Deer Creek	Jct 24
B6	682	10yr	White Deer Creek Rd. over Sand Spring Run	Jct 23/22
B7	6145	25yr	Gray Hill Road over White Deer Creek (Covered Bridge)	Jct 5
B8	8083	25yr	S.R. 15 over White Deer Creek	Jct 2/3
B9	8[illegible]	25yr	Depot Road over unnamed trib. to White Deer Creek	Jct 2
B10	4996	25yr	Harbers Road over White Deer Creek	Jct 1
C1	42	10yr	Arnold Road over unnamed trib. to White Deer Creek	Sub 9
C2	108	<2yr	Driveway Culvert	Sub 6
C3	143	2yr	Driveway Culvert	Sub 6
C4	64	<10yr	Gray Hill Road over unnamed trib. to White Deer Creek	Sub 6
C5	151	<2yr	Driveway Culvert	Jct 2

Source: Union County GIS Department, March 2003
State Plane Coordinates, North Zone, NAD 83



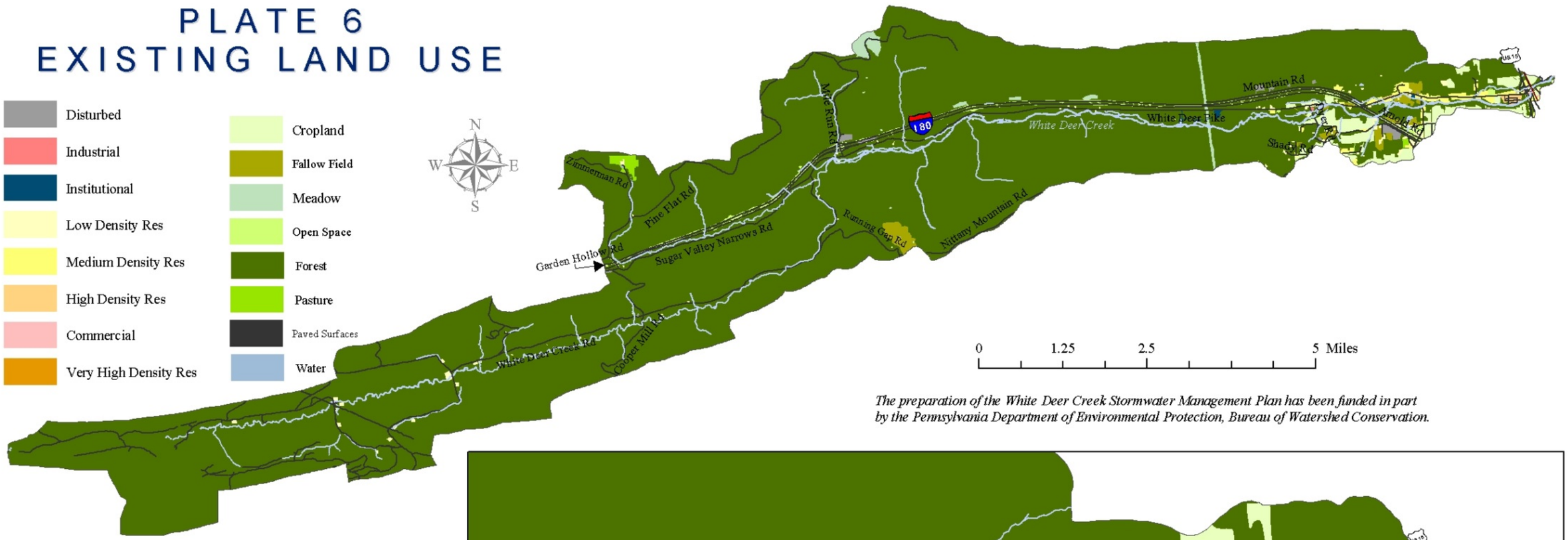


The preparation of the White Deer Creek Stormwater Management Plan has been funded in part by the Pennsylvania Department of Environmental Protection, Bureau of Watershed Conservation.

PLATE 6
EXISTING LAND USE

- Disturbed
- Industrial
- Institutional
- Low Density Res
- Medium Density Res
- High Density Res
- Commercial
- Very High Density Res
- Cropland
- Fallow Field
- Meadow
- Open Space
- Forest
- Pasture
- Paved Surfaces
- Water

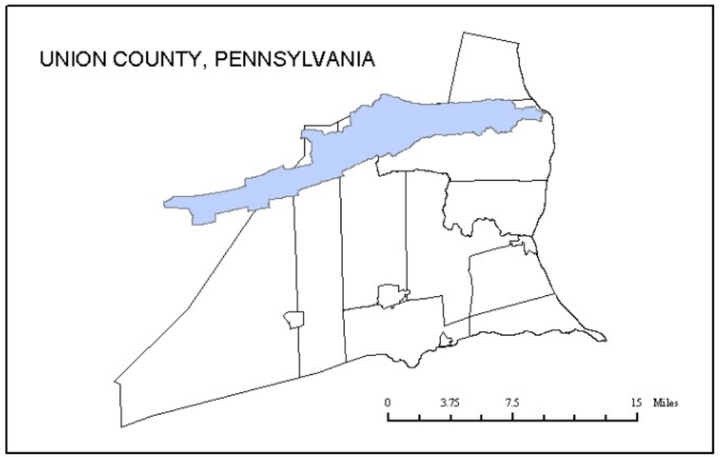
N W E S

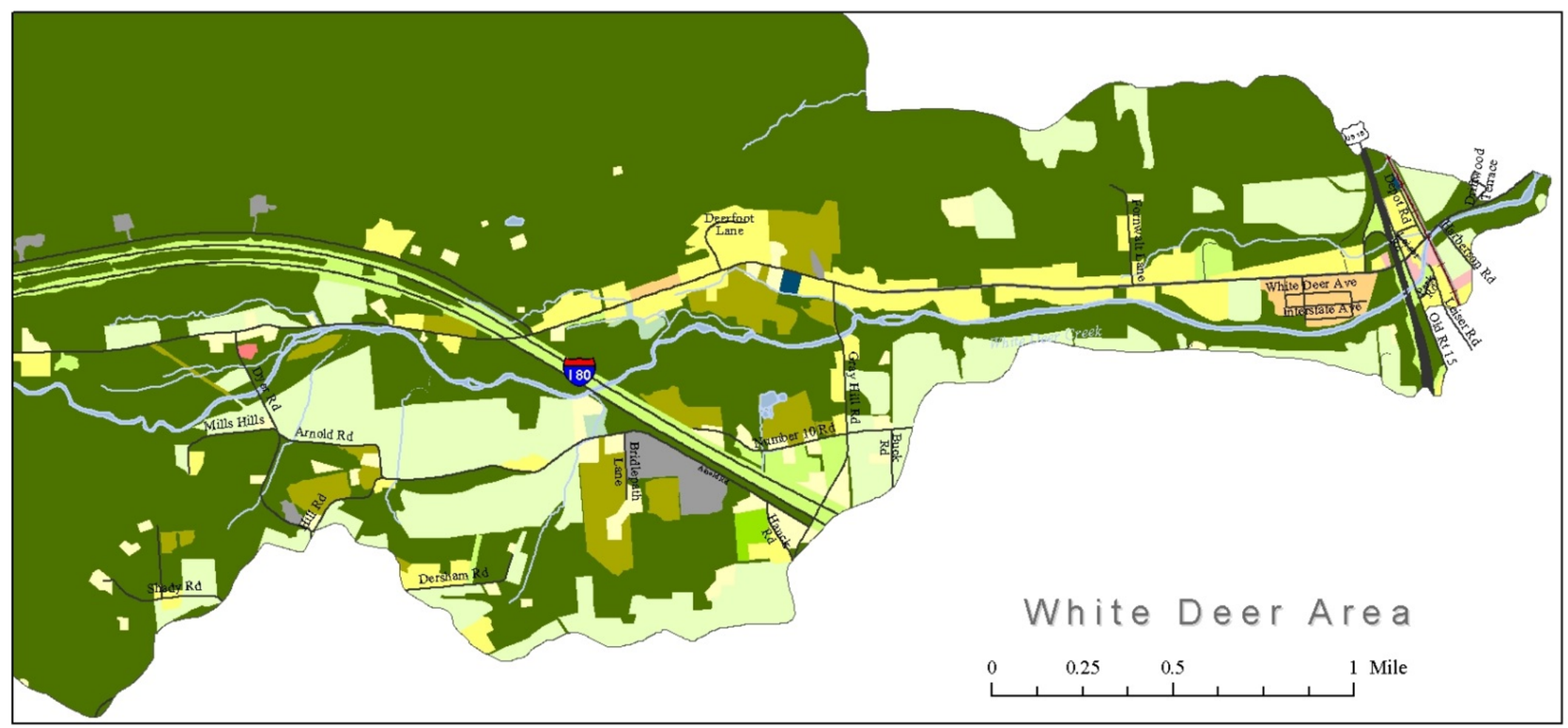


0 1.25 2.5 5 Miles

The preparation of the White Deer Creek Stormwater Management Plan has been funded in part by the Pennsylvania Department of Environmental Protection, Bureau of Watershed Conservation.

Source: Union County GIS Department, March 2003
State Plane Coordinates, North Zone, NAD 83





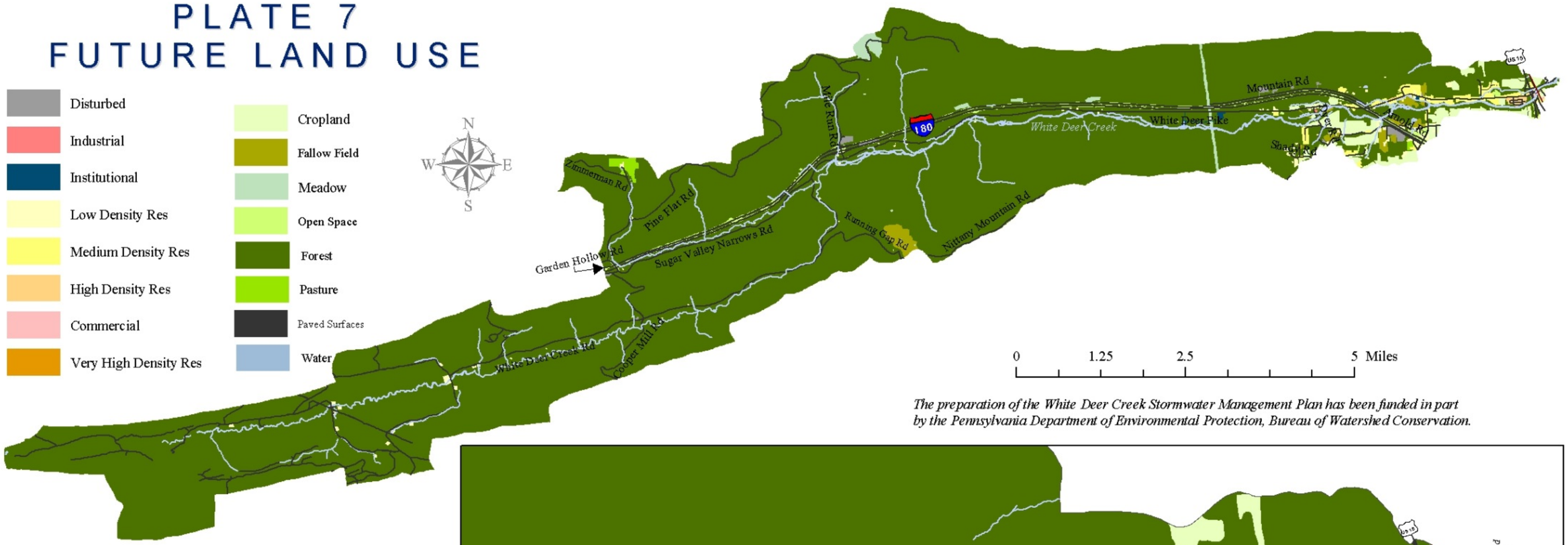
White Deer Area

0 0.25 0.5 1 Mile

PLATE 7
FUTURE LAND USE

- Disturbed
- Industrial
- Institutional
- Low Density Res
- Medium Density Res
- High Density Res
- Commercial
- Very High Density Res
- Cropland
- Fallow Field
- Meadow
- Open Space
- Forest
- Pasture
- Paved Surfaces
- Water

N W E S

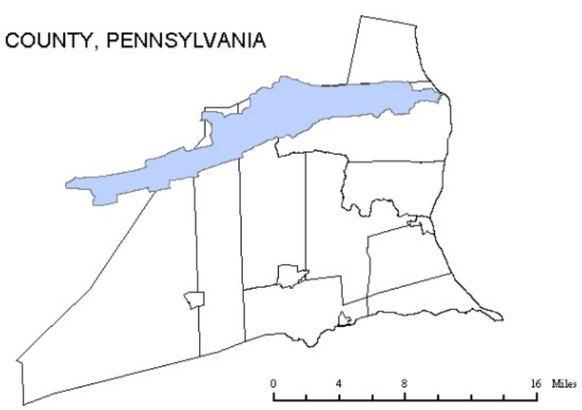


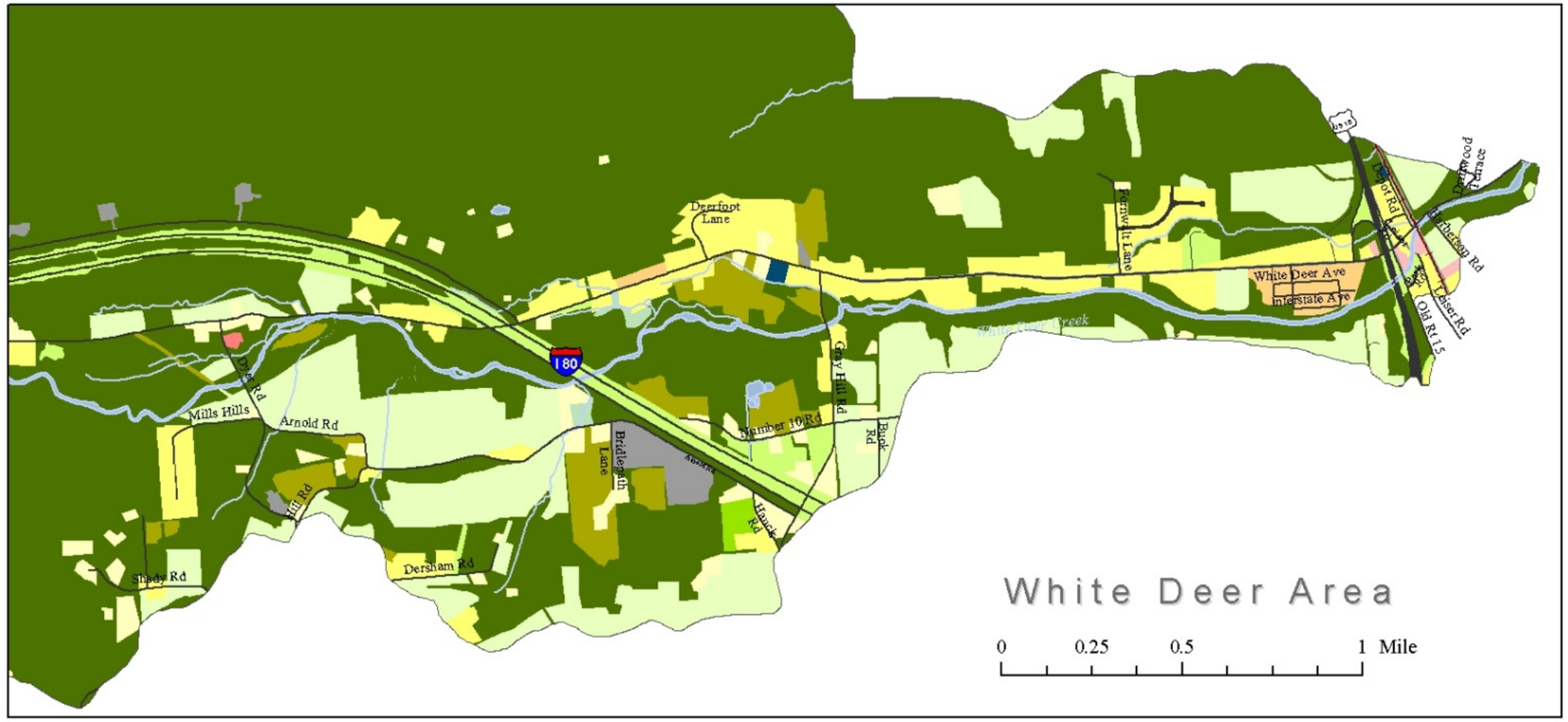
0 1.25 2.5 5 Miles

The preparation of the White Deer Creek Stormwater Management Plan has been funded in part by the Pennsylvania Department of Environmental Protection, Bureau of Watershed Conservation.

Source: Union County GIS Department, March 2003
State Plane Coordinates, North Zone, NAD 83

UNION COUNTY, PENNSYLVANIA





White Deer Area

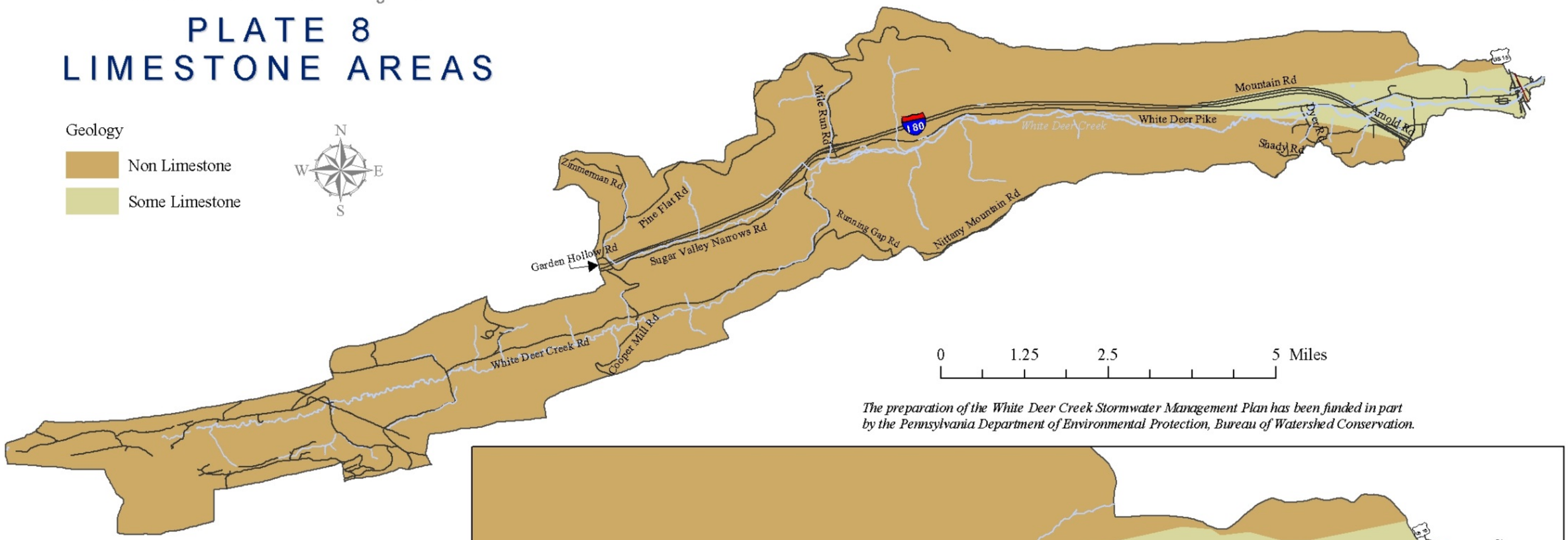
0 0.25 0.5 1 Mile

PLATE 8
LIMESTONE AREAS

Geology

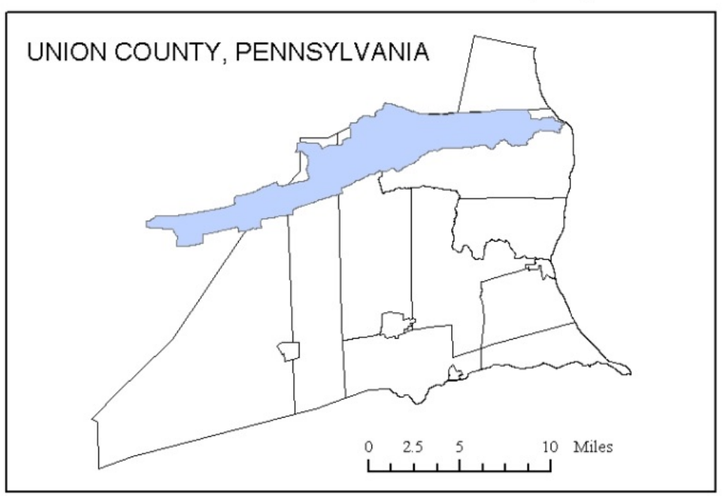
- Non Limestone
- Some Limestone

N W E S



The preparation of the White Deer Creek Stormwater Management Plan has been funded in part by the Pennsylvania Department of Environmental Protection, Bureau of Watershed Conservation.

Source: Union County GIS Department, March 2003
State Plane Coordinates, North Zone, NAD 83
Surface Geology for Pennsylvania by
Environmental Resource Research Institute (ERRI), 1994



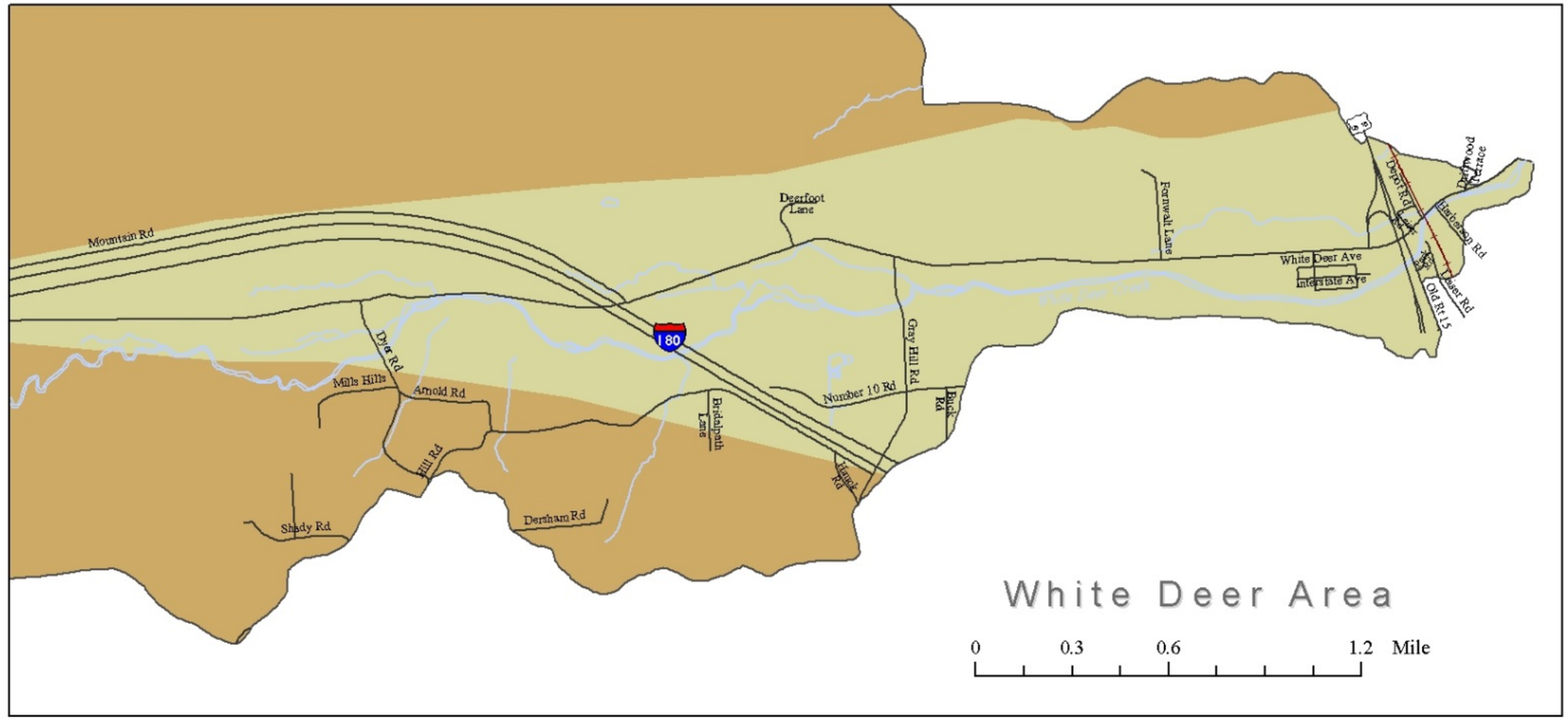
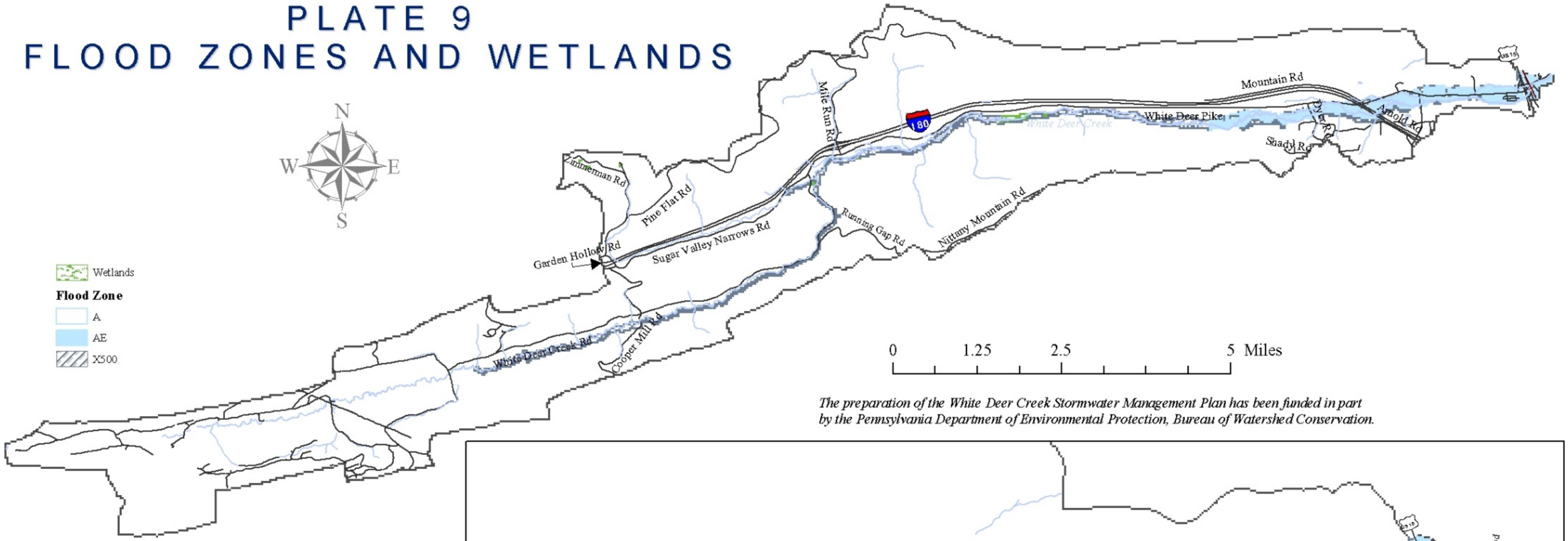
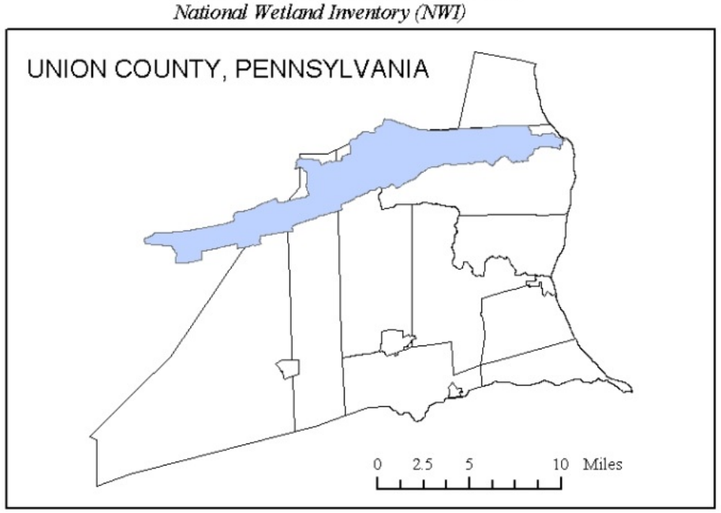


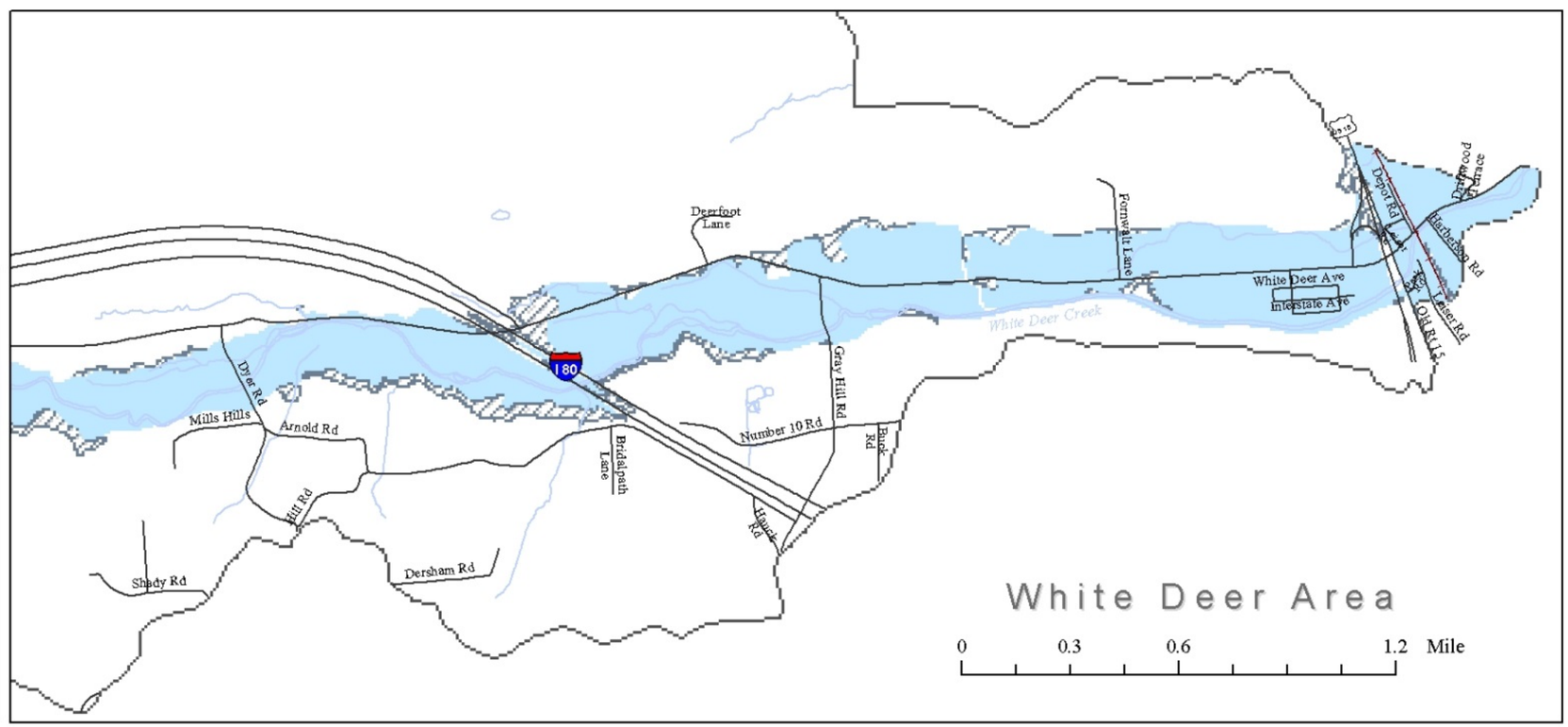
PLATE 9
FLOOD ZONES AND WETLANDS



The preparation of the White Deer Creek Stormwater Management Plan has been funded in part by the Pennsylvania Department of Environmental Protection, Bureau of Watershed Conservation.

Source: Union County GIS Department, March 2003
State Plane Coordinates, North Zone, NAD 83
FEMA Flood Zone provided by SEDA COG
Wetlands as they exist in data provided by
National Wetland Inventory (NWI)





Appendix A
Review of Related Documents

APPENDIX A
REVIEW OF RELATED DOCUMENTS

PREVIOUS STUDY NO: 1
Section 905(b)(WRDA 86) Analysis Lower West Branch, Susquehanna River

I. GOALS AND OBJECTIVES

a. The purposes of this study are to determine Federal interest in environmental restoration, streambank protection, floodplain management, flood damage reduction, and other allied purposes for the Lower West Branch Susquehanna River Basin; develop a Project Study Plan (PSP) to conduct further feasibility studies; and identify a non-Federal sponsor(s) to cost-share the feasibility phase with the Federal Government.

II. IDENTIFIED PROBLEMS

a. Flooding: Of the five problem locations in Union County the major problems were located in White Deer Township and Buffalo Township and Lewisburg and Mifflinburg Boroughs.

b. Erosion and Streambank Stabilization: Of the eight sites identified in Union County the major problems were threats to roadways and bridges in White Deer and Gregg Townships and Mifflinburg, Harleton, New Berlin and Lewisburg Boroughs.

III. POTENTIAL SOLUTIONS AND ACTION TAKEN

a. Environmental restoration solutions were addressed on a site-specific basis; however, due to the size of the study area these solutions could be applied to numerous locations within the watershed. These solutions include: riprap armoring, bank grading and to protection, channel realignment, gabion walls, stream deflectors, boulder placement, rock weirs, removal of fish blockages, reforestation, shrub and fasche plantings, riparian revegetation, wetland creation, floodplain creation, sediment and water quantity detention basins, stormwater facility retrofits, and stormwater diversion.

b. Flood damage reduction solutions included seeking federal funds through the Flood Control Act of 1936. Various site-specific improvements were identified including: dams, reservoirs, channelization measures, levees, diversion channels, ice-control structures, bridge modification, implementing floodproofing measures, permanent relocation of structures, flood warning systems, and regulation of floodplain uses.

No action taken. A US Army Corps of Engineers investigation found that the sites within the White Deer Creek Watershed do not meet the Federal Cost Benefit requirements. This is largely due to the fact that the property values of flood prone areas are low.

PREVIOUS STUDY NO: 2
H&H Report for S.R. 1014 / S.R. 1010, Section 004 Over West Branch Susquehanna River and White Deer Creek, July 2001

I. INTRODUCTION

a. This report is intended to present information to the PA Department of Environmental Protection, the PA Fish and Boat Commission and any other agencies, for the purpose of obtaining a waterway permit.

b. This report documents the hydrologic and hydraulic studies conducted for the rehabilitation of a deteriorated nine span reinforced concrete arch bridge. The arch bridge carries S.R. 1010, Section 004/S.R. 1014 Section 004 over the Susquehanna River between the Watsontown Borough, Northumberland County and White Deer Township, Union County, PA. Within the report the potential backwater from this structure is analyzed on White Deer Creek.

II. GOALS AND OBJECTIVES

a. To design a bridge with an appropriate opening which will not increase the 100-year flood elevation, while considering public risk and cost.

III. ACTION TAKEN

b. A bridge was designed that will have a very minimal backwater increase on White Deer Creek.

Summary:

The proposed rehabilitated structure will maintain hydraulic conditions similar to those of the existing structure. The West Branch Susquehanna River and White Deer Creek were modeled separately to study the hydraulic effects of the proposed project. White Deer Creek was modeled for isolated storm events in its drainage area (flash flooding). During high water events on the West Branch of the Susquehanna River, the entire study area of White Deer Creek is inundated.

Appendix B
Review of Existing Municipal Ordinances

Appendix B – Review of Relevant Municipal Ordinances and Flood Insurance Studies

I. Gregg Township

A. Zoning Ordinance, Gregg Township, July 1990

1. GOALS AND OBJECTIVES

   a. To provide the minimum conditions necessary to achieve the goals of the Comprehensive Plan for Gregg Township.
   b. To promote the public's health, safety, morals, and the general welfare, encourage the most appropriate use of land, conserve and stabilize the value of property, provide adequate open spaces for light and air, prevent undue concentration of population, and lessen congestion on streets and highways.

B. Subdivision and Land Development Ordinance, Gregg Township, March 4, 1991

1. GOALS AND OBJECTIVES

   a. Providing for the equitable processing of subdivision and land development plans through uniform standards and procedures;
   b. Providing for the protection of soil and water resources and storm water management facilities;
   c. Providing for the health, safety, and general welfare of the township;
   d. Providing for the safe and efficient movement of pedestrians and vehicles;
   e. Promoting energy efficient subdivision and land development design;
   f. Avoid unsound development in floodplain areas;
   g. Providing and protecting sites with recreation, conservation, land development, streets, and utilities.
   h. Providing for the orderly and efficient integration of subdivision, land development, streets, and utilities.

2. SPECIFIC REQUIREMENTS (STORMWATER)

   a. The anticipated peak runoff from the site must not exceed the pre-development rate of runoff for the 2-, 10-, and 100-year storms.

C. Floodplain Management Ordinance, Gregg Township, November 7, 1988

1. GOALS AND OBJECTIVES

   a. Promote the general health, welfare, and safety of the community
   b. Encourage the utilization of appropriate construction practices in order to prevent or minimize flood damage in the future.
   c. Minimize danger to public health by protecting water supply and natural drainage.

d. Reduce financial burdens imposed on the community, its governmental units, and its residents, by preventing excessive development in areas subject to flooding.

e. To protect adjacent landowners and those both upstream and downstream from damages resulting from development within a floodplain and the consequent obstruction or the increase in flow of flood waters.

2. SPECIFIC REQUIREMENTS

a. All adjacent municipalities must be notified prior to any encroachment, alteration, or improvement of any watercourse.

b. Any new construction, development, use, activity, or encroachment, proposed within a floodway, which would cause any increase in flood elevations is prohibited.

c. No new construction or development shall be allowed within a floodway unless a permit is obtained from the Department of Environmental Protection.

D. Flood Insurance Study, Gregg Township, March 1979

1. GOALS AND OBJECTIVES

a. To investigate the existence and severity of flood hazards in the respective municipality and to aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

b. Initial use of this information is to convert the respective Township to the regular program of flood insurance by the Federal Insurance Administration (FIA).

c. Further use of this information will be made by local and regional planners in efforts to promote sound land use and floodplain development.

II. Greene Township

A. Zoning Ordinance, Greene Township (Clinton County), September 29, 1971

1. GOALS AND OBJECTIVES

a. To promote, protect and facilitate the public health, safety, morals, coordination and practical community development and other aspects of the general welfare of the Township of Greene, Clinton County, Pennsylvania.

B. Subdivision and Land Development Ordinance, Greene Township (Clinton County), Nov. 6, 1975

1. GOALS AND OBJECTIVES

a. No specific goals are listed.

C. **Floodplain Management Ordinance, Greene Township (Clinton County), December 9, 1986**

1. GOALS AND OBJECTIVES

   a. Promote the general health, welfare, and safety of the community.
   b. Encourage the utilization of appropriate construction practices in order to prevent or minimize flood damage in the future.
   c. Minimize danger to public health by protecting water supply and natural drainage.
   d. Reduce financial burdens imposed on the community, its governmental units, and its residents, by preventing excessive development in areas subject to flooding.
   e. Comply with federal and state floodplain management requirements.

III. Hartley Township

A. **Zoning Ordinance, Hartley Township, June 10, 1996**

1. GOALS AND OBJECTIVES

   a. To provide the minimum conditions necessary to achieve the goals of the Comprehensive Plan for Hartley Township.
   b. To promote the public's health, safety, morals, and the general welfare, encourage the most appropriate use of land, conserve and stabilize the value of property, provide adequate open spaces for light and air, prevent undue concentration of population, and lessen congestion on streets and highways.

B. **Subdivision and Land Development Ordinance, Hartley Township (Union County SALDO), September 13, 1990**

1. GOALS AND OBJECTIVES

   a. Assisting in the orderly, efficient integration of subdivision within the county;
   b. Insuring conformance of subdivision plans with public improvement plans;
   c. Insuring coordination of inter-municipal public improvement plans and programs;
   d. Securing protection of water resources and drainage ways;
   e. Facilitating the efficient movement of traffic;
   f. Securing equitable handling of all subdivision plans by providing uniform standards and procedures;
   g. In general, promoting the general health, safety and welfare of the citizens of the county;
   h. Securing adequate sites for recreation, conservation, scenic and other open space purposes.

C. <u>Floodplain Management Ordinance, Hartley Township, February 1, 1988</u>

1. GOALS AND OBJECTIVES

   a. Promote the general health, welfare, and safety of the community
   b. Encourage the utilization of appropriate construction practices in order to prevent or minimize flood damage in the future.
   c. Minimize danger to public health by protecting water supply and natural drainage.
   d. Reduce financial burdens imposed on the community, its governmental units, and its residents, by preventing excessive development in areas subject to flooding.
   e. Comply with federal and state floodplain management requirements.

2. Specific Requirements

   a. All adjacent municipalities must be notified prior to any encroachment, alteration, or improvement of any watercourse.
   b. Any new construction, development, use, activity, or encroachment, proposed within a floodway, which would cause any increase in flood elevations is prohibited.
   c. No new construction or development shall be allowed within a floodway unless a permit is obtained from the Department of Environmental Protection.

D. <u>Flood Insurance Study, Hartley Township, March 4, 1998</u>

1. GOALS AND OBJECTIVES

   a. To investigate the existence and severity of flood hazards in the respective municipality and to aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.
   b. The study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates and assist the community in its efforts to promote sound floodplain management.

IV. Lewis Township

A. <u>Subdivision and Land Development Ordinance for Lewis Township, see Union County SALDO above.</u>

B. <u>Floodplain Management Ordinance, Lewis Township, September 22, 1987</u>

1. GOALS AND OBJECTIVES

a. Promote the general health, welfare, and safety of the community
b. Encourage the utilization of appropriate construction practices in order to prevent or minimize flood damage in the future.
c. Minimize danger to public health by protecting water supply and natural drainage.
d. Reduce financial burdens imposed on the community, its governmental units, and its residents, by preventing excessive development in areas subject to flooding.
e. Comply with federal and state floodplain management requirements.

C. <u>Flood Insurance Study, Lewis Township, September 30, 1987</u>

1. GOALS AND OBJECTIVES

a. To investigate the existence and severity of flood hazards in the respective municipality and to aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.
b. The study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates and assist the community in its efforts to promote sound floodplain management.

V. West Buffalo Township

A. <u>Zoning Ordinance, West Buffalo Township, no date</u>

1. GOALS AND OBJECTIVES

a. To provide the minimum conditions necessary to achieve the goals of the Comprehensive Plan for West Buffalo Township.

b. To promote the public's health, safety, morals, and the general welfare, encourage the most appropriate use of land, conserve and stabilize the value of property, provide adequate open spaces for light and air, prevent undue concentration of population, and lessen congestion on streets and highways.

B. <u>Subdivision and Land Development Ordinance for West Buffalo Township, see Union County SALDO above.</u>

C. <u>Flood Insurance Study, West Buffalo Township, September 30, 1987</u>

1. GOALS AND OBJECTIVES

a. To investigate the existence and severity of flood hazards in the respective municipality and to aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.
b. The study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates and assist the community in its efforts to promote sound floodplain management.

VI. White Deer Township

A. <u>Zoning Ordinance, White Deer Township, July 25, 1999</u>

1. GOALS AND OBJECTIVES

a. To promote orderly growth and development of White Deer Township.
b. To simplify the zoning program in order to crate greater understanding and acceptance by the general public.
c. To improve the flexibility and enforcement of the Township's land use regulations.

2. ENVIRONMENT

a. To preserve, as far as possible, the rural character of White Deer Township by concentrating commercial, industrial, and residential development in the eastern section of the Township. Agricultural and forest uses shall be encouraged in central and western sections.
b. To provide for compatible uses in floodplain areas (e.g. agriculture, open space, etc.)
c. To continue to provide adequate water and sewer facilities to serve the more intensely developed areas of the Township.
d. To insure that new development is not a detriment to the environment.
e. To improve stormwater management planning and control.

B. <u>Subdivision and Land Development Ordinance, White Deer Township, June 1990</u>

1. GOALS AND OBJECTIVES

a. Providing for the equitable processing of subdivision and land development plans through uniform standards and procedures;
b. Providing for the protection of soil and water resources and storm water management facilities;
c. Providing for the health, safety, and general welfare of the township;
d. Providing for the safe and efficient movement of pedestrians and vehicles;
e. Promoting energy efficient subdivision and land development design;
f. Avoid unsound development in floodplain areas;
g. Providing and protecting sites with recreation, conservation, land development, streets, and utilities.
h. Providing for the orderly and efficient integration of subdivision, land development, streets, and utilities.

C. Floodplain Management Ordinance, White Deer Township, August 28, 1979

1. GOALS AND OBJECTIVES

a. Promote the general health, welfare, and safety of the community
b. Encourage the utilization of appropriate construction practices in order to prevent or minimize flood damage in the future.
c. Minimize danger to public health by protecting water supply and natural drainage.
d. Reduce financial burdens imposed on the community, its governmental units, and its residents, by preventing excessive development in areas subject to flooding.

D. Flood Insurance Study, White Deer Township, March 1979

1. GOALS AND OBJECTIVES

a. To investigate the existence and severity of flood hazards in the respective municipality and to aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.
b. Initial use of this information is to convert the respective Township to the regular program of flood insurance by the Federal Insurance Administration (FIA).
c. Further use of this information will be made by local and regional planners in efforts to promote sound land use and floodplain development.

VII. Washington Township

A. Zoning Ordinance, Washington Township (Lycoming County Zoning) Enacted December 31, 1991 Revised October 3, 1996

1. GOALS AND OBJECTIVES - LAND USE PATTERNS AND COMMUNITY CHARACTER

a. To provide for a rational and orderly pattern of land use by establishing districts of distinct community character according to the use of land and buildings, the intensity of such use (including bulk and height), and the surrounding open space.
b. To provide for a harmonious relationship between areas of different community character.
c. To secure adequate natural light, clean air, privacy, convenient and safe access to property, and a safe environment.
d. To identify, preserve, and enhance the existing character of communities within the County.
e. To encourage quality, attractive, and economically sound residential, commercial, and industrial development.
f. To ensure that proposed public facilities and development are consistent with the character and environmental limitations of the area.

2. NATURAL RESOURCES

a. To preserve and protect the County's natural resources.
b. To avoid or lessen the hazards of flooding, soil erosion, and stormwater accumulation and runoff.
c. To preserve the best agricultural soils for future production.
d. To preserve and protect natural habitats for wildlife.
e. To prevent air and ground water contamination.
f. To protect and maintain the aesthetic and environmental qualities of the County.

3. PUBLIC INFRASTRUCTURE

a. To create an environment that is reasonably safe from fire, flood, and other dangers.
b. To guide the development of the County in order to provide the most efficient use of existing and planned public facilities and utilities.
c. To develop partnerships between local governments and developers to assure the provision of adequate infrastructure.
d. To reduce the danger and congestion of traffic on roads and highways by controlling the location and limiting the number of intersections and driveways.
e. To protect residential streets from degradation by nonresidential traffic.
f. To ensure adequate and safe roads and facilities by limiting land use intensity to the capacity of the roads and facilities.
g. To promote economy in local government expenditures.

4. JUSTIFIABLE EXPECTATIONS AND TAXABLE VALUE

a. To stabilize the taxable values of land and buildings.
b. To protect landowners from potential adverse impacts of adjoining developments.
c. To protect and respect the justifiable reliance of existing residents, businesses, and taxpayers on the continuation of existing, established, and planned land use patterns.

B. <u>Subdivision and Land Development Ordinance, Washington Township, January 3, 1995</u>

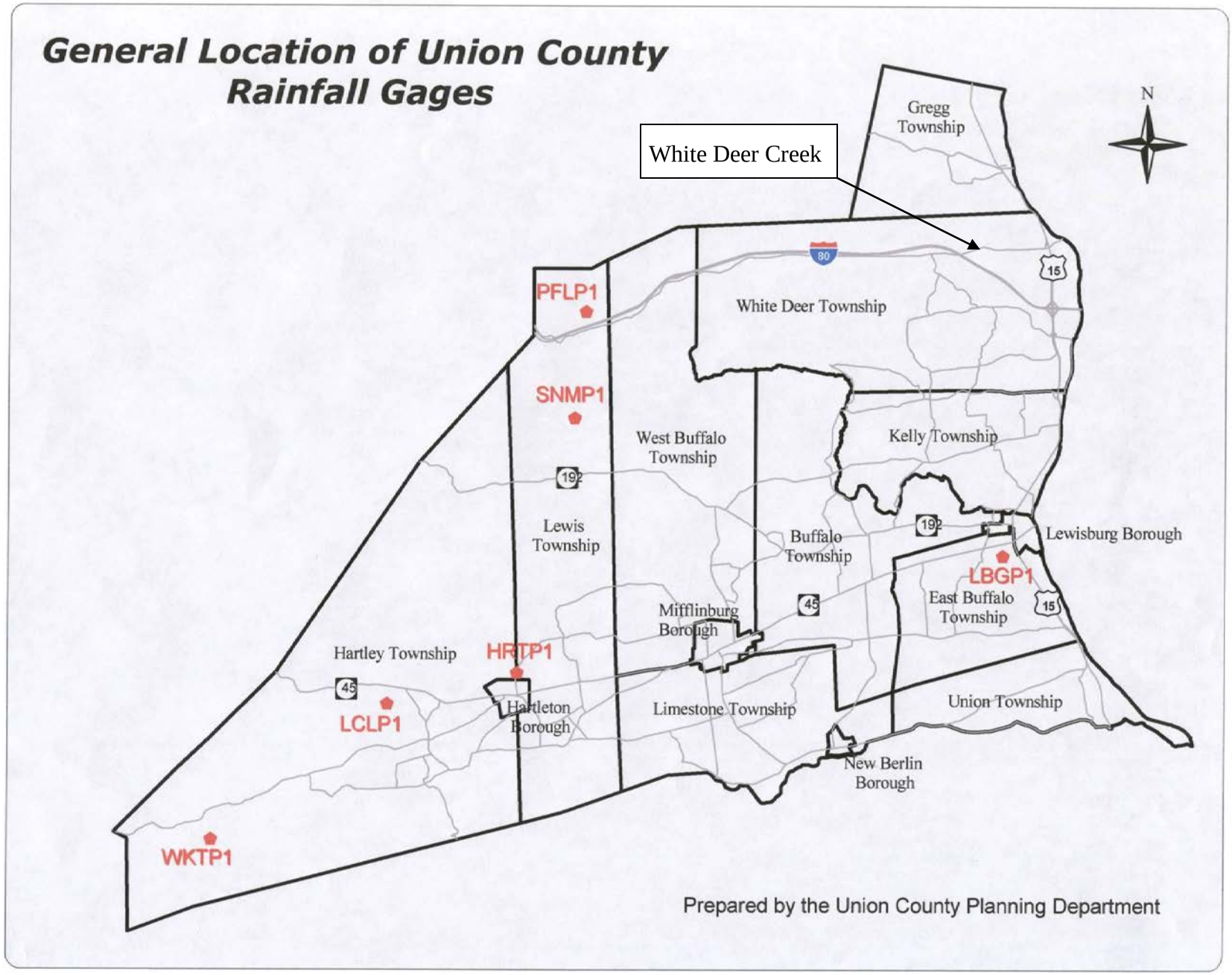
1. GOALS AND OBJECTIVES

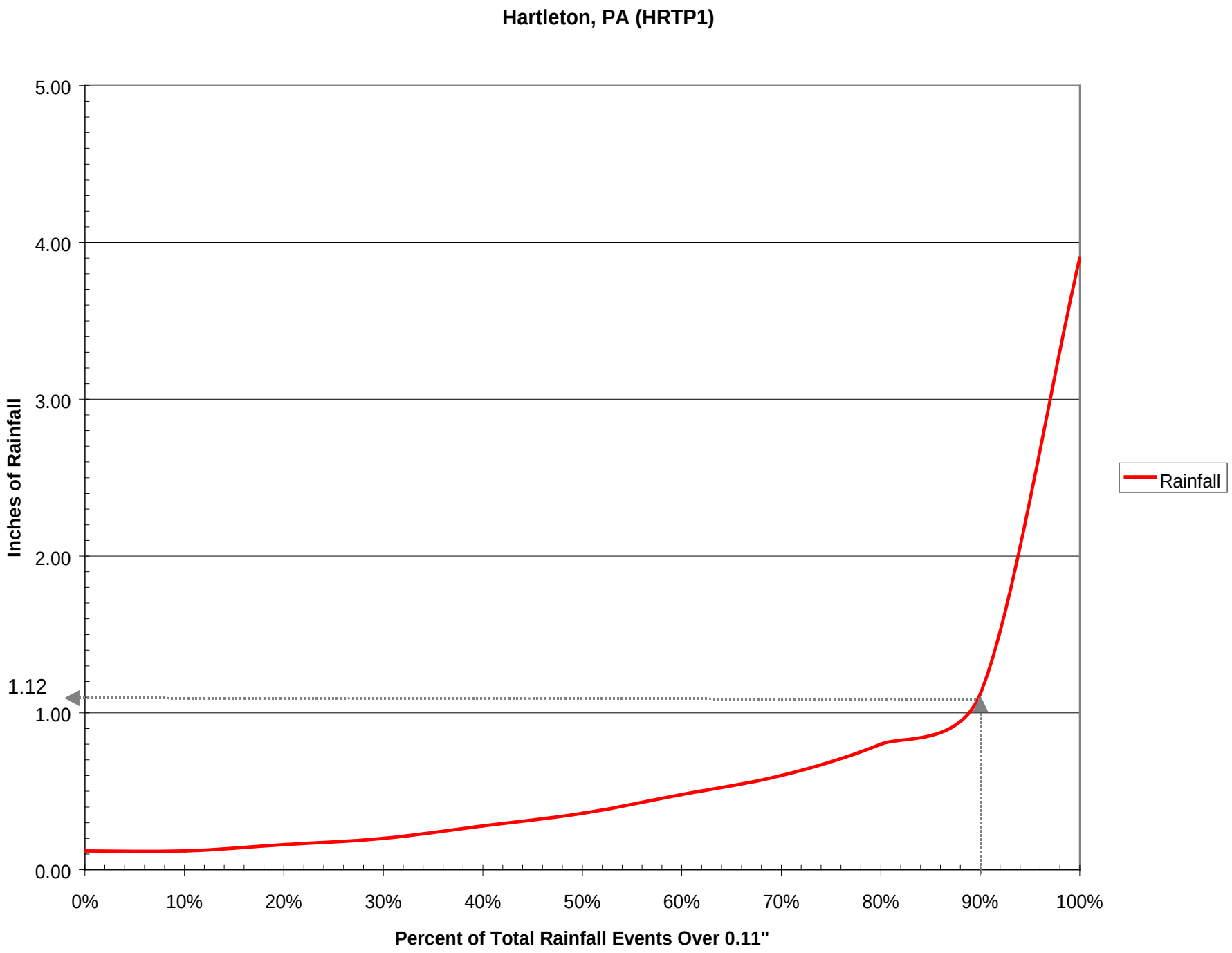
   a. To assist in the orderly and efficient integration of subdivisions and land development within the Township.
   b. To ensure conformance of subdivision and land development plans with public improvement plans.
   c. To ensure coordination of inter-municipal public improvement plans and programs.
   d. To secure the protection of soil and water resources and natural drainageways through proper management and control of stormwater.
   e. To facilitate the safe and efficient movement of traffic.
   f. To secure equitable handling of all subdivision and land development plans by providing uniform standards and procedures.
   g. To promote the greater health, safety, welfare, and morals of citizens of the Township.
   h. To secure adequate sites for recreation, conservation, scenic, and other open space purposes.
   i. To encourage the utilization of flood hazard areas in a manner that will not increase flood hazard.
   j. To preserve and restore the flood-carrying capacity of streams; maintain existing flows and quality of streams and watercourses.

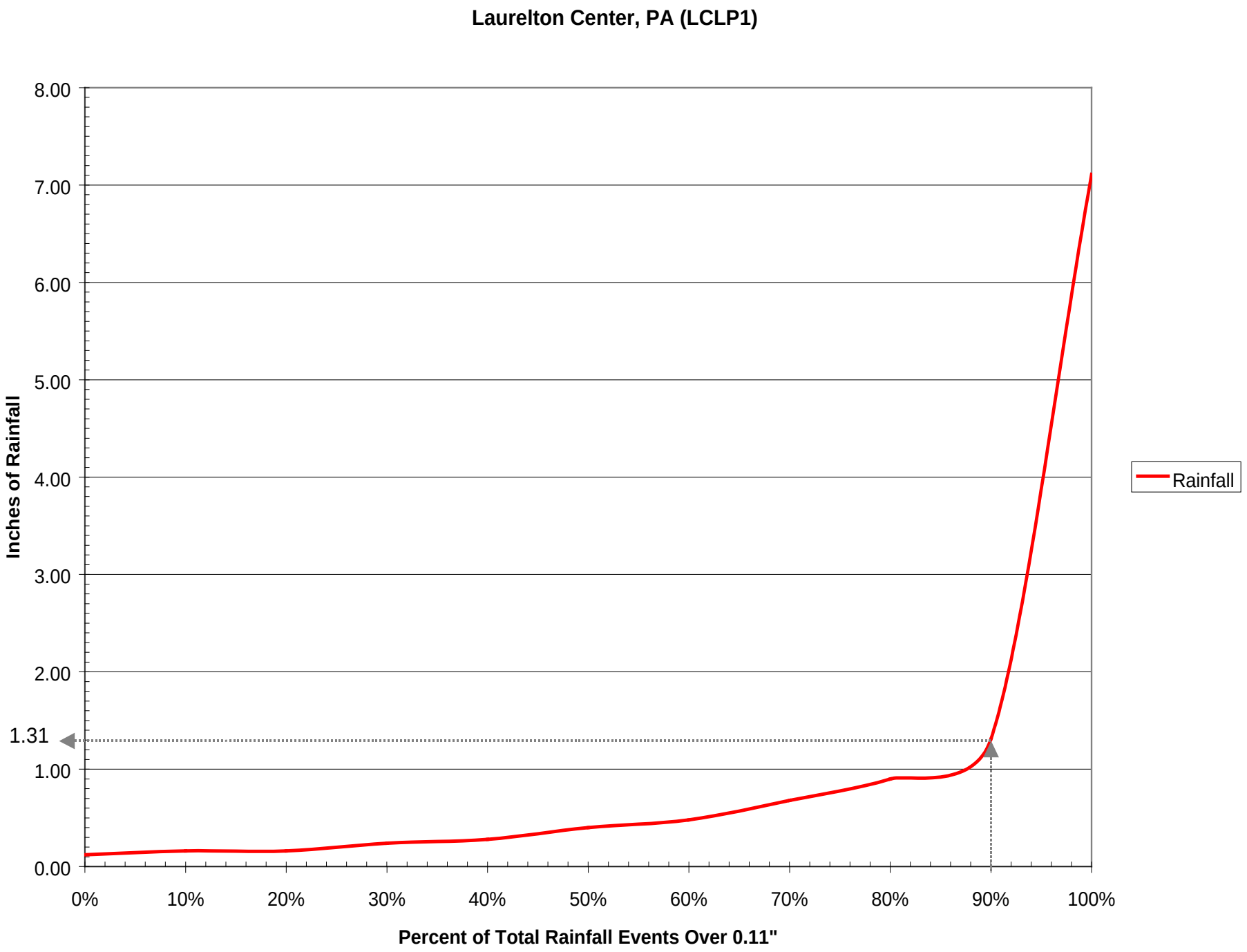
C. <u>Floodplain Management Ordinance, Washington Township</u>

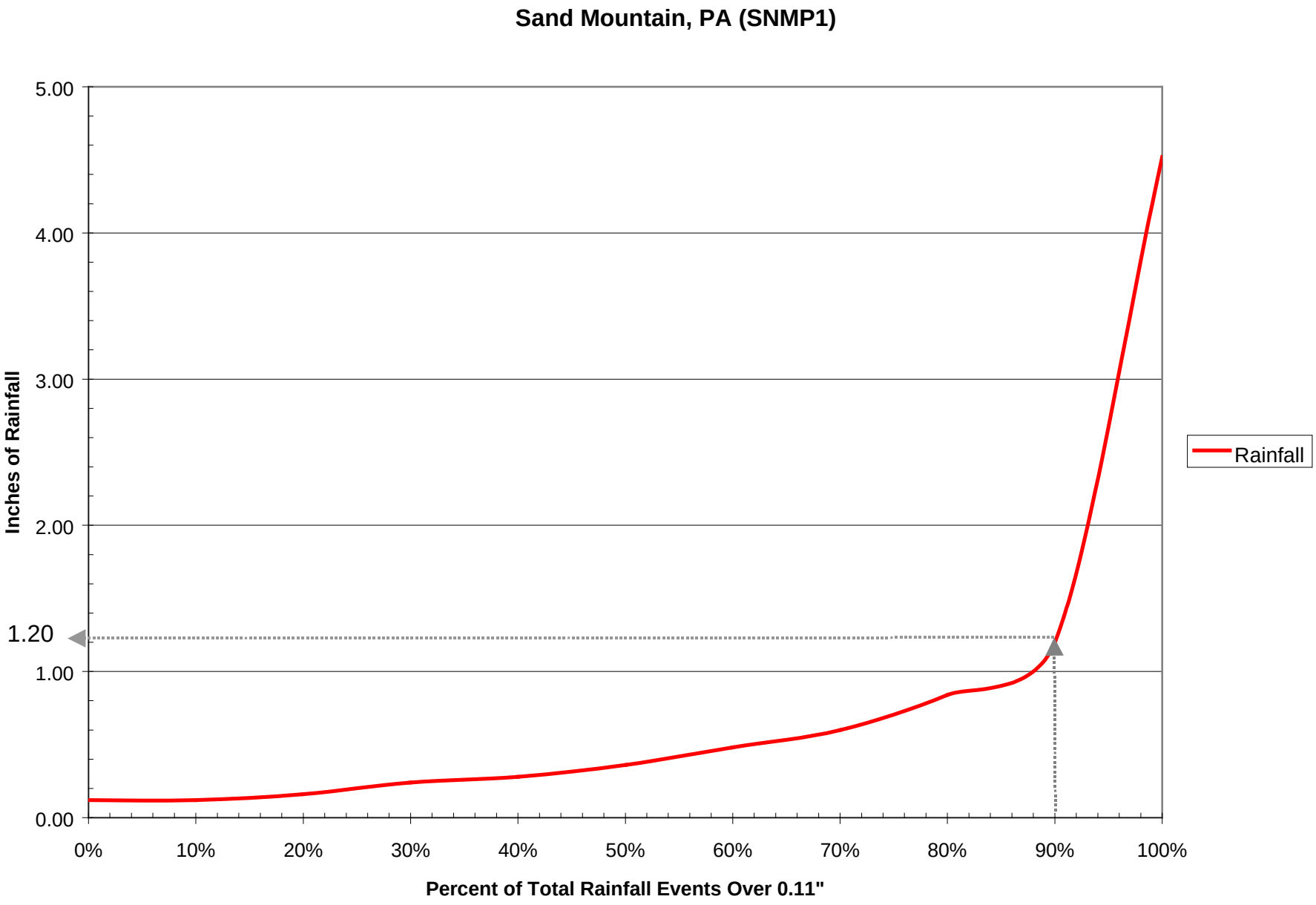
1. Under County Administration

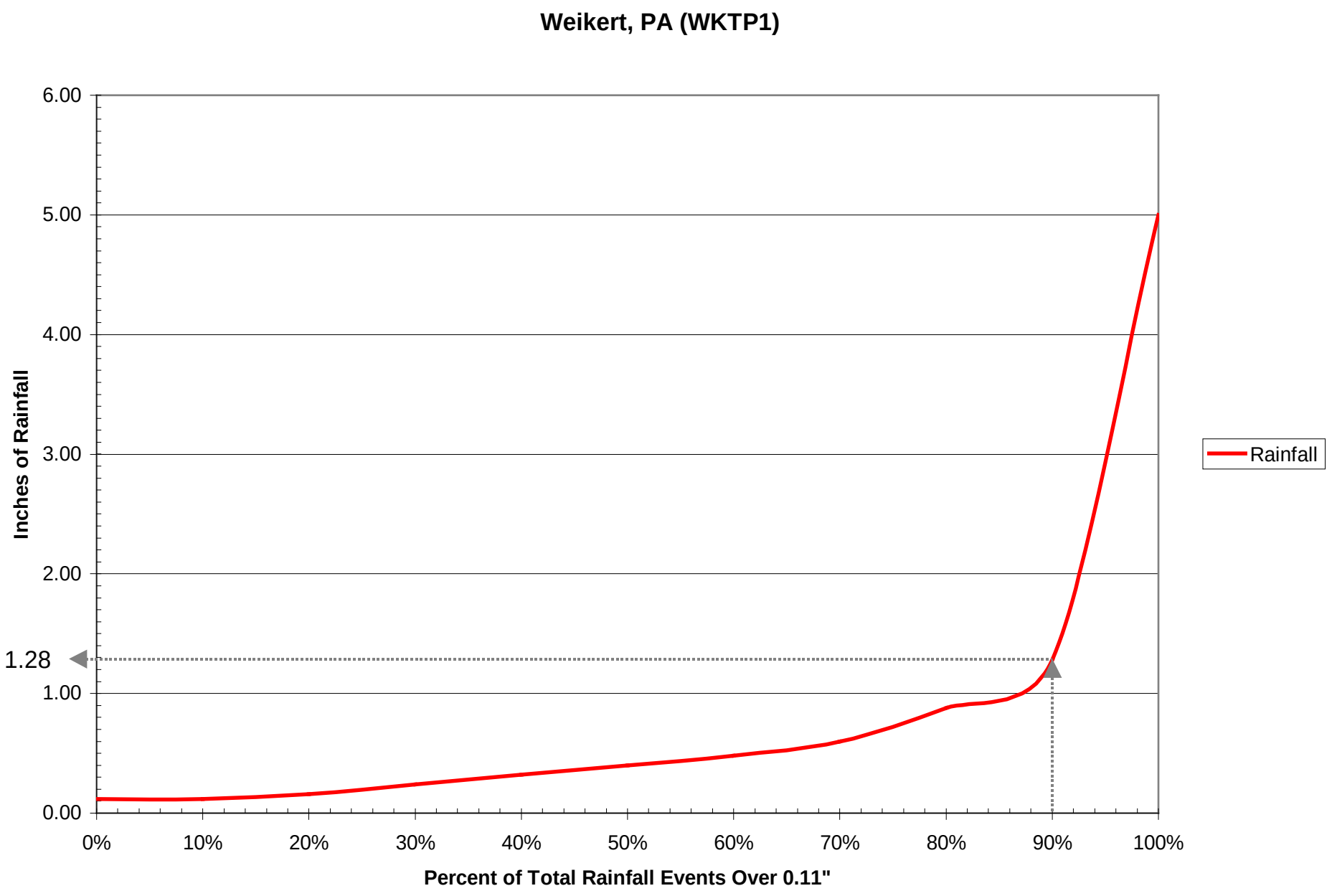
Appendix C
Union County Rainfall Data

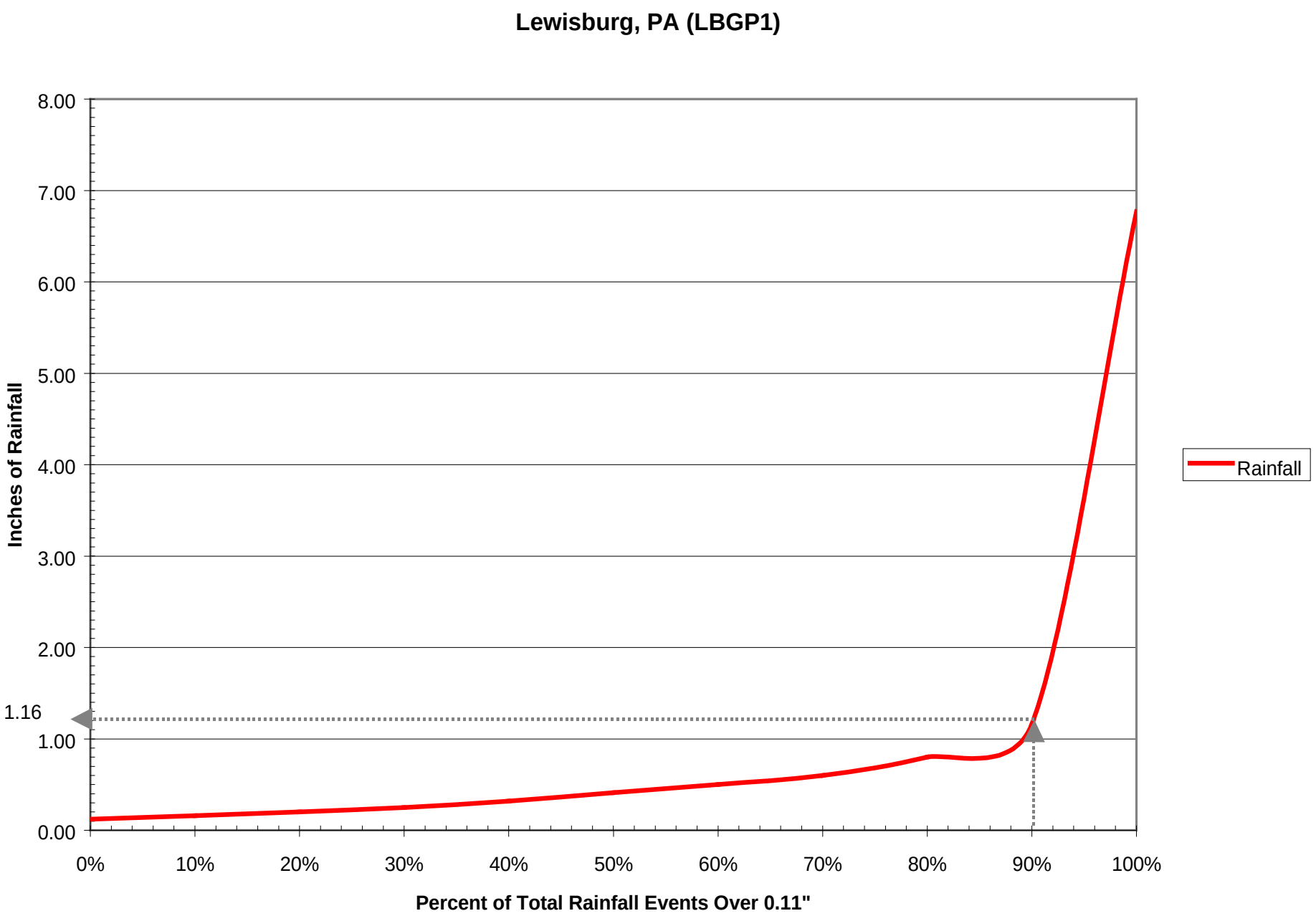

General Location of Union County Rainfall Gages
White Deer Creek
N
Gregg Township
White Deer Township
PFLP1
SNMP1
West Buffalo Township
Kelly Township
Lewis Township
Buffalo Township
Lewisburg Borough
LBGP1
East Buffalo Township
Mifflinburg Borough
Hartley Township
HRTP1
LCLP1
Hartleton Borough
Limestone Township
Union Township
New Berlin Borough
WKTP1
80
15
192
45
Prepared by the Union County Planning Department

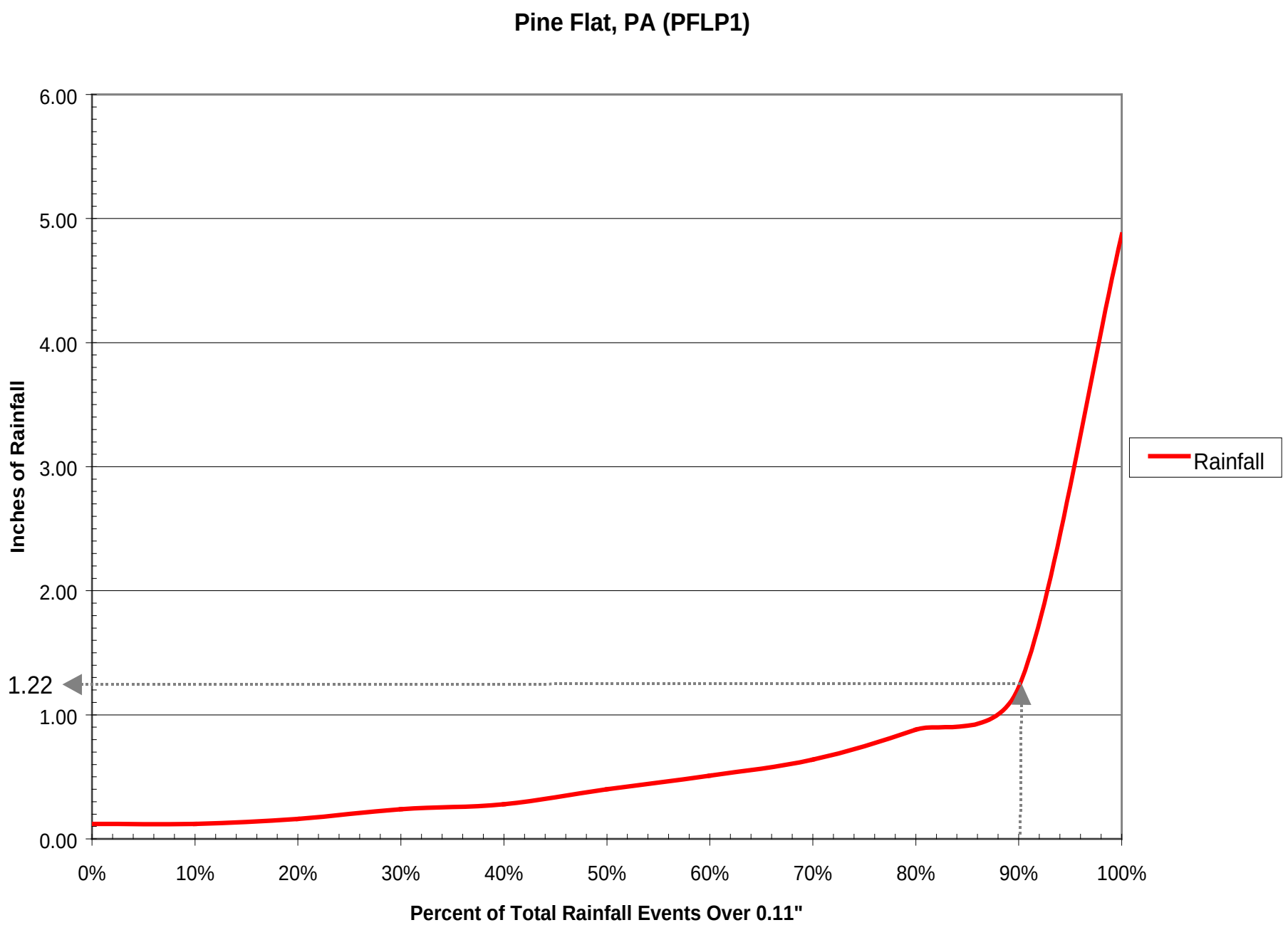

Hartleton, PA (HRTP1)
5.00
4.00
3.00
2.00
1.12
1.00
0.00
Inches of Rainfall
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Total Rainfall Events Over 0.11"
Rainfall


Laurelton Center, PA (LCLP1)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.31
1.00
0.00
Inches of Rainfall
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Total Rainfall Events Over 0.11"
Rainfall


Sand Mountain, PA (SNMP1)
5.00
4.00
3.00
2.00
1.20
1.00
0.00
Inches of Rainfall
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Total Rainfall Events Over 0.11"
Rainfall


Weikert, PA (WKTP1)
6.00
5.00
4.00
3.00
2.00
1.28
1.00
0.00
Inches of Rainfall
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Total Rainfall Events Over 0.11"
Rainfall


Lewisburg, PA (LBGP1)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.16
1.00
0.00
Inches of Rainfall
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Total Rainfall Events Over 0.11"
Rainfall


Pine Flat, PA (PFLP1)
6.00
5.00
4.00
3.00
2.00
1.22
1.00
0.00
Inches of Rainfall
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Total Rainfall Events Over 0.11"
Rainfall

Appendix D
Stormwater Credits for Effective Site Planning

APPENDIX D
STORMWATER CREDITS FOR EFFECTIVE SITE PLANNING

D.1 Stormwater Credits

In Pennsylvania, there are many programs at both the State and local level that seek to minimize the impact of land development. Critical areas, forest conservation, and local stream buffer requirements are designed to reduce nonpoint source pollution. Non-structural practices can play a significant role in reducing water quality impacts and are increasingly recognized as a critical feature of every stormwater BMP plan, particularly with respect to site design. In most cases, non-structural practices must be combined with structural practices to meet stormwater requirements. The key benefit of non-structural practices is that they can reduce the generation of stormwater from the site; thereby reducing the size and cost of stormwater storage. In addition, they can provide partial removal of many pollutants. Non-structural practices have been classified into six broad groups and are designed to mesh with existing state and local programs (e.g., forest conservation, stream buffers, etc.). To promote greater use, a series of six stormwater credits are provided for designers that use these site planning techniques.

Credit 1. Natural Area Conservation
Credit 2. Disconnection of Rooftop Runoff
Credit 3. Disconnection of Non-Rooftop Runoff
Credit 4. Sheet Flow to Buffers
Credit 5. Grass Channel
Credit 6. Environmentally Sensitive Development

This appendix describes each of the credits for the six groups of non-structural practices, specifies minimum criteria to be eligible for the credit, and provides an example of how the credit is calculated. Designers should check with the Municipal Engineer to ensure that the credit is applicable to their jurisdiction.

In general, the stormwater sizing criteria provide a strong incentive to reduce impervious cover at development sites. Storage requirements for all five stormwater sizing criteria are directly related to impervious cover. Thus, significant reductions in impervious cover result in smaller required storage volumes and, consequently, lower BMP construction costs.

These and other site design techniques can help to reduce impervious cover, and consequently, the stormwater treatment volume needed at a site. The techniques presented in this appendix are considered options to be used by the designer to help reduce the need for stormwater BMP storage capacity. Due to local safety codes, soil conditions, and topography, some of these site design features will be restricted. Designers are encouraged to consult with the Municipal Engineer to determine restrictions on non-structural strategies.

NOTE: In this appendix, *italics* indicate mandatory performance criteria, whereas suggested design criteria are shown in normal typeface.

These credits are an integral part of a project's overall stormwater management plan and BMP storage volume calculation. Therefore, use of these credits shall be documented at the initial (concept) design stage, documented with submission of final grading plans, and verified with "as-built" plans. If a planned credit is not implemented, then BMP volumes shall be increased appropriately to stormwater sizing criteria.

Table D.1 Summary of Stormwater Credits

Stormwater Credit	WQ_v	Re_v	Cp_v or Q_p
Natural Area Conservation	Reduce site area	No credit. Use as receiving area w/Percent Area Method.	Forest/meadow CN for natural areas
Disconnection of Rooftop Runoff	Reduced R_v	No credit. Use with Percent Area Method.	Longer tc (increased flow path). CN credit.
Disconnection of Non-Rooftop Runoff	Reduced R_v	No credit. Use with Percent Area Method.	Longer tc (increased flow path) CN credit
Sheet Flow to Buffers	Subtract contributing site area to BMP.	Reduced Re_v	CN credit
Open Channel Use	May meet WQ_v	Meets Re_v	Longer tc (increased flow path). No CN credit.
Environmentally Sensitive Development	Meets WQ_v	Meets Re_v	No CN credit. tc may increase.

D.2 Natural Area Conservation Credit

A stormwater credit is given when natural areas are conserved at development sites, thereby retaining predevelopment hydrologic and water quality characteristics. A simple WQ_v credit is granted for all **conservation areas permanently protected under conservation easements or other locally acceptable means**. Examples of natural area conservation include:

- forest retention areas
- non-tidal wetlands and associated buffers
- other lands in protective easement (floodplains, open space, steep slopes)
- stream systems

Under the credit, a designer can subtract conservation areas from total site area when computing the water quality volume. **The volumetric runoff coefficient, R_v, is still calculated based on the percent impervious cover for the entire site.**

As an additional incentive, the post development curve number (CN) used to compute the Cp_v or Qp2, and Qp10 for all natural areas protected by conservation easements can be assumed to be woods in good condition when calculating the total site CN.

As an example, the required WQ_v for a ten acre site with three acres of impervious area and three acres of protected conservation area before the credit would be:

WQ_v = [(P)(R_v)(A)]/12; where P= 1.2”, R_v= 0.05+0.009(30%)
WQ_v = [(1.2”) (0.32)(10 acres)]/12 = 0.320 ac-ft

Under the credit, three acres of conservation are subtracted from total site area, which yields a smaller storage volume:

WQ_v =[(P)(R_v)(A)]/12; where P=1.2”, R_v=0.05+0.009(30%)
WQ_v =[(1.2”)(0.32)(10-3 acres)]/12 = 0.224 ac-ft

The recharge requirement (Re_v) is not reduced using this credit.

Criteria for Natural Area Credit

To receive the credit, the proposed conservation area:

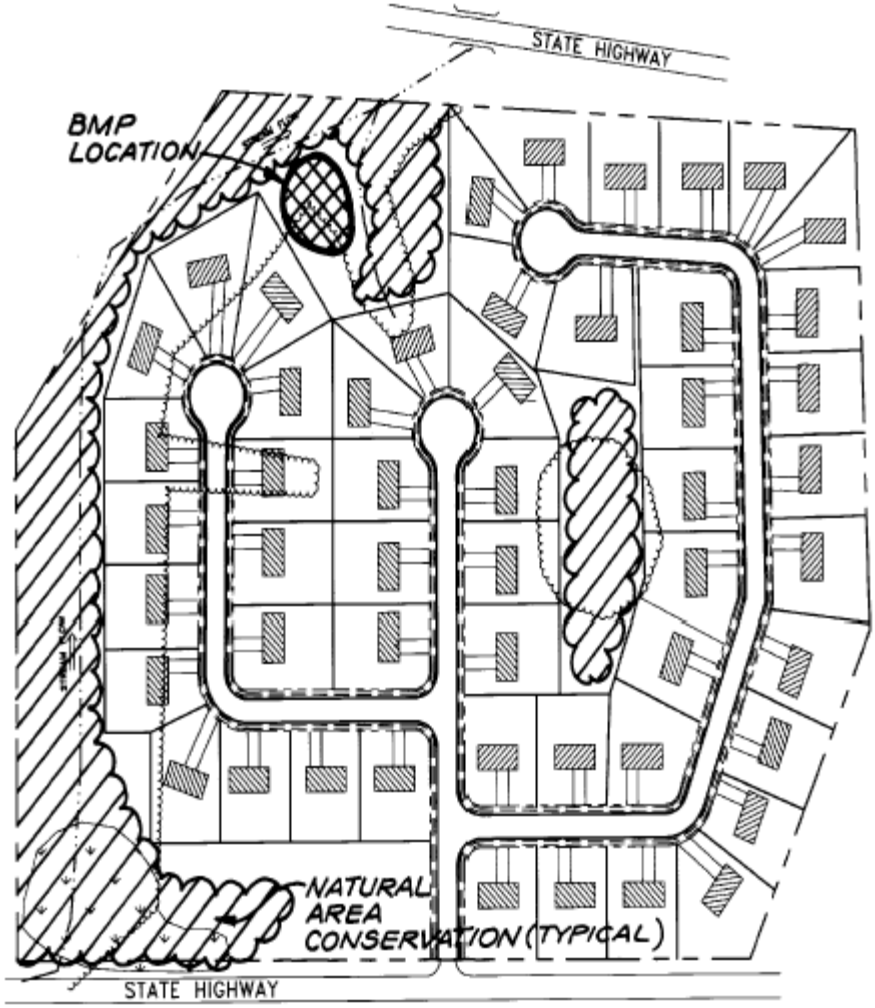
- *Shall not be disturbed during project construction (e.g., cleared or graded) except for temporary impacts associated with incidental utility construction or mitigation and aforestation projects,*

- *Shall be protected by having the limits of disturbance clearly shown on all construction drawings and delimited in the field except as provided for above,*

- *Shall be located within an acceptable conservation easement or other enforceable instrument that ensures perpetual protection of the proposed area. The easement must clearly specify how the natural area vegetation shall be managed and boundaries will be marked* [Note: managed turf (e.g., playgrounds, regularly maintained open areas) is not an acceptable form of vegetation management], *and shall be located within the project site.*

Example of Calculating Natural Area Credit

Site Data - 51 Single Family Lots
Area = 38 ac
Conservation Area = 7.0 ac
Impervious Area = 13.8 ac
R_v = .38, P= 1.2”
Post dev. CN = 78
Original WQ_v = 1.44 ac-ft
Original Re_v = 0.25 ac-ft
Original Cp_v = 1.65 ac-ft



Computation of Stormwater Credits

$WQ_v = [(P)(R_v)(A)]/12$
$= [(1.2)(.38)(38.0 - 7.0 \text{ ac})]/12$
$= 1.18$ ac-ft

Re_v = Same as original
(However, area draining to Natural Area may be used with the Percent Area Method)
CN reduced from 78 to 75

D.3 Disconnection of Rooftop Runoff Credit

A credit is given when rooftop runoff is disconnected and then directed to a pervious area where it can either infiltrate into the soil or filter over it. The credit is typically obtained by grading the site to promote overland filtering or by providing bioretention areas on single family residential lots.

If a rooftop is adequately disconnected, the disconnected impervious area may be deducted from total impervious cover (therefore reducing WQ_v). In addition, disconnected rooftops can be used to meet the Re_v requirement as a non-structural practice using the percent area method.

Post development CN's for disconnected rooftop areas used to compute Cp_v and Q_p can be assumed to be woods in good condition.

Criteria for Disconnection of Rooftop Runoff Credit

The credit is subject to the following restrictions:

- *Rooftop cannot be within a designated hotspot,*
- *Disconnection shall cause no basement seepage,*
- *The contributing area of rooftop to each disconnected discharge shall be 500 square feet or less,*
- *The length of the "disconnection" shall be 75 feet or greater, or compensated using Table D.1,*
- *Dry wells, french drains, raingardens, or other similar storage devices may be utilized to compensate for areas with disconnection lengths less than 75 feet. (See Table D.1 and Figure D.1, dry wells are prohibited in "D" soils),*
- *In residential development applications, disconnections will only be credited for lot sizes greater than 6000 square feet,*
- *The entire vegetative "disconnection" shall be on an average slope of 5% or less,*
- *The disconnection must drain continuously through a filter strip, vegetated channel, or through a swale to the property line or BMP,*
- *Downspouts must be at least 10 feet away from the nearest impervious surface to discourage "re-connections", and*
- *For those rooftops draining directly to a buffer, only the rooftop disconnection credit or the buffer credit may be used, not both.*

Figure D.1 Schematic of Dry Well

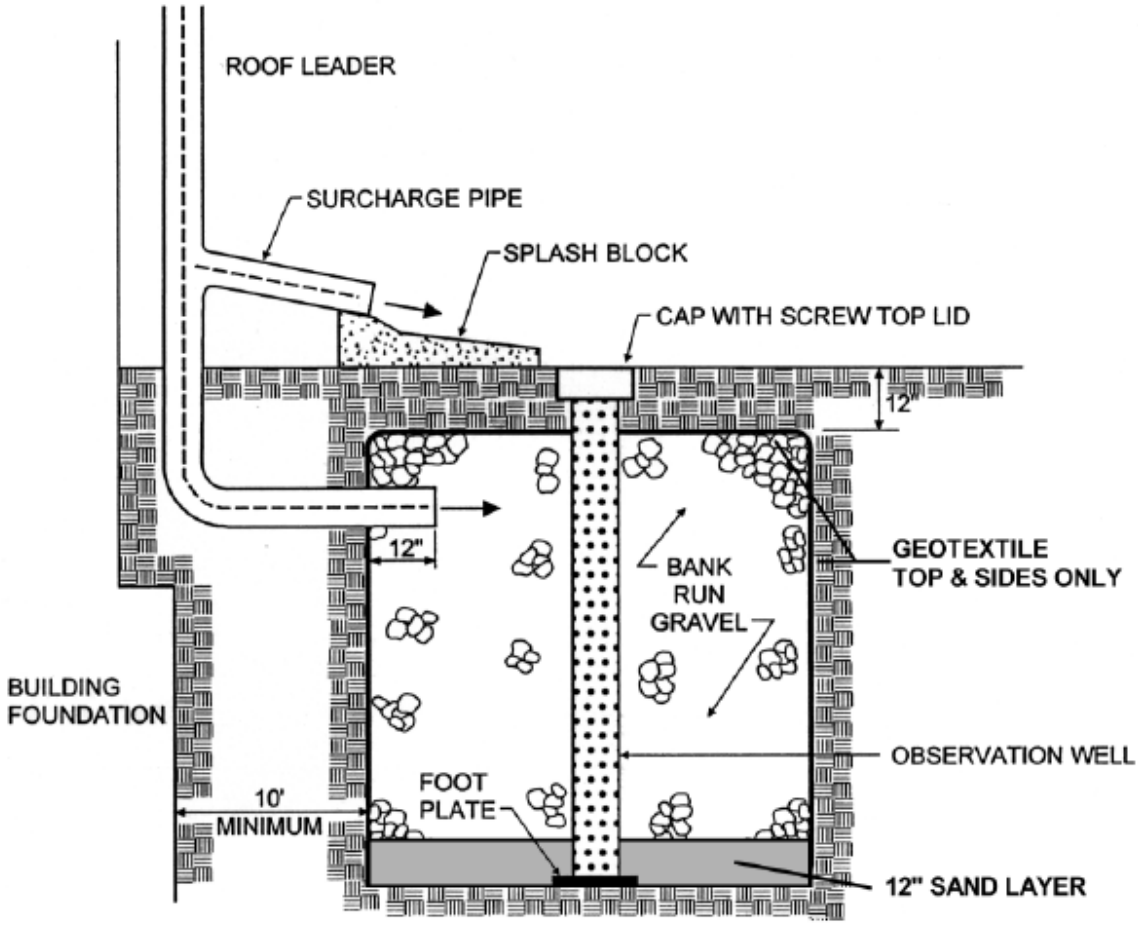


Table D.1 Rooftop Disconnection Compensation Storage Volume Requirements (Per Disconnection Using Drywells, Raingardens, etc.)

Disconnection Length Provided	**0 - 14 ft.**	**15 - 29 ft.**	**30 - 44 ft.**	**45 - 59 ft.**	**60 - 74 ft.**	**≥ 75 ft.**
% WQ_v Treated by Disconnect	**0%**	**20%**	**40%**	**60%**	**80%**	**100%**
% WQ_v Treated by Storage	**100%**	**80%**	**60%**	**40%**	**20%**	**0%**
Max. Storage Volume*	**48 cu-ft.**	**39 cu-ft.**	**30 cu-ft.**	**21 cu-ft.**	**12 cu-ft.**	**0 cu-ft.**

*Assuming 500 square feet roof area to each downspout.

Example of Using the Rooftop Disconnection Credit

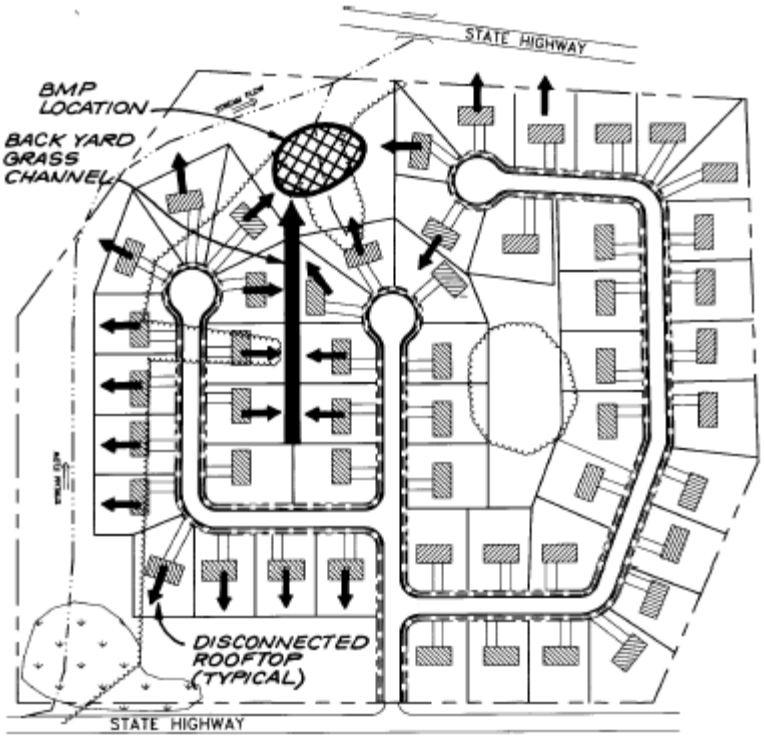
Site Data - 51 Single Family Lots
Area = 38 ac, ½ ac lots
Original Impervious Area = 13.80 ac
Original R_v = 0.38
Post dev. CN = 78
# of Disconnected Rooftops = 22
Original WQ_v = 1.44 ac-ft
Original Re_v = 0.25 ac-ft
Original Cp_v = 1.65 ac-ft

60% B Soils
40% C Soils
Composite *S*=0.218 (21.8%)

22 Lots Disconnected w/5
Downspouts each
2500 sf. each lot

Net impervious area reduction =
(22)(2500)/43560 = 1.3 ac

Net Impervious Area =
13.8 - 1.3 = 12.5 ac



Computation of Stormwater Credit:

New R_v= 0.05+0.009 (12.5 ac/38 ac) = 0.35
WQ_v= [(1.2)(.35)(38 ac)]/ 12 = 1.33 ac-ft

Required Re_v (Percent Area Method)
Re_v = 21.8%x13.8 ac. =3.01 ac
Re_v treated by disconnection =1.3 ac
Re_v remaining for treatment = 1.71 acres non structurally or 0.14 ac-ft structurally

CN reduced from 78 to 76

D.4 Disconnection of Non-Rooftop Runoff Credit

Credit is given for practices that disconnect surface impervious cover runoff by directing it to pervious areas where it is either infiltrated into the soil or filtered (by overland flow). This credit can be obtained by grading the site to promote overland vegetative filtering or providing bioretention areas on single family residential lots.

These "disconnected" areas can be subtracted from the impervious area when computing WQ_v. In addition, disconnected surface impervious cover can be used to meet the Re_v requirement as a non-structural practice using the percent area method.

Criteria for Disconnection of Non-Rooftop Runoff Credit

The credit is subject to the following restrictions:

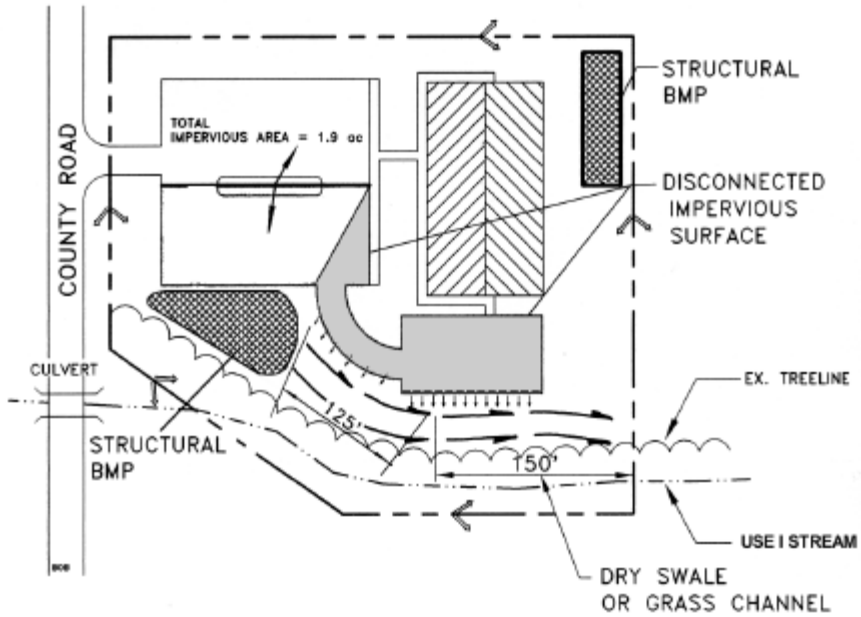
- *Runoff cannot come from a designated hotspot,*
- *The maximum contributing impervious flow path length shall be 75 feet,*
- *The disconnection must drain continuously through a filter strip, vegetated channel, or through a swale to the property line or BMP,*
- *The length of the "disconnection" must be equal to or greater than the contributing length,*
- *The entire vegetative "disconnection" shall be on an average slope of 5% or less,*
- *The surface impervious area to any one discharge location cannot exceed 1,000 ft^2.*
- *If the site cannot meet the required disconnect length, a spreading device, such as a french drain, gravel trench or other storage device may be needed for compensation, and*
- *For those areas draining directly to a buffer, only the non rooftop disconnection credit or the stream buffer credit can be used, not both.*

Example of Calculating the Non-Rooftop Disconnection Credit

Site Data -Community Center
Area = 3.0 ac
Original Impervious Area =
1.9 ac = 63.3%
Original R_v = .62
Post dev. CN = 83
B Soils, S = 0.27
Original WQ_v = 8102 ft^3
Original Re_v = 1688 ft^3
Original Cp_v = N/A

0.33 ac of surface imperviousness disconnected

Net impervious area reduction
1.9 - 0.33 = 1.57 ac



Computation of Stormwater Credit:

New R_v = 0.05+.009 (1.57 ac/3.0 ac)= .52
WQ_v = [(1.2)(0.52)(3.0 ac)] 12 = 0.16 ac-ft (6795 $ft.^3$)

Required Re_v (Percent area method)
Re_v = (S)(Ai) = (0.27)(1.9 ac) = 0.51 ac
Re_v treated by disconnection = 0.33 ac
Re_v remaining for treatment = 0.18 ac non structurally or 595.8 cf structurally

Post developed CN may be reduced

D.5 Sheetflow to Buffers Credit

This credit is given when stormwater runoff is effectively treated by a natural buffer to a stream or forested area. Effective treatment is achieved when pervious and impervious area runoff is discharged to a grass or forested buffer through overland flow. The use of a filter strip is also recommended to treat overland flow in the green space of a development site.

The credits include:

1. The area draining by sheet flow to a buffer is subtracted from the total site area in the WQ_v calculation.

2. The area draining to the buffer contributes to the recharge requirement, Re_v.

3. A *wooded* CN can be used for the contributing area if it drains to a forested buffer.

Criteria for Sheetflow to Buffers Credit

The credit is subject to the following conditions:

- *The minimum buffer width shall be 50 feet as measured from bankfull elevation or centerline of the buffer,*

- *The maximum contributing length shall be 150 feet for pervious surfaces and 75 feet for impervious surfaces,*

- *Runoff shall enter the buffer as sheet flow. Either the average contributing overland slope shall be 5.0% or less, or a concrete level spreading device shall be used where sheet flow can no longer be maintained,*

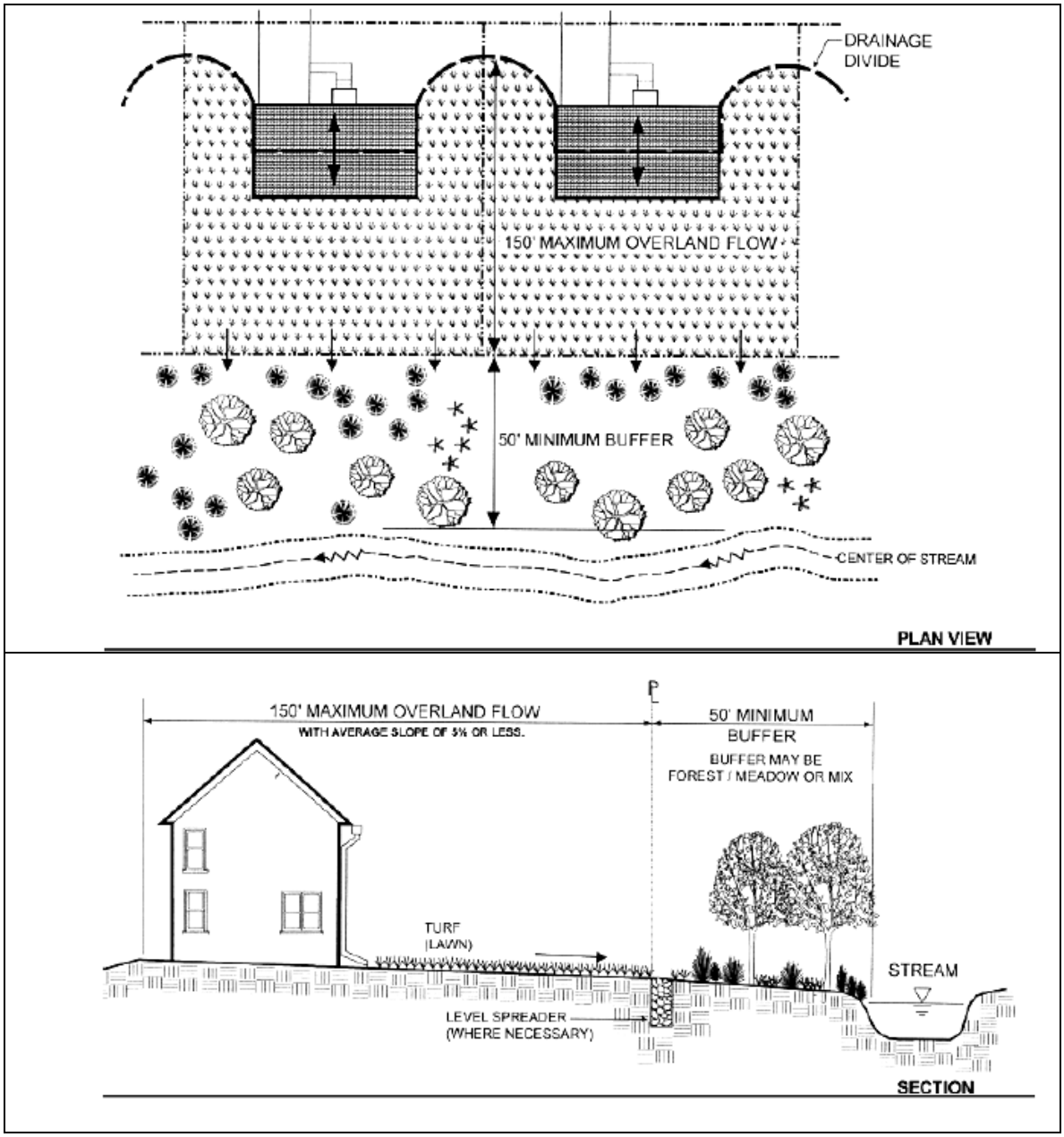
- *Not applicable if rooftop or non rooftop disconnection is already provided,*

- *Buffers shall remain unmanaged other than routine debris removal, and*

- *Shall be located within an acceptable conservation easement or other enforceable instrument that ensures perpetual protection of the proposed area. The easement must clearly specify how the natural area vegetation shall be managed and boundaries will be marked* [Note: managed turf (e.g., playgrounds, regularly maintained open areas) is not an acceptable form of vegetation management].

Figure D.2 illustrates how a buffer or filter strip can be used to treat stormwater from adjacent pervious and impervious areas.

Figure D.2 Example of Sheetflow to Buffers Credit

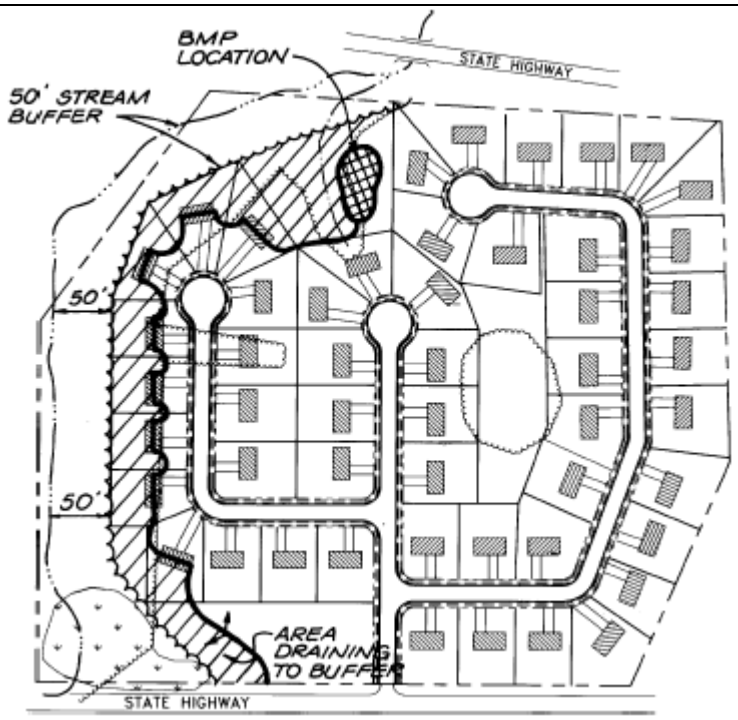


Example of Using the Sheetflow to Buffers Credit

Site Data - 51 Single Family
Area = 38.0 ac
Original Impervious Area =
13.8 ac = 36.3%
Original R_v = .38
Post-dev. CN = 78

Original WQ_v = 1.44 ac-ft
Original Re_v = 0.24 ac-ft
Original Cp_v = 1.65 ac-ft

Credit
5.0 ac draining to buffer/filter strip
Rooftops represent 3% of site
imperviousness = 0.41 ac



Computation of Stormwater Credits

New drainage area = 38 ac - 5 ac= 33.0 ac
R_v remains unchanged to BMP; R_v=0.05+0.009(36.3)=0.38

WQ_v =[(P)(R_v)(A)]/12
=[(1.2)(0.38)(33.0 ac.)]/12
= 1.25 ac-ft

Required Re_v (Percent Area Method)
Re_v = 21.8%×13.8 ac. = 3.01 acres
Re_v treated by disconnection = 0.41 acres
Re_v remaining for treatment = 2.60 acres non structurally or 0.207 ac-ft structurally

CN is reduced slightly

D.6 Grass Channel Credit (in lieu of Curb and Gutter)

Credit may be given when open grass channels are used to reduce the volume of runoff and pollutants during smaller storms (e.g., < 1 inch). The schematic of the grass channel is provided in Figure D.3.

Use of a grass channel will automatically meet the Re_v for impervious areas draining into the channel. However, Re_v for impervious areas not draining to grass channels must still be addressed. If designed according to the following criteria, the grass channel will meet the WQ_v as well.

CNs for channel protection or peak flow control (Cp_v or Q_p) will not change.

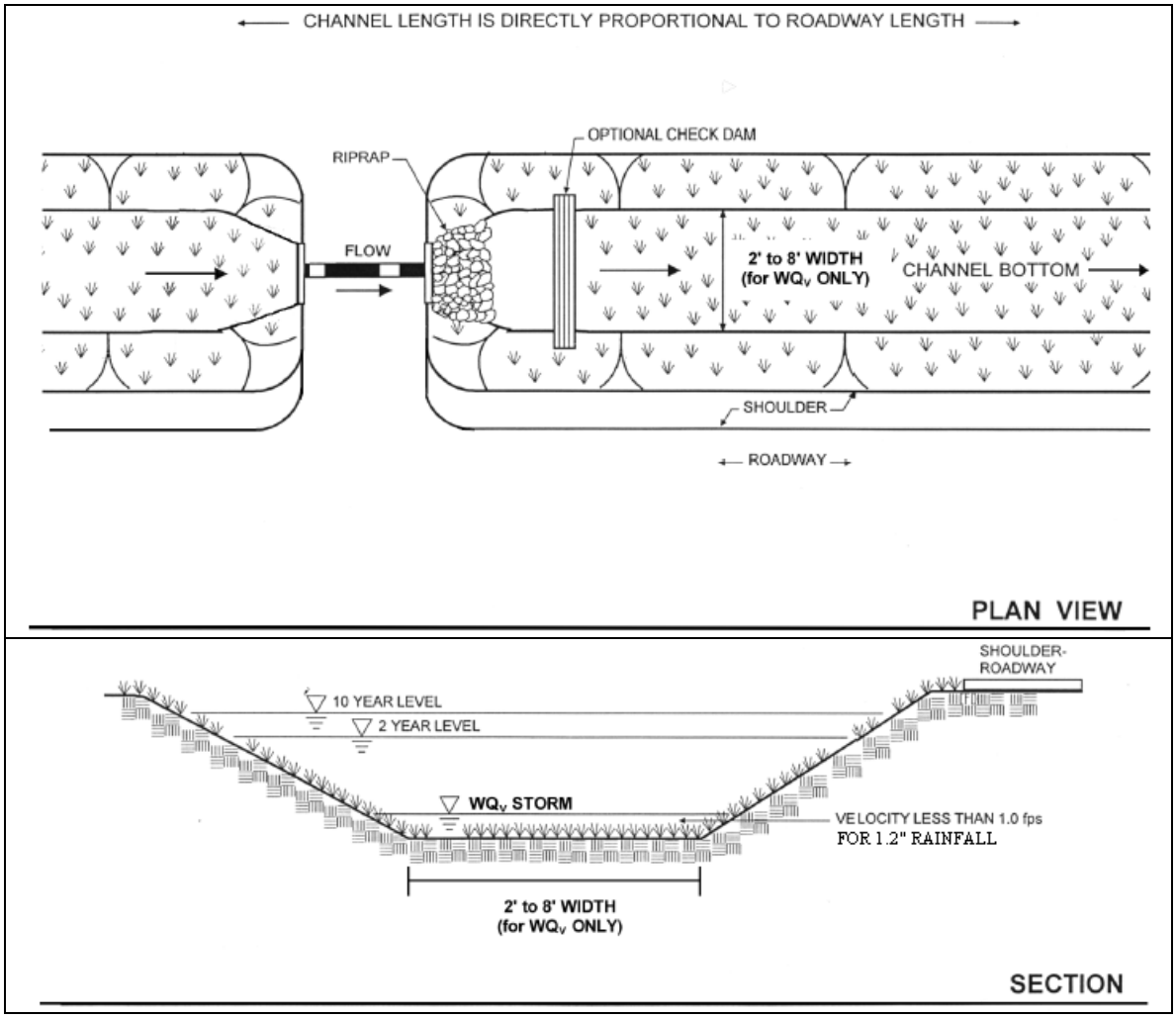
Criteria for the Grass Channel Credit

The WQ_v credit is obtained if a grass channel meets the following criteria:

- *The maximum flow velocity for runoff from the 1.2 inch rainfall shall be less than or equal to 1.0 fps (see Appendix E for methodology to compute flowrate),*
- *The maximum flow velocity for runoff from the 10-year design event shall be non-erosive,*
- *The bottom width shall be 2 feet minimum and 8 feet maximum,*
- *The side slopes shall be 3:1 or flatter,*
- *The channel slope shall be less than or equal to 4.0%, and*
- *Not applicable if rooftop disconnection is already provided (see Credit 2).*

An example of a grass channel is provided in Figure D.3.

Figure D.3 Example of Grass Channel

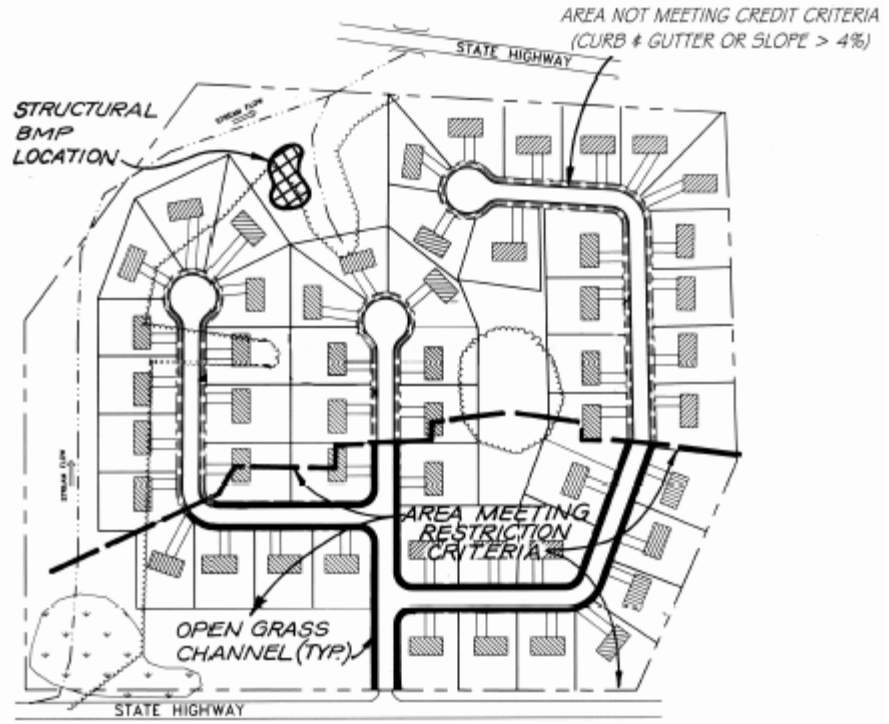


Example of Grass Channel Credit

Site Data - 51 Single Family Residences
Area = 38.0 ac
Original Impervious Area = 13.8 = 36.3%
R_v = 0.38
CN = 78

Original WQ_v = 1.44 ac-ft
Original Re_v = 0.25 ac-ft
Original Cp_v = 1.65 ac-ft

Credit
12.5 ac meet grass channel criteria



Computation of Stormwater Credits

New WQ_v Area = 38 ac - 12.5 ac = 25.5 ac
WQ_v = [(1.2)(0.38)(25.5 ac)]/12
= 0.97 ac-ft

Required Re_v (Percent Area Method)
Rev =21.8%×13.8 ac =3.01 ac
4.5 ac of imperviousness lie within area drained by grass channels, and
4.5 ac > 3.01 ac
Re_v requirement is met
Cp_v and Q_p: No change

D.7 Environmentally Sensitive Development Credit

Credit is given when a group of environmental site design techniques are applied to low density or residential development. The credit eliminates the need for structural practices to treat both the Re_v and WQ_v and is intended for use on large lots.

Criteria for Environmentally Sensitive Development Credit

These criteria can be met without the use of structural practices in certain low density residential developments when the following conditions are met:

For Single Lot Development:

- *total site impervious cover is less than 15%,*
- *lot size shall be at least two acres,*
- *rooftop runoff is disconnected in accordance with the criteria outlined in Section D.3, and*
- *grass channels are used to convey runoff versus curb and gutter.*

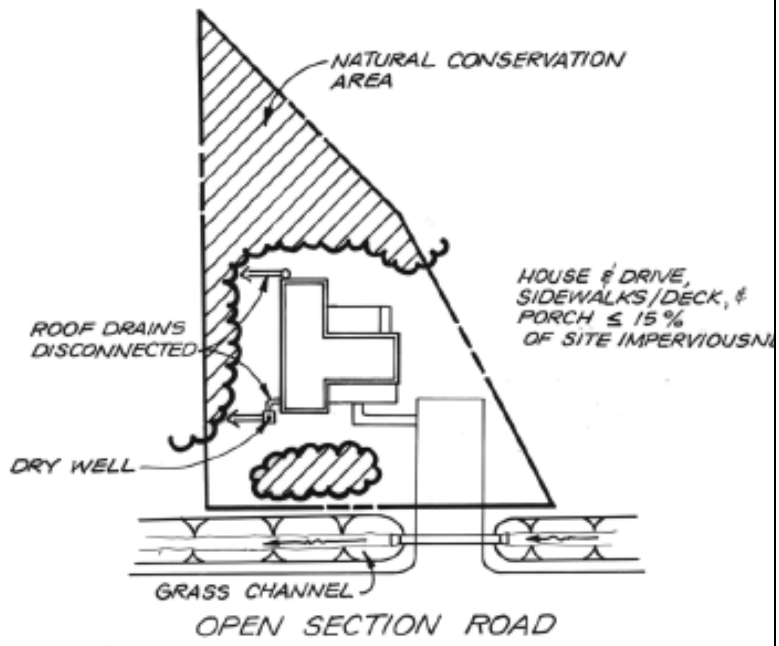
For Multiple Lot Development:

- *total site impervious cover is less than 15%,*
- *lot size shall be at least two acres if clustering techniques are not used,*
- *if clustering techniques are used, the average lot size shall not be greater than 50% of the minimum lot size as identified in the appropriate local zoning ordinance and shall be at least one half acre,*
- *rooftop runoff is disconnected in accordance with the criteria outlined in Section D.3,*
- *grass channels are used to convey runoff versus curb and gutter,*
- *a minimum of 25% of the site is protected in natural conservation areas (by permanent easement or other similar measure), and*
- *the design shall address stormwater (Re_v, WQ_v, Cp_v, and extreme events) for all roadway and connected impervious surfaces.*

Example of Environmentally Sensitive Development Credit

Site Data - 1 Single Family Lot
Area = 2.5 ac
Conservation Area = 0.6 ac
Impervious Area = .35 ac (includes adjacent road surface) = 14%
B soils
R_v = 0.05+0.009(14) = 0.18
CN = 65

WQ_v : Use P=0.2 as I<15%
WQ_v = [(0.2)(A)]/12
= [(0.2)(2.5)]/12×(43560 ft/ac)
= 1,815 ft^3
Re_v = [(S)(R_v)(A)] 12
= [(0.27)(0.18)(2.5)]/ 12×(43,560ft/ac)
= 441.0 ft^3



Computation of Stormwater Credits:

WQ_v is met by site design
Re_v is met by site design
Cp_v: No change in CN, tc may be longer which would reduce Q_p requirements

Appendix E
Computation of Peak Discharge for Water Quality Storm

APPENDIX E
COMPUTATION OF PEAK DISCHARGE FOR WATER QUALITY STORM
(Adapted from Claytor and Schueler, 1996)

E.1 Computation Methodology

The peak rate of discharge is needed for the sizing of off-line diversion structures and to design grass channels. Conventional SCS methods underestimate the volume and rate of runoff for rainfall events less than 2 inches. This discrepancy in estimating runoff and discharge rates can lead to situations where a significant amount of runoff by-passes the filtering treatment practice due to an inadequately sized diversion structure or leads to the design of undersized grass channels.

The following procedure can be used to estimate peak discharges for small storm events. It relies on the volume of runoff computed using the Small Storm Hydrology Method (Pitt, 1994) and utilizes the NRCS, TR-55 Graphical Peak Discharge Method (USDA, 1986).

Using the WQ_V methodology, a corresponding Curve Number (CN) is computed utilizing the following equation:

$$CN = \frac{1000}{[10 + 5P + 10Q_a - 10(Q_a^2 + 1.25\, Q_a P)^{1/2}]}$$

where: P = rainfall, in inches (use 1.2 inches for the Water Quality Storm)
Q_a = runoff volume, in inches (equal to $P \times R_v$)

Note: The above equation is derived from the SCS Runoff Curve Number method described in detail in NEH-4, Hydrology (SCS 1985) and SCS TR-55 Chapter 2: Estimating Runoff. The CN can also be obtained graphically using Figure E.1 or from TR-55.

Once a CN is computed, the time of concentration (t_c) is computed (based on the methods identified in TR-55, Chapter 3: "Time Of Concentration And Travel Time").

Using the computed CN, t_c and drainage area (A), in acres; the peak discharge (Q_p) for the Water Quality Storm is computed (based on the procedures identified in TR-55, Chapter 4: "Graphical Peak Discharge Method"). Use Rainfall distribution type II.

- Read initial abstraction (I_a), compute I_a/P
- Read the unit peak discharge (q_u) from TR-55 Exhibit 4-II for appropriate t_c
- Using the runoff volume (Q_a), compute the peak discharge (Q_p); $\boldsymbol{Q_p = q_u \times A \times Q_a}$

where: Q_p = the peak discharge, in cfs
q_u = the unit peak discharge, in cfs/mi²/inch
A = drainage area, in square miles
Q_a = runoff volume, in watershed inches

E.2 Example Calculation of Peak Discharge for Water Quality Storm

Using a 3.0 acre small shopping center having a 1.0 acre flat roof, 1.6 acres of parking, and 0.4 acres of open space, and using P = 1.2”; the weighted volumetric runoff coefficient (R_v) is:

R_v = 0.05+0.009(I); I = 2.6 ac/3.0 ac = 0.867 (86.7%)
= 0.05+0.009(86.7%)
= 0.83

The runoff volume, Q_a is:

Q_a = $P \times R_v$
= 1.2”×0.83
= 1.0 watershed inches

and WQ_v is:

$$WQ_v = \frac{[1.2”)(1.0)(3.0\ ac)]}{12} \times \frac{43{,}560\ ft^2}{ac} = 13{,}016\ ft^3$$

Using Q_a = 1.0 watershed inches and P = 1.2”; CN for the water quality storm is:

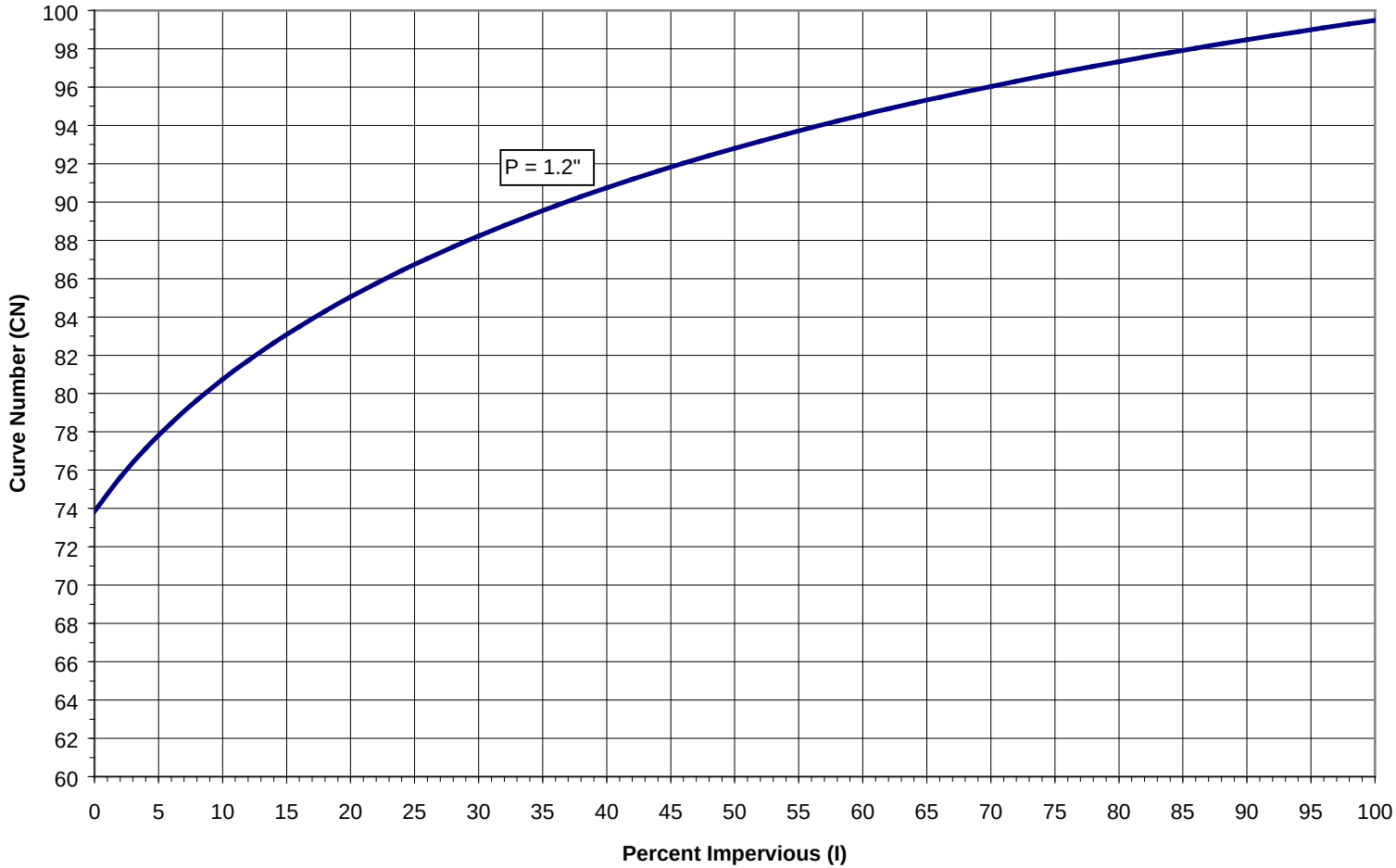
$$CN = \frac{1000}{[10 + (5)(1.2”) + (10)(1.0) - 10((1.0)^2 + 1.25(1.0)(1.2”))^{½}]} = 98$$

Using: t_c = 10 minutes (0.17 hour);
I_a = (200/CN)-2=0.041;
I_a/P = (0.041/1.2”) = 0.049; (Use I_a/P = *0.10, Ref: TR-55 Limitations)*
q_u = 850 csm/inch (from TR-55 Exhibit 4-II); and
A = 3.0 ac ×1/640 mi^2 per ac = 0.0047 mi^2
Q_p = (850 csm/inch)(0.0047 mi^2)(1.0”) = 4.0 cfs

For computing runoff volume and peak rate for storms larger than the Water Quality Storm (i.e., 2-, 10- and 100-year storms), use the published CN’s from TR-55 and follow the prescribed procedure in TR-55.

In some cases the Rational Formula may be used to compute peak discharges associated with the Water Quality Storm. The designer must have available reliable intensity, duration, frequency (IDF) tables or curves for the storm and region of interest. This information may not be available for many locations and therefore the TR-55 method described above is recommended.

Figure E.1 Curve Number (CN) for Water Quality Storm (Rainfall P = 1.2")



Appendix F
Computation of Channel Protection Storage Volume

Figure F.1 SCS Graphical Method of Determining Peak Discharge (qu) in csm/in
For 24-Hour Type II Storm Distribution

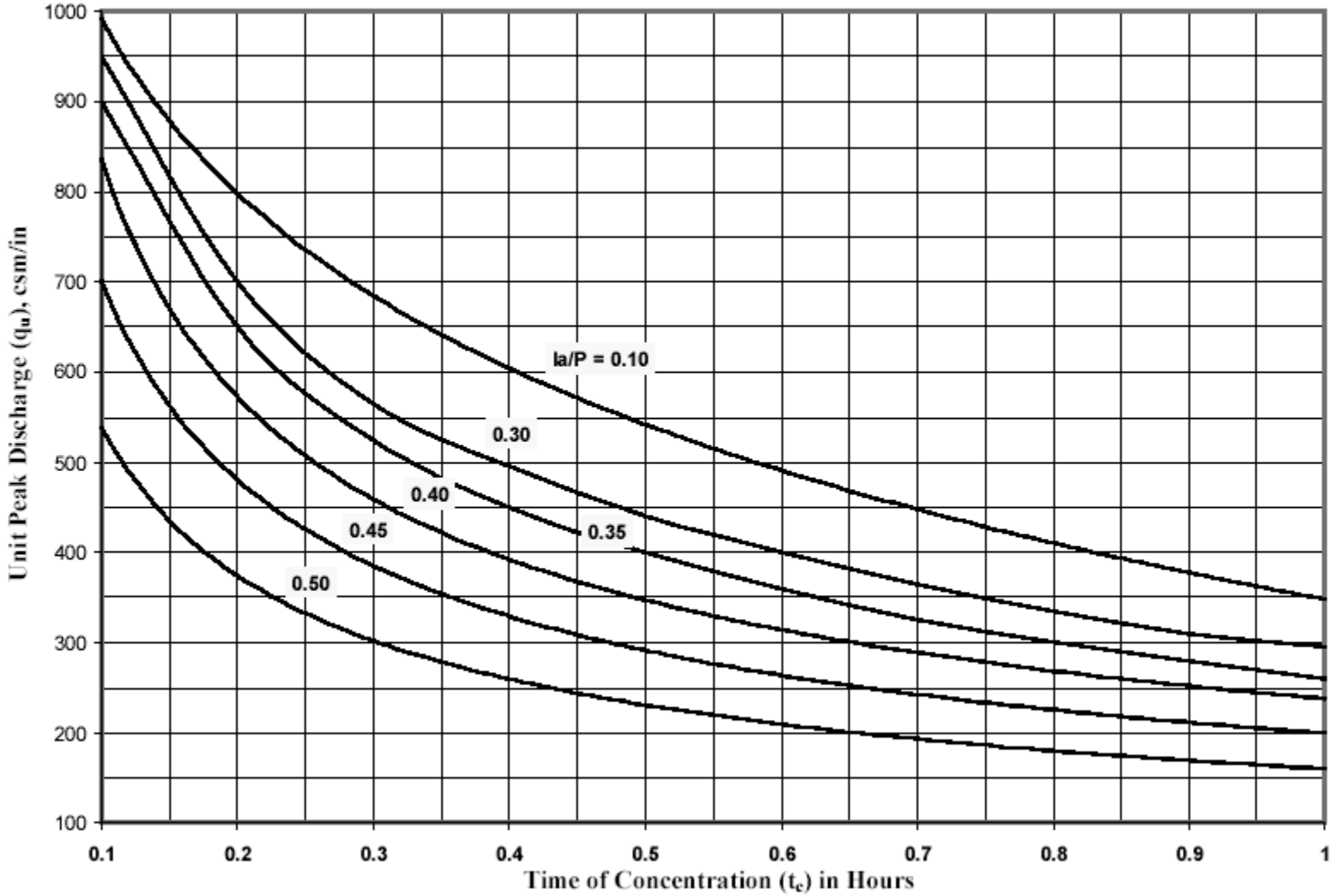
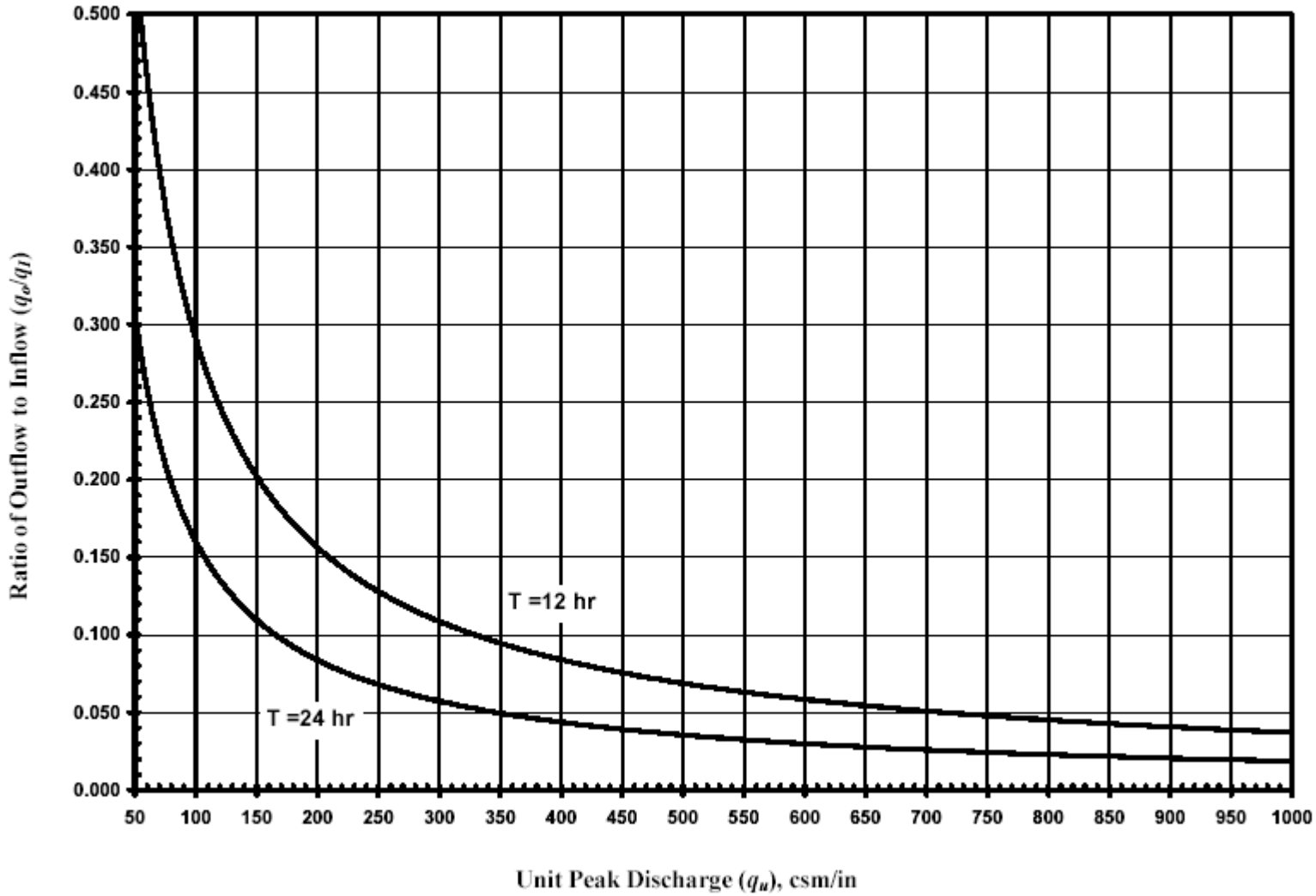


Figure F.2 Detention Time Versus Discharge Ratios (qo/qi)



Appendix G
Watershed Data & Release Rate Computations

APPENDIX G
Watershed Data and Release Rate Computations

G.0 Watershed Data

The Union County GIS was utilized to determine hydrologic information on a subwatershed level.

Table G.1 – Hydrologic Data for White Deer Creek Subwatersheds

Subwatershed	Existing CN	Future CN	Area (mi^2)	Lag Time (min)
1	76	76	0.07	41
2	72	73*	0.44	66
3	75	75	0.43	58
4	72	73*	0.46	62
5	72	72	0.82	54
6	71	71	1.16	51
7	71	71	1.19	50
8	77	77	0.51	51
9	68	70*	0.14	45
10	72	72	2.99	61
11	71	71	2.45	54
12	68	68	3.09	61
13	63	63	1.26	66
14	57	57	0.95	47
15	68	68	0.98	48
16	63	63	2.36	53
17	60	60	1.70	49
18	70	70	0.75	44
19	72	72	0.30	43
20	70	70	0.12	40
21	62	62	0.57	46
22	64	64	3.28	89
23	63	63	1.34	66
24	69	69	0.12	42
25	65	65	1.72	48
26	65	65	2.22	68
27	62	62	4.31	104
28	60	60	2.18	88
29	60	60	1.93	65
30	57	57	2.18	48
31	61	61	1.24	49
32	60	60	0.74	49
33	61	61	0.25	48
34	61	61	0.13	50
35	61	61	1.49	68
36	61	61	1.43	59

* Denotes a subwatershed with a future CN greater than current CN

Table G.2 – Existing Land Use Data for White Deer Creek

			PERCENT OF	PERCENT	SOILS GROUPS			
	ACRES	SQUARE MI.	UNDEVELOPED	OF TOTAL	A	B	C	D
UNDEVELOPED	**28219.40**	**44.09**	**100.00%**	**96.49%**				
Forest	26990.98	42.17	95.65%	92.29%	30	55	70	77
Meadow	151.57	0.24	0.54%	0.52%	43	65	76	82
Fallow Field	194.82	0.30	0.69%	0.67%	35	56	70	77
Pasture	56.38	0.09	0.20%	0.19%	49	69	79	84
Cropland	412.26	0.64	1.46%	1.41%	60	72	80	83
Open Space	311.77	0.49	1.10%	1.07%	39	61	74	80
Water	101.62	0.16	0.36%	0.35%	100	100	100	100
			PERCENT OF	PERCENT				
			DEVELOPED	OF TOTAL				
DEVELOPED	**708.52**	**1.11**	**100.00%**	**2.42%**				
Residential	319.16	0.50	45.05%	1.09%				
Low Density	124.77	0.19	17.61%	0.43%	49	67	78	83
Medium Density	171.39	0.27	24.19%	0.59%	56	71	81	86
High Density	23.00	0.04	3.25%	0.08%	61	75	83	87
Commercial	3.26	0.01	0.46%	0.01%	89	92	94	95
Industrial	1.17	0.00	0.16%	0.00%	81	88	91	93
Institutional	14.46	0.02	2.04%	0.05%	81	88	91	93
Paved Surface	302.29	0.47	42.66%	1.03%	98	98	98	98
Disturbed	68.18	0.11	9.62%	0.23%	79	86	91	94
TOTAL		45.20		100.00%				

Table G.3 – Future Land Use Data for White Deer Creek

	ACRES	SQUARE MI.	PERCENT OF UNDEVELOPED	PERCENT OF TOTAL	AREA CHANGE SQUARE MI.
UNDEVELOPED	**28167.35**	**44.01**	**100.00%**	**97.37%**	**-0.08**
Forest	26956.60	42.12	95.70%	93.19%	-0.05
Meadow	151.57	0.24	0.54%	0.52%	0.00
Fallow Field	180.60	0.28	0.64%	0.62%	-0.02
Pasture	56.38	0.09	0.20%	0.19%	0.00
Cropland	408.82	0.64	1.45%	1.41%	-0.01
Open Space	311.77	0.49	1.11%	1.08%	0.00
Water	101.62	0.16	0.36%	0.35%	0.00
			PERCENT OF DEVELOPED	PERCENT OF TOTAL	
DEVELOPED	**760.57**	**1.19**	**100.00%**	**2.63%**	**0.08**
Residential	368.86	0.58	48.50%	1.28%	0.08
Low Density	132.46	0.21	17.42%	0.46%	0.01
Medium Density	213.40	0.33	28.06%	0.74%	0.07
High Density	23.00	0.04	3.02%	0.08%	0.00
Commercial	3.26	0.01	0.43%	0.01%	0.00
Industrial	1.17	0.00	0.15%	0.00%	0.00
Institutional	14.46	0.02	1.90%	0.05%	0.00
Paved Surface	304.63	0.48	40.05%	1.05%	0.00
Disturbed	68.18	0.11	8.96%	0.24%	0.00
TOTAL		45.20		100%	

G.1 Recharge Volume Computation

Future developments in the White Deer Creek Watershed will be required to meet water quality as well as water quantity standards. The recharge volume Re_v is part of the water quality requirement. This parameter is a volume of water to be infiltrated into the ground post development and is intended to approximate the volume of runoff that was originally infiltrated into the ground before development. There are a number of structural as well as non-structural BMPs that can be utilized to meet this criterion. In reality this standard will be met on an individual development level. This will involve multiple practices being employed across the watershed to replenish the portion of the total watershed Re_v that would be potentially removed from the groundwater supply by that individual development. For the purposes of this model an overall Re_v was computed for subwatersheds 2, 4, and 9 (as these are the only areas where development is predicted). This Re_v was computed as follows:

The relevant subwatershed parameters were determined:

Subwatershed #2:

- S = 10% D, 30% B, 60 % C Therefore the composite **S = 0.17**
- I = percent impervious, actually the percent increase in impervious area for this application was estimated to be **4%** based on existing and future curve numbers utilizing Fig 2-3 and Table 2.2a in TR-55. Watershed Area is **281 acres**
- Assume all will be treated structurally

$Re_v = (S \times R_v \times A)/12$

where: S = Soil specific recharge factor
$R_v = 0.05 + 0.009(I)$
A = area in acres

$Re_v = (0.17 \times 0.086 \times 281)/12$

$Re_v = 0.34$ ac-ft

This methodology computes a total volume of runoff that must be infiltrated. However, a typical infiltration facility will infiltrate runoff throughout the entire runoff event. Therefore, infiltration will affect hydrographs. To address this issue a infiltration rate in cubic feet per second was determined for use in the model. The method used to determine this infiltration rate is described below:

- A facility will be required to capture and treat 0.34 ac-ft
- Assuming the minimum allowable infiltration rate of 0.5in/hr and assuming that the entire facility would have to drain within 72 hours the maximum depth that could be obtained the facility would be about 3 ft.
- Using this depth of 3 ft. the facility would need a surface area of 0.113 acres (i.e. 0.34 ac-ft/3 ft = 0.113 ac).

With a known surface area and an infiltration rate of 0.5 in/hr the groundwater recharge rate can be computed:

0.113 ac x 0.5 in/hr = **0.057 cfs**

Therefore, in the future conditions model subwatershed #2 has 0.057 cfs removed from the surface water by a diversion element.

Similar calculations yielded groundwater recharge rates of 0.049 cfs and 0.027 cfs for subwatersheds #4 and #9 respectively.

G.5 HEC-HMS model

The above hydrologic parameters and a watershed delineation were combined and modeled in HEC-HMS version 2.2.1. The following figures illustrate a sample of the layout of the model in HEC-HMS as well as a sample of the meteorological information as entered into the model. The information that was entered for each subarea is identified in Table G.1.

Figure G.1 – White Deer Creek HEC-HMS Schematic with Release Rate

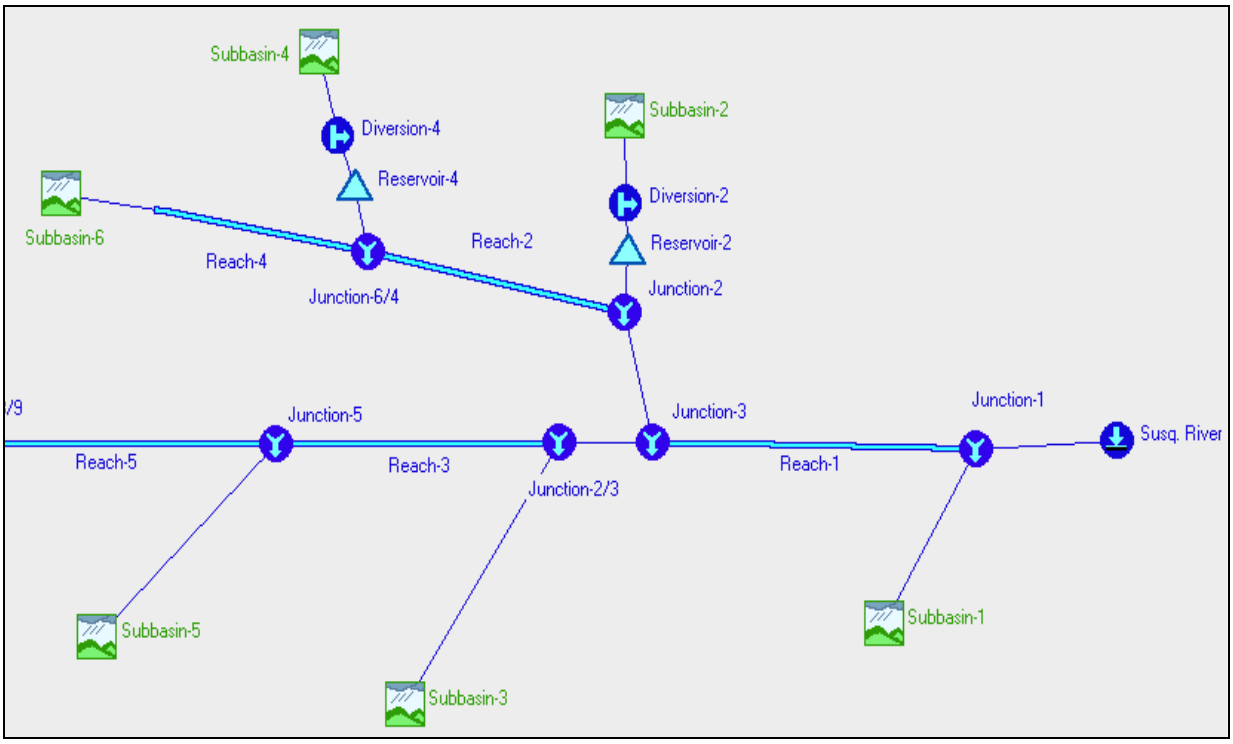


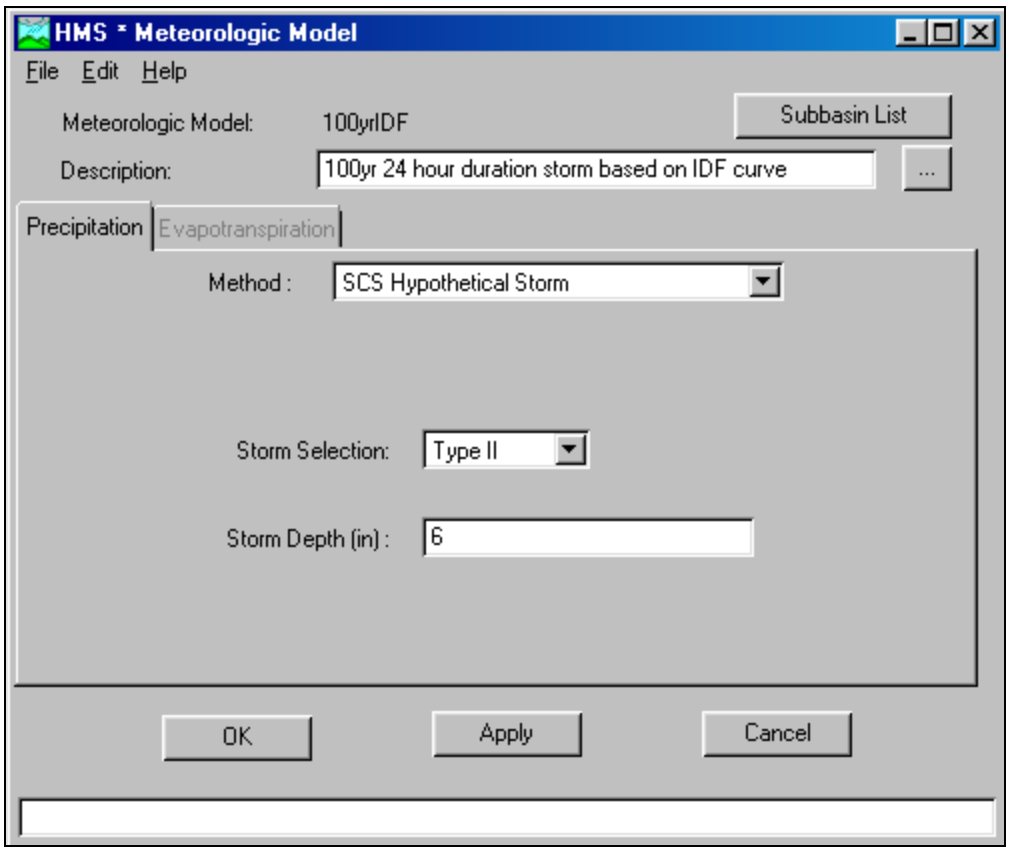
Table G.4 indicates the rainfall depths used for the 24 hour duration storms which were modeled. These rainfall depths were determined from the PENNDOT intensity duration frequency curves (IDF).

Table G.4 – White Deer Creek Watershed Rainfall Depths*

Storm Event	24 hr. rainfall (inches)
2-yr	2.6
5-yr	3.1
10-yr	3.8
25-yr	4.6
50-yr	5.3
100-yr	6.0

*Rainfall depths were determined from PENNDOT IDF

Figure G.2 - Miller Run HEC-HMS Sample Meteorological Input Data



G.6 Release Rate Calculation

HEC-HMS models were created with relative rainfall input for each storm event including the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year. The output data were analyzed in an effort to determine release rates for the individual subwatersheds. However, as evident from Table G.1, there is little change in future curve number, and therefore runoff, throughout White Deer Creek Watershed. Subwatersheds 2, 4, and 9 are the only areas where an increase in development is expected. Therefore, release rate computations are only necessary for these subwatersheds. The release rates and resulting outflows were computed based on the following formulas.

EQUATION 1

Pre-development Subbasin Peak Discharge Contribution to Watershed Peak = $Q_{sub\ contrib}$
Pre-development Subbasin Peak Discharge = $Q_{sub\ peak}$
Assigned Release Rate Percentage = RR

$$RR = Q_{sub\ contrib}\ 4\ \ Q_{sub\ peak}$$

EQUATION 2

Pre-development Subbasin Peak Discharge = $Q_{sub\ peak}$
Assigned Release Rate Percentage = RR
Allowable Post-development Peak Discharge = Q_{allow}

$$Q_{allow} = Q_{sub\ peak} \text{ x } RR$$

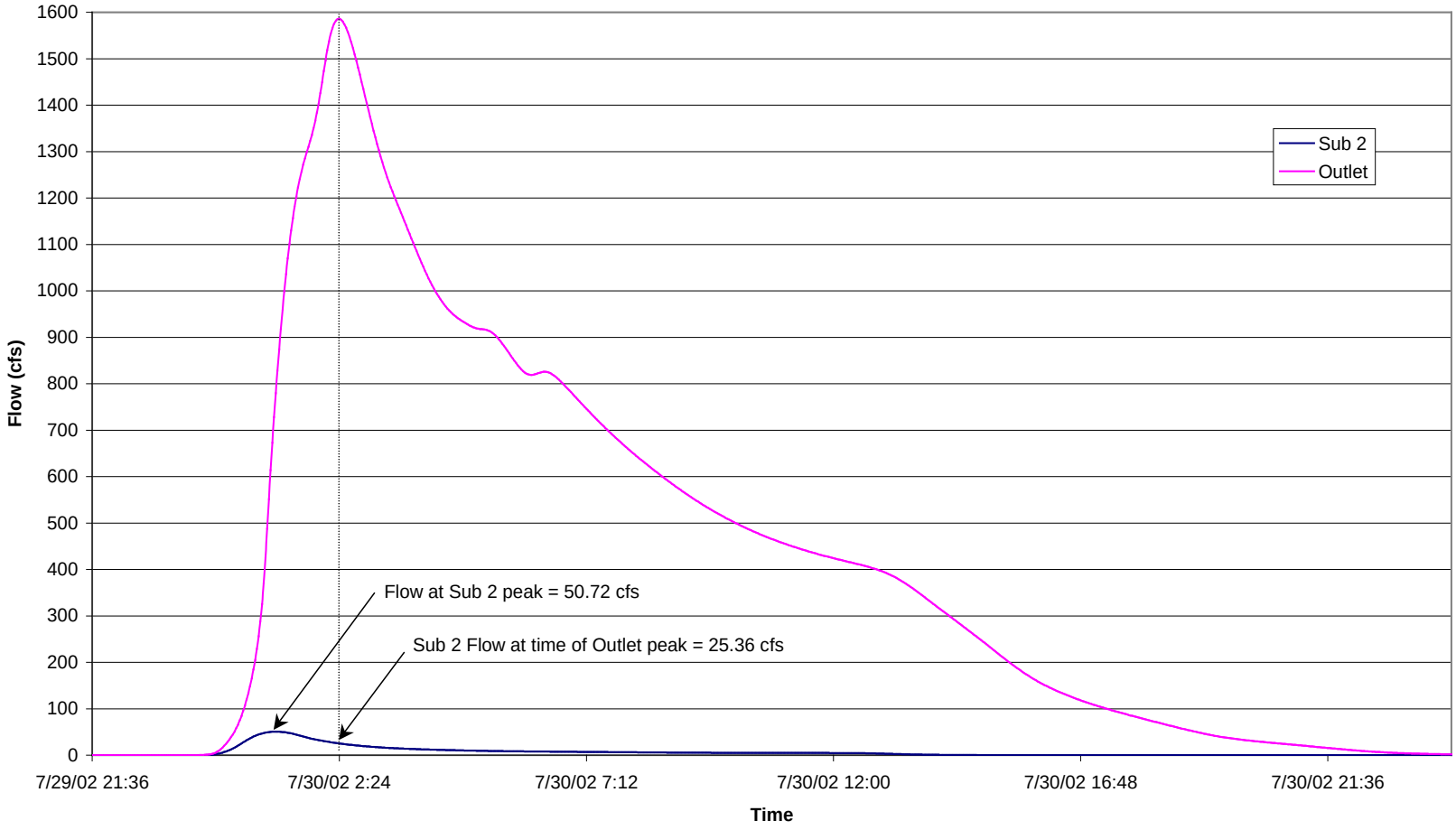
Based on this methodology Figure G.3 illustrates the hydrograph relationships for subwatershed 2 and the watershed outlet using the 2-year storm as an example. In addition Table G.4 illustrates the release rate computations for all storms.

Table G.4 – Release Rate Computations for White Deer Creek

			Subwatershed 2	Subwatershed 4	Subwatershed 9
1 yr	(1) Flow @ outlet peak	7/30/02 5:54	1.01	1.05	0.13
	(2) Flow @ area peak		1.32	1.4	0.13
	Release Rate = (1)/(2)*100		77%	75%	100%
	Max allow flow at release rate		1.01	1.05	0.13
2 yr	(1) Flow @ outlet peak	7/30/02 2:24	25.36	25.08	4.60
	(2) Flow @ area peak		50.72	55.6	14.10
	Release Rate = (1)/(2)*100		50%	45%	33%
	Max allow flow at release rate		25.36	25.08	4.6
5 yr	(1) Flow @ outlet peak	7/30/02 2:06	44.63	44.31	8.11
	(2) Flow @ area peak		79.39	87.12	24.15
	Release Rate = (1)/(2)*100		56%	51%	34%
	Max allow flow at release rate		44.63	44.31	8.11
10 yr	(1) Flow @ outlet peak	7/30/02 1:54	79.29	78.31	14.60
	(2) Flow @ area peak		128.89	141.52	42.52
	Release Rate = (1)/(2)*100		62%	55%	34%
	Max allow flow at release rate		79.29	78.31	14.6
25 yr	(1) Flow @ outlet peak	7/30/02 1:46	122.26	120.5	22.81
	(2) Flow @ area peak		183.77	201.72	63.59
	Release Rate = (1)/(2)*100		67%	60%	36%
	Max allow flow at release rate		122.26	120.5	22.81
50 yr	(1) Flow @ outlet peak	7/30/02 1:40	173.39	170.12	32.7
	(2) Flow @ area peak		242.25	266.01	86.57
	Release Rate = (1)/(2)*100		72%	64%	38%
	Max allow flow at release rate		173.39	170.12	32.7
100 yr	(1) Flow @ outlet peak	7/30/02 1:36	228.51	224.12	43.58
	(2) Flow @ area peak		303.51	333.19	110.91
	Release Rate = (1)/(2)*100		75%	67%	39%
	Max allow flow at release rate		228.51	224.12	43.58

To determine the actual release rate to be applied to a particular subwatershed a release rate for each storm event must be computed and the most restrictive would be selected as the overall release rate. As can be seen from Table G.4 many of the storms resulted in very restrictive release rates. Therefore, as described in Section 4 a release rate of 100 % will be applied to all subwatersheds throughout the White Deer Creek Watershed. This approach will address the peak flows leaving each development, however it will not address the effects of the timing of the hydrographs at other points in the watershed.

Figure G.3 - White Deer Creek Outlet & Subwatershed #2 Hydrographs (2-year storm)



G.7 Release Rate Calculation

Once a release rate is applied its effects must be evaluated at all points downstream. This is due to the fact that the volume of runoff that is stored to reduce the peak flow is released over time. This may result in higher flows on all or a portion of the downstream leg of the hydrograph. One cannot be certain, without actually checking, that this augmentation of an upstream hydrograph will not adversely affect conditions at a downstream location. To assure that there are no undesirable conditions created at locations downstream from an area with a release rate applied, existing and proposed hydrographs were compared at all junctions downstream from subwatersheds 2, 4, and 9 to evaluate the possibility of an increase in peak flow at any of these points. The data indicate the use of a 100% release rate will result in some minor increases in peak flows at some points within the watershed. However, these increases are all less than 1% of the total flow at that location. Therefore, these potential increases in peak flows are negligible.

Table G.5 – Comparison of Flows at Junctions Downstream From Applied 100% Release Rates

100-YEAR	Flow (cfs)		
Location	Existing 100-year	With Release Rates Applied	Difference
JCT 7/8/9	13976	13978	2
JCT 5	14351	14355	4
JCT 2/3	14470	14474	4
JCT 3	15637	15659	22
JCT 1	15654	15668	14
50-YEAR	Flow (cfs)		
Location	Existing 50-year	With Release Rates Applied	Difference
JCT 7/8/9	10598	10601	3
JCT 5	10887	10890	3
JCT 2/3	10977	10980	3
JCT 3	11872	11887	15
JCT 1	11885	11902	17
25-YEAR	Flow (cfs)		
Location	Existing 25-year	With Release Rates Applied	Difference
JCT 7/8/9	7506	7507	1
JCT 5	7714	7717	3
JCT 2/3	7780	7783	3
JCT 3	8423	8452	29
JCT 1	8430	8443	13
10-YEAR	Flow (cfs)		
Location	Existing 10-year	With Release Rates Applied	Difference
JCT 7/8/9	4784	4786	2
JCT 5	4920	4923	3
JCT 2/3	4967	4969	2
JCT 3	5387	5420	33
JCT 1	5393	5403	10

5-YEAR	Flow (cfs)		
Location	Existing 5-year	With Release Rates Applied	Difference
JCT 7/8/9	2539	2540	1
JCT 5	2617	2618	1
JCT 2/3	2648	2650	2
JCT 3	2880	2891	11
JCT 1	2883	2891	8
2-YEAR	Flow (cfs)		
Location	Existing 2-year	With Release Rates Applied	Difference
JCT 7/8/9	1384	1385	1
JCT 5	1430	1430	0
JCT 2/3	1450	1451	1
JCT 3	1583	1590	7
JCT 1	1586	1591	5
1-YEAR	Flow (cfs)		
Location	Existing 1-year	With Release Rates Applied	Difference
JCT 7/8/9	19.37	19.37	0
JCT 5	20.77	20.8	0.03
JCT 2/3	22.24	22.28	0.04
JCT 3	26.84	27.44	0.6
JCT 1	27.10	27.70	0.6

Appendix H
Stormwater Problem Areas and Possible Solutions

APPENDIX H

STORMWATER PROBLEM AREAS AND POSSIBLE SOLUTIONS

To be used in conjunction with Plate 3 of the
White Deer Creek Stormwater Management Plan

Location 1 – Railroad Bridge and roadway bridge are acting as obstructions. (6 pictures)

CLEARANCE

Possible Solutions: Remove the existing railroad pier from the creek. The pier is approximately centered in the middle of the creek and is causing great amounts of sedimentation, as water carries the sediment from upstream and then deposits after velocity drops from coming in contact with the pier. If removing the pier is an option, the channel could be dredged afterwards to remove small rock deposits. The meandering of the channel causes deposits along the right side of the creek, while the left bank is stabilized from erosion by riprap. The bridge over Harberson Road does not seem to cause noticeable changes, although the bridge's 25-yr capacity is undersized to pass large storm events.

Location 2 – Debris in creek causes creek to flood road. (2 pictures)

Possible Solutions: Debris should be removed from the tributary under Depot Road. The backwater effect of the culvert passing under White Deer Pike, downstream, likely causes flooding. Once the water level rises in White Deer Creek, it inundates the culvert under White Deer Pike, which in turns backs water into the culvert under Depot Road. During less frequent storm events, the debris and heavy vegetation along the banks of the tributary to White Deer Creek may be reducing its capacity. Regular maintenance will allow the channel to more easily convey less frequent storm events. Both box culverts have less then 25-yr capacities and are undersized to pass large storm events, resulting in water to rise and pond on the roadway.

Location 3 – Ice jam reportedly caused flooding from Park Road to carwash. (4 pictures)

Possible Solutions: The area of concern between Park road and White Deer Creek lies in a topographic depression. A series of inlets collect the water and outfalls into the creek via a 24" CMP. The pipe outfalls at a very low elevation relative to the normal depth of the creek. During high flow events, the pipe is most likely inundated with flow and backs water into the collection system. An ice event could have either "sealed" the outlet pipe or covered the only inlet in the depression area, causing water to pond. Adding another inlet to catch the runoff from Park Road in the right roadway swale would eliminate some of the flow into the depression area. However, during events that cause White Deer Creek to rise significantly above the outfall pipe, this system will not adequately convey water. To alleviate this condition the swale could be continued from the downstream inlet to the creek in order to provide positive overland drainage.

Location 4 –Pipe under T-520 diverts runoff from west of road towards residence. (4 pictures)

Possible Solutions: Disconnect rooftop runoff point sources to promote infiltration and groundwater recharge. The 12” CMP under Leiser Road and the 24” CIP under the railroad track appear to be in good condition and functioning properly. Where the 24” CIP outlets on the East side of Leiser Road, timbers should be removed as to not backwater into the pipes. The swale is extremely vegetated and overgrown and should be maintained. It appears that the left bank of the drainage swale (railroad dike) is near vertical, therefore water can only flow out of the swale on the right side, consequently flooding the backyards of property owners. Building a berm on the right side to confine the water to the swale would alleviate some flooding along with a collection system to reduce the amount of overland flow.

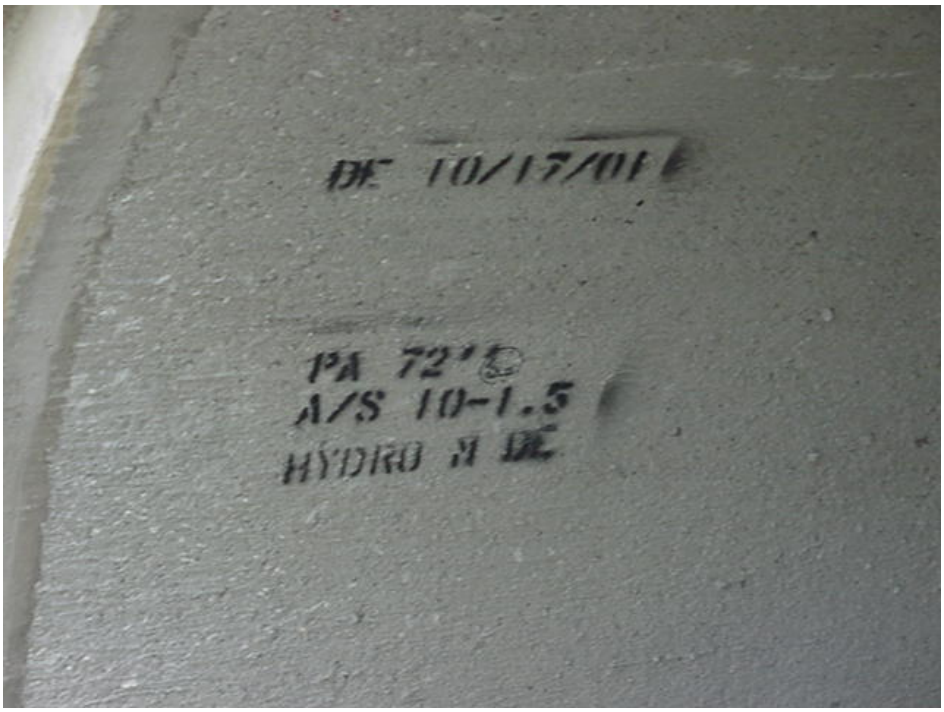
Location 5 –S.R.1011 Bridge (4 pictures)

Possible Solutions: It appears that the right pier of the bridge carrying U.S. 15 over White Deer Creek has caused the stream to meander. The left bank is protected with riprap. Higher velocities upstream carry stones that are deposited downstream of the piers. In addition, backwater from the S.R. 1010 bridge and railroad pier may be reducing upstream velocities and causing sediment to be deposited here. Removing the pier and/or increasing the less than 25-year capacity of the S.R. 1010 bridge may alleviate this condition. As a temporary solution the channel could be dredged so that flow can resume to a somewhat natural state.

Location 6 –A dike was installed many years ago, confines stream flow. (6 pictures)

Possible Solutions: Dike appears to be installed to protect the mobile home units from flooding, as the right bank is a near vertical slope, higher water surface elevations would inundate the homes. There are cases of erosion on the right bank. Additionally, landslides have occurred, possibly from the stream undermining the right bank. Slope and channel protection would reduce the effects of shear stress on the right bank. However, this condition will continue as long as the dike is confining the stream against the right bank.

Location 7 –Old culvert was recently replaced. The old culvert caused backwater. (5 pictures)


PA 72"
A/S 10-1.5
HYDRO

Possible Solutions: The new 6' RCP was installed under White Deer Pike. The pipe is at a very shallow slope and water continues to back into the pipe. The previous sized pipe may have been undersized, consequently flooding upstream lands. The new pipe appears to have alleviated some of the flooding.

Location 8 – No additional data given. (0 pictures)

Location 9 – Covered bridge and many curves in stream at this location. (3 pictures)

Possible Solutions: The upstream and downstream banks do not appear to be eroded. To reduce flooding, the low chord of the covered bridge and the roadway approaches would need to be raised, and span of bridge increased.

Location 10 – Small bridge causes backwater to flood property. (4 pictures)

Possible Solutions: Upstream channel is filled with heavy vegetation. Culvert running under Gray Hill Road is very flat. Water downstream could easily back water upstream of the culvert. Maintaining the upstream channel to similar downstream channel conditions would alleviate some flooding. Steam modeling indicates that this structure passes less than the 10-year storm.

Location 11 – Debris is causing stream to back up and flood. (4 pictures)

Possible Solutions: The area upstream of the culverts is very flat and is in a local depression. The channel could be graded to provide a positive drainage to the culverts. Downstream the channel is not well defined and is overgrown with vegetation. Channel maintenance should be provided.

Location 12 –Infiltration sewer lines along north berm of White Deer Pike. (4 pictures)

Possible Solutions: 4’ CMP culvert running under White Deer Pike has old concrete sidewalk lining the upstream left bank. At the downstream outlet of the pipe, debris has accumulated and needs to be cleaned and maintained. The debris is causing a dam like structure to back water into the culvert.

Location 13 – I-80 Underpass (5 pictures)

Possible Solutions: 4’ CMP carries runoff under Mountain Road. Grading could be done from I-80 underpass to Mountain Road to provide positive drainage to the culverts. Inlets could then be placed at any low points where runoff cannot be directed to the culvert. If this is not possible due to lack of available slope, the water could then be piped under Mountain Road to the natural channel or to the existing headwall if the pipe has an adequate slope.

Location 14 – Stormwater from private drives are impacting Township Roads. (8 pictures)

Possible Solutions: From the crest of Mountain Road to the end of the paved East shoulder section, an inlet, in conjunction with a vane rack, collects the runoff. During a field view, the rack was almost entirely filled with leaves. The runoff is then piped across the roadway. There are signs of erosion on the West side bank. A riprap channel would minimize the effects of erosion. Further down the East side of the road, accelerated erosion problems exist. Runoff from development is not being detained and spilling out uncontrolled through a series of pipes and eroding a deep ravine. Geotextile and appropriate rock lining could be placed in the ravine to stop the erosion. In addition, outlet protection could be provided for end of pipe treatment, to dissipate energy and decelerate the erosive velocities.

Location 15 – Roadway is at an elevation even with stream bank. (7 pictures)

Possible Solutions: An elliptical 2’ long by 1’ high CMP carries runoff under White Deer Pike. Upstream of the pipe there is a lot of low lying areas where runoff tends to puddle. A better-defined channel could be constructed and a larger pipe could be provided under White Deer Pike to reduce instances of roadway flooding. A channel could be graded to convey the water from downstream of the pipe to White Deer Creek. Positive drainage is absent in this area and water ponds. Roadway swales could be graded along both sides of the pavement to capture runoff from offsite drainage before it drains unto the roadway.

Location 16 – Obstructions from Susquehanna River. (4 pictures)

Possible Solutions: Right stream bank has accelerated erosion and sedimentation. Deposits of rocks, gravel, and sand are found throughout the downstream channel leading into the confluence with the Susquehanna River. Stream bank protection is needed along the right bank. Additionally, removing the railroad pier and dredging the channel upstream may improve downstream conditions.