BULL RUN WATERSHED

ACT 167

STORMWATER MANAGEMENT PLAN UPDATE

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

JULY 2002

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

BULL RUN WATERSHED

ACT 167

STORMWATER MANAGEMENT PLAN UPDATE

JULY 2002

TABLE OF CONTENTS

PAGE

TABLES ***PAGE***

FIGURES ***PAGE***

APPENDICES

PLATES

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
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 - Lawyer's Advisory Committee
MEC - Municipal Engineer's Advisory Committee
NRCS - Natural Resource Conservation Service (previously SCS)
NWI – National Wetlands Inventory
P – Precipitation Depth
PENNDOT – Pennsylvania Department of Transportation
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
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
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

BULL RUN WATERSHED
ACT 167
STORMWATER MANAGEMENT PLAN UPDATE

Section I – Introduction

1.0 Introduction

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. The Act also specifies the need to periodically update plans. This guarantees a dynamic system of runoff control sensitive to changing study area characteristics. The original *Bull Run Watershed Act 167 Stormwater Management Plan* was adopted by Union County in June 1993. This update incorporates significant hydrologic changes in the watershed, and provides a more detailed analysis of the Miller Run sub-watershed.

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 program 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 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 water control sensitive to changing study area characteristics.

1.1 Plan Preparation Strategy

The "Bull Run Watershed - Act 167 - Stormwater Management Plan Update" 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 which 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, was further subdivided as follows

A.1 - Data Collection/Review/Analysis

This task involved the reviewing and analyzing of the original Plan data and data reflecting changes since the completion of the Plan as required to complete the technical and institutional planning steps for the Bull Run Act 167 Watershed Stormwater Management Plan Update.

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). It should be noted that, other than the original Plan adopted in 1993, there appear to be no other detailed studies of this nature that have been or are being conducted at this time.

A.2 - Municipal Ordinance Reviews/Evaluations

This task involved the detailed update of the Municipal Ordinances in order to prepare a Municipal Ordinance comparison matrix. This matrix, as depicted in Table 1.0, 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 and the preparation of the matrix is to easily and effectively see 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. For a detailed review of existing Municipal Ordinances see Appendix B.

Table 1.0 - Existing Municipal Ordinance Matrix, Bull Run Watershed

Municipality	Zoning	Floodplain	Subdivision & Land Development	Within Subdivision & Land Development			
				Stormwater	Floodplain	Road	E&S
East Buffalo Twp	Yes, 1996	Yes, no date	Yes, 1981	Sect 505	---	Sect 402	Sect 514
Buffalo Twp	Yes, 1992	Yes, 1977	Yes, 1998	Sect 4.17	Sect 4.20	Sect 4.4-4.7	Sect 4.18
Lewisburg Borough	Yes, 2000	Yes, 1985	Yes, 1994	Part 8	---	Sect 408	Sect 804

A.3 - Data Preparation For Technical Analysis

This task involved the engineering work necessary to update 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 the Miller Run Watershed only for modeling and display purposes.

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 (limestone) 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.

3. Guidelines for stormwater management in limestone areas were 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. In the case of this watershed, the release rates have already been established as part of the

original Plan and according to the municipal survey, appear to be working. However, due to the noted problem areas around Bucknell, and preliminary analysis of the release rates for this area, it was determined that the Miller Run Watershed would be remodeled and new release rates evaluated.

2. For the Miller Run Subwatershed, all steps were completed. For the remainder of the Bull Run Watershed, only the first three objectives, (water quality, groundwater recharge, streambank erosion) were evaluated and revised.

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).

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 1.1 - Bull Run Watershed Plan Advisory Committee (WPAC)

Municipality/Organization	Name
Herbert, Rowland & Grubic, Inc.	Al Brulo
Herbert, Rowland & Grubic, Inc.	Thomas Wilson
Lewisburg Borough	David Clouser
Buffalo Township	Larry Berger
Buffalo Township	Joseph Wise
Buffalo Township Planning Commission	Douglas Hovey
Union County Planning Commission	Madeline Layos
East Buffalo Township	Ralph Hess
Union County Planning Commission – Engineer	Lake Randall
Union County GIS	Sue Hunter
Union County GIS	Casey McCracken
Union County Planning Commission	Shawn McLaughlin
Union County Conservation District	Ted Retallack
Department of Environmental Protection	Lynn Manahan
Bucknell Construction and Planning Group	James Hostetler

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 1.2 - Bull Run Watershed Municipal Engineer's Committee (MEC)

Municipality/Organization	Name
East Buffalo Township	Lake Randall
Buffalo Township	Raymond Robbins
Lewisburg Borough	Larson Design Group

The Legal Advisory Committee (LAC) will include the solicitors representing every Municipality in the watershed. A meeting with the LAC will be convened one time 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 1.3 - Bull Run Watershed Lawyer's Advisory Committee (LAC)

Municipality/Organization	Name
East Buffalo Township	Peter Matson
Buffalo Township	Jeffery Crossland
Lewisburg Borough	Andrew Lyons

A municipal official's handbook was developed tailored to the watershed to provide guidance to 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

This update to the Plan was prepared to include the various components of the Plan that were researched and updated.

The general framework for the Bull Run Act 167 Plan Update 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 function and to develop the runoff control criteria for new development has been adapted to the Bull Run Watershed from the original Bull Run Plan and other Act 167 Studies. As part of the development of the Bull Run Plan update, 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.

1.2 Bull Run Watershed Characteristics

General Description

The Bull Run Watershed is situated in the southeastern portion of Union County in north-central Pennsylvania. The watershed encompasses approximately 8.4 square miles. A general watershed map is presented as Plate 1: Bull Run Watershed. Bull Run is the only major tributary in the watershed. Bull Run flows into the Susquehanna River at the eastern boundary of Lewisburg Borough.

Political Features

The watershed is contained entirely within Union County. Portions of the following municipalities lies within the Bull Run Watershed as indicated in Table 1.4.

Table 1.4 - Municipalities Lying Within The Watershed

Municipality	Area In Watershed (sq. miles)	Percent of Watershed (percent)
Lewisburg Borough	0.58	6.9
Buffalo Township	2.15	25.6
East Buffalo Township	5.67	67.5

The townships are of the 2nd Class and employ the township supervisor style of government. Lewisburg Borough is governed by a council - mayor form of government.

Natural Features

The Bull Run Watershed is located in the Northern Appalachian Mountain section of the Valley and Ridge Physiographic Provinces. The terrain of the basin consists primarily of rolling hills. The elevations within the watershed vary from a minimum of 430 feet at the confluence of the Susquehanna River and Bull Run up to a maximum 700 feet above sea level along the periphery of the watershed. Due to the generally hilly character of the watershed, streams feeding into the Susquehanna River tend to mirror that of the mountain ridges.

Geological formations of the Silurian Period, represented by Wills Creek, Tonoloway, and Keyser formations, underlay the watershed. The southernmost section of the watershed contains bedrock of the Tonoloway formation with a band of the Wills Creek formation to the north which forms the shale and sandstone topography in this area. The north central area of the Bull Run Watershed consists of the Tonoloway formation which forms limestone bedrock. At the northern tip of the watershed is a small area of the Keyser formation which forms a limestone bedrock. Limestone regions generally have a gently rolling topography with prolific sinkholes, depressions, and solution caverns.

A detailed soil survey of the watershed was conducted by the U.S. Department of Agriculture, Soil Conservation Service, in cooperation with Penn State University. There are basically five soil associations identified in the watershed. Two of these associations have characteristics of flooding at slightly different levels of occurrence. They are located in the eastern section of the watershed and along various streams. The southern two-thirds of the watershed contains the Edom-Kutztown developed from calcareous materials. The northern one-third of the watershed is limestone derived soils with sinkholes,

depressions, solution caverns, and undulating terrain. The United States Soil Conservation Service (S.C.S.) 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 soil groups throughout the watershed is provided in Plate 2: Hydrologic Soils. The distribution of soil groups throughout the watershed was determined based upon soil series information mapped on the S.C.S. soil survey for Union County. The aggregation of individual soil series into appropriate hydrologic soils groups was performed using S.C.S. Technical Release 55 information.

As the data indicates, the majority of the soils in the watershed are in Soil Group C, tending to produce a moderately high rate of stormwater runoff.

1.3 Hydrology

The Bull Run Watershed is elongated in shape. The total length of the watershed measures approximately 2.0 miles along its long (north-south) axis and is roughly 4.5 miles wide at its widest point. The total area drained is approximately 8.4 square miles. With the exception of Bull Run (Limestone Run), Miller Run is the only other named waterway in the watershed.

Bull Run itself generally flows in an easterly direction from its origin to its mouth on the west branch of the Susquehanna River. Approximately 8 unnamed tributaries, Miller Run, and direct runoff feed Bull Run.

Section II – Background/Five Phase Approach

2.0 Introduction

This chapter presents a unified approach for sizing stormwater BMPs in the Bull Run Watershed to meet pollutant removal goals, maintain groundwater recharge, and reduce channel erosion. For a summary, please consult Table 2.0 below. The remaining sections describe the sizing criteria in detail and present guidance on how to properly compute and apply the required storage volumes.

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

Table 2.0 - Summary of the Watershed-Wide Stormwater Criteria

Sizing Criteria	Description of Stormwater Sizing Criteria
Water Quality Volume (WQ_v) (ac-ft)	$WQ_v = [(P)(R_v)(A)]/12$ P = 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.

2.1 Water Quality Volume (WQ_v)

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

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

$$WQ_v = \frac{(1.2)\,(R_v)(A)}{12}$$

P = 1.2 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 (see 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 2.0.

*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 2.0 - 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 2.8, 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.

2.2 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), a non-structural practice (e.g., buffers, disconnection of rooftops), or a combination of both.

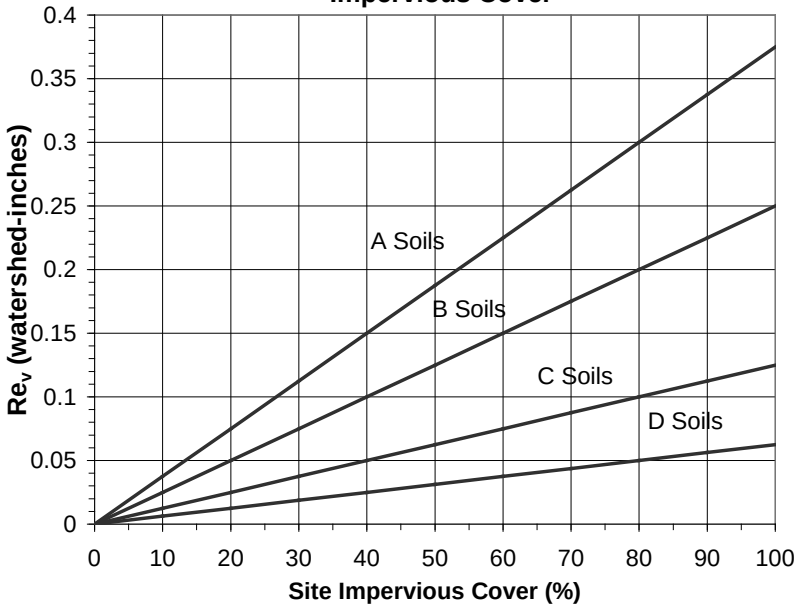
Drainage areas having no impervious cover and no proposed disturbance during development may be excluded from the Re_v calculations. Designers are encouraged to use these areas as non-structural practices for Re_v treatment (see Appendix D).

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.

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 2.1.

Figure 2.1 - 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 4.3).

- 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.

2.3 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.

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.

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 2.2.

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.

$$Qa = \frac{(2.4 - Ia)^2}{(2.4 - Ia) + S}$$ where S = (1000/CN) - 10, Ia = (200/CN) - 2

- Compute the ratio *Ia/2.4* where 2.4 is the one-year rainfall depth (Source: NRCS (SCS) TR-55).

- 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.

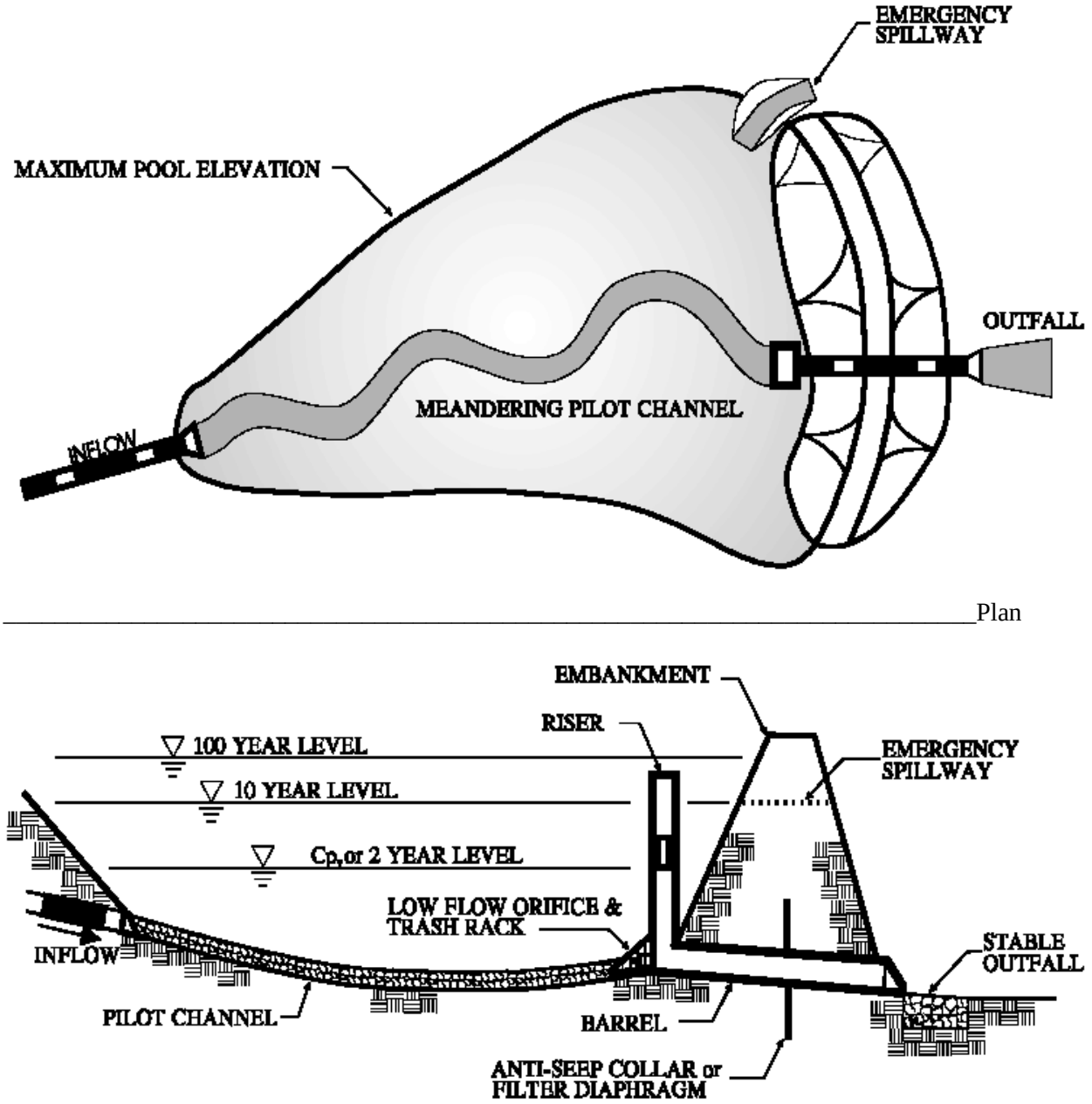
- **If *qi* $\leq$ 2.0 cfs, Cp_v is not required**. Provide for water quality (WQ_v) and groundwater recharge (Re_v) as necessary.

- 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 $V_s = (V_s/V_r) x V_r$ (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 2.2 - Example of Conventional Stormwater Detention Pond



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.

- Rainfall depth for the one-year, 24-hour storm event in Union County is 2.4 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.

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

It is through the development and application of release rate percentage based peak discharge standards that the Stormwater Management Plan truly assumes a watershed wide status. The methods for computing release rates are discussed in this section and supporting calculations are contained in Appendix G. The investigations, which serve as the basis for the establishment of release rate percentage standards, represent the principal means through which the watershed wide implications of control strategies are evaluated, considered and incorporated into specific control standards. It should be noted that these measures for control of extreme events are applicable to the water ways located within the Bull Run Watershed but do not address backwater from the Susquehanna River. A number of structures are regularly inundated by backwater from the Susquehanna River during extreme events (see Appendix H).

The scope of this Plan update includes determination of updated release rates for the Miller Run Watershed only. Release rates for the remainder of the Bull Run Watershed remain unchanged from the original Plan.

Table 2.1 contains a summary of the release rates for the Miller Run Watershed. See Plate 3 for a map of the sub-watersheds.

Table 2.1 - Miller Run Watershed Release Rates

Sub-Watershed	Release Rate
37	100
38	100
39	100
40	100
42	100
43	100
44	100
45	100
46	75
47	100
49	100
50	100
51	100

To utilize the release rate for a particular site in one of the delineated release rate percentage areas, 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 increase infiltration and reduce impervious surfaces. Recompute the post-development runoff rate for the 2-, 10-, 25-, and 100-year storms; and if the resulting post-development rate is less than or equal to the pre-development rate multiplied by the applicable release rate, the requirements of this Plan have been met. Otherwise, stormwater detention or retention will be required and the developer should proceed to Step 3.

3. Multiply the assigned release rate percentage for the area times the pre-development peak runoff rate to determine the allowable total peak runoff rate from the development area. Design the necessary detention/retention facilities to meet the allowable peak runoff rate standard.

2.5 Release Rate Percentage Concept

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.

The general approach employed in the Bull Run 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.

The supporting calculations behind the development and application of release rate percentage based stormwater management criteria are discussed in Appendix G. A brief summary of those calculations and the final release rates are presented below.

Release rates were determined for the following storm events: 2-, 5-,10-, 25-, 50-, and 100-year. The most restrictive release rate from these events was selected to be used for all events. After further analysis of the existing and proposed curve numbers (See Table 2.2), release rates were applied to subshed 46 only. This is due to the fact that little future development is expected in the Miller Run Watershed during the scope of this update. In fact, some developed areas of the watershed are expected to be reverted to a more pervious surface in the future. Therefore, all of the subsheds except 46 had future curve numbers equal to or less than their existing curve numbers. No release rate restrictions were placed on subsheds where flows are expected to remain constant or be reduced in the future.

Table 2.2 - Hydrologic Data for Miller Run Subwatersheds

Subshed ID	Subshed Area (sf)	Subshed Area (sqmi)	Exist. Weighted Curve #	Exist. S_{wtd}	Exist. Ia	Future Land Use Weighted Curve #	Future S_{wtd}	Future Ia	Tc (hrs)	Lag Time (hrs)
51	472682	0.017	88.058	1.356	0.271	88.058	1.356	0.271	0.59	0.36
46	1986629	0.071	80.556	2.414	0.483	84.224	1.873	0.375	0.42	0.25
44	5344164	0.192	76.146	3.133	0.627	75.622	3.224	0.645	0.58	0.35
49	931323	0.033	82.560	2.112	0.422	78.846	2.683	0.537	0.28	0.17
50	491963	0.018	78.852	2.682	0.536	78.852	2.682	0.536	0.42	0.25
42	2723188	0.098	83.827	1.929	0.386	83.232	2.015	0.403	0.36	0.21
39	2060666	0.074	80.430	2.433	0.487	80.086	2.487	0.497	0.38	0.23
43	2223978	0.080	75.506	3.244	0.649	75.506	3.244	0.649	0.35	0.21
37	1919960	0.069	76.938	2.997	0.599	76.673	3.042	0.608	0.42	0.25
40	3161748	0.113	71.943	3.900	0.780	71.804	3.927	0.785	0.57	0.34
47	697398	0.025	82.699	2.092	0.418	82.699	2.092	0.418	0.25	0.15
45	677850	0.024	77.255	2.944	0.589	77.255	2.944	0.589	0.34	0.20
38	2310491	0.083	77.066	2.976	0.595	77.064	2.976	0.595	0.37	0.22
Overall Weighted Curve Number			**77.974**			**77.884**				

Table 2.3 - Land Use Data for The Bull Run Watershed

	Current Acres	% of DEV	Future Est.		% change
Developed	**1726.08**	**100.00%**	**1929.48**		**11.80%**
R1	329.14	19.1%	356.58		8.30%
R2	384.32	22.3%	543.32		41.40%
R3	201.86	11.7%	224.34		11.10%
R4	104.47	6.1%	93.3		-10.70%
Residential	**1019.79**	**59.1%**	**1217.54**		**19.40%**
Industrial	84.27	4.9%	94.99		12.70%
Institutional	173.54	10.1%	179.59		3.50%
Commercial	156.4	9.1%	202.33		29.40%
Disturbed	100.62	5.8%	43.57		-56.70%
Smooth	191.46	11.1%	191.46		0%
		% of Total		% of Total	
Undeveloped	**3658.72**	**67.9%**	**3488.84**	**64.8%**	**-4.60%**
Forest	418.63	7.8%	403.35	7.5%	-3.70%
Meadow	120.15	2.2%	120.15	2.2%	0%
Pasture	187.71	3.5%	181.51	3.4%	-3.30%
Agriculture	2458.89	45.7%	2357.19	43.8%	-4.10%
Open Space	473.34	8.8%	393.12	7.3%	-16.90%

HEC-HMS models were created with relative rainfall input for each storm event including the 2-, 5-, 10-, 25-, 50-, and 100-year. The output data were analyzed in an effort to determine a release rate for subwatershed 46, as well as to analyze any downstream impacts resulting from the application of this release rate. A summary of the analysis performed for subwatershed 46 is presented in Table 2.4.

Table 2.4 – Release Rate Computations for Miller Run Subwatershed 46

		Date / Time	FLOW OUTLET CFS	FLOW SUBBASIN-46 CFS
2-yr	(1) $Q_{sub\ contrib}$	12/4/2001 21:16	479.59	40.497
	(2) $Q_{sub\ peak}$			51.128
	RR = (1)/(2)*100			79%
	Max allow flow at release rate			40.497
	RR			75%
	Q_{allow}			38.35
5-yr	(1) $Q_{sub\ contrib}$	12/4/2001 21:14	838.80	72.423
	(2) $Q_{sub\ peak}$			84.21
	RR = (1)/(2)*100			86%
	Max allow flow at release rate			72.423
	RR			75%
	Q_{allow}			63.16
10-yr	(1) $Q_{sub\ contrib}$	12/4/2001 21:14	1,135.90	94.91
	(2) $Q_{sub\ peak}$			111.27
	RR = (1)/(2)*100			85%
	Max allow flow at release rate			94.91
	RR			75%
	Q_{allow}			83.45
25-yr	(1) $Q_{sub\ contrib}$	12/4/2001 21:12	1,353.90	121.16
	(2) $Q_{sub\ peak}$			131.01
	RR = (1)/(2)*100			92%
	Max allow flow at release rate			121.16
	RR			75%
	Q_{allow}			98.26
50-yr	(1) $Q_{sub\ contrib}$	12/4/2001 21:12	1,627.00	142.9
	(2) $Q_{sub\ peak}$			154.99
	RR = (1)/(2)*100			92%
	Max allow flow at release rate			142.9
	RR			75%
	Q_{allow}			116.24
100-yr	(1) $Q_{sub\ contrib}$	12/4/2001 21:12	1,856.30	161.13
	(2) $Q_{sub\ peak}$			175.13
	RR = (1)/(2)*100			92%
	Max allow flow at release rate			161.13
	RR			75%
	Q_{allow}			131.35

As can be seen from this table, the release rates are first computed, rounded down to the next nominal percentage, and the most restrictive release rate is applied for all storm events. In this situation the 2-year storm (75%) is the most restrictive and therefore was selected for use during all storm events. Once

applied, an analysis of all downstream locations was performed to ensure that no adverse impacts will be created by augmentation of upstream hydrographs.

2.6 Design Example: Computing Stormwater Storage Volumes

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

Design Example No. 1: Residential Development - The Meadows

Site data and the layout of The Meadows subdivision are shown in Figure 2.3.

Step 1. Compute WQ_v Volume

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

Step 1a. Compute Volumetric Runoff Coefficient (R_v)

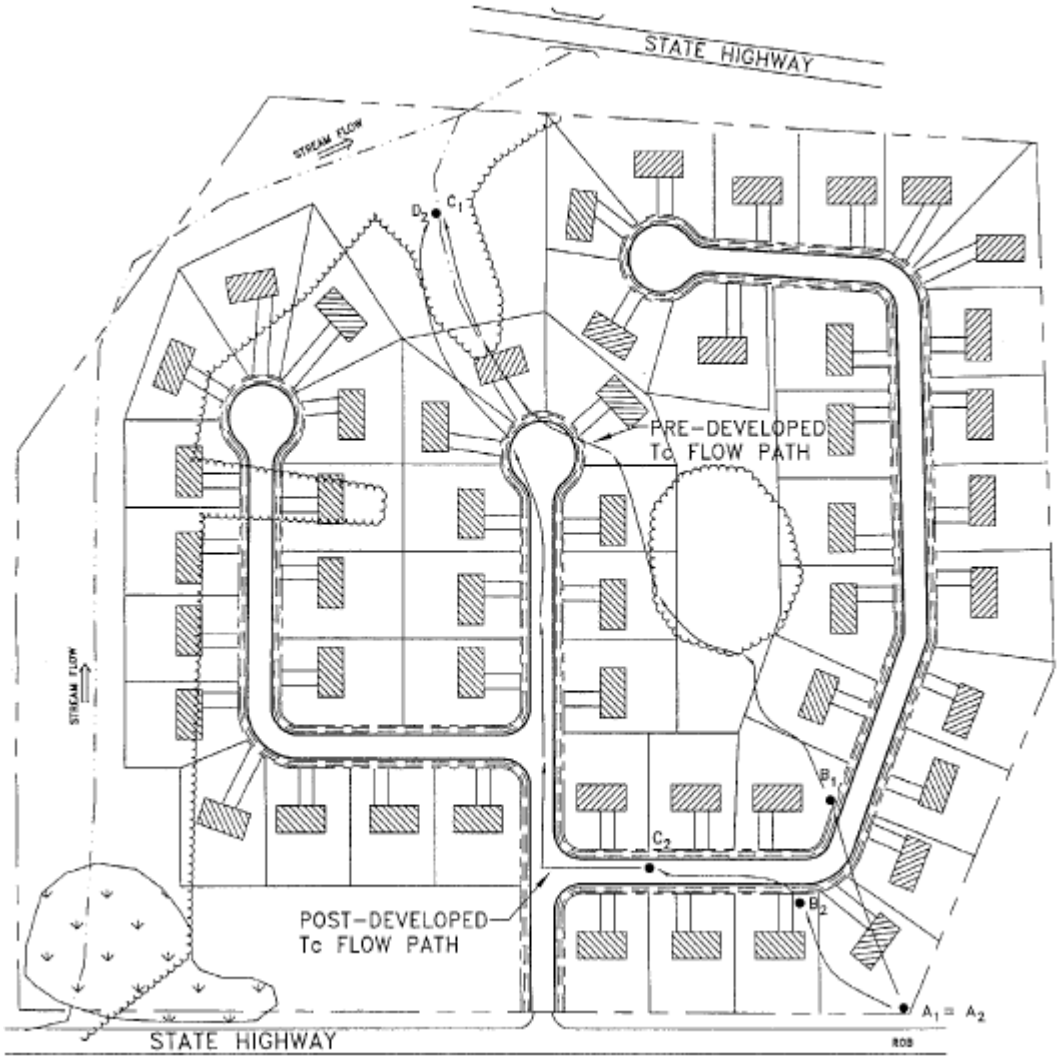
R_v = 0.05 + (0.009) (I); I = 13.8 ac/38.0 ac = 36.3%
= 0.05 + (0.009) (36.3) = 0.38

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 2.3 - 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)

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

or

$Re_v = (S)(Ai)$ (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	0.2	4.62
developed	78	0.19	0.8	35.0

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)/2.4" = 0.235
tc = 0.19 hours

Figure F.1 (Appendix F), *qu* = 740 csm/in

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

Peak outflow discharge/peak inflow discharge (*qo/qi*) = 0.024

With *qo/qi*, compute *Vs/Vr* for a Type II rainfall distribution,

$Vs/Vr = 0.683 - 1.43(qo/qi)+1.64(qo/qi)\ 2 - 0.804(qo/qi)^3$ (Appendix F)
Vs/Vr = 0.65

Therefore, *Vs* = 0.65(0.8.)(1/12)(38 ac) = 1.65 ac-ft

Step 3d. Define the Cp_v Release Rate

qi is known (35.0 cfs), therefore,
qo = (*qo/qi*) *qi* = .024 (35.0) = .84 cfs

Step 4. Compute Overbank and Extreme Event Requirements

Compute assuming a release rate of 75%

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.)

Union County 24 hour Rainfall for Various Frequencies (in.)					
2yr	5yr	10yr	25yr	50yr	100yr
2.8	3.7	4.4	4.9	5.5	6.0

$S = (1000/CN) - 10$

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)					
2yr	5yr	10yr	25yr	50yr	100yr
15.2	30.4	49.4	53.2	68.4	83.6

Step 4b. Compute post-development runoff peak flow

Summary of Post-Development Peak Flows (cfs)					
2yr	5yr	10yr	25yr	50yr	100yr
38.0	64.6	95.0	91.0	117.8	136.8

Step 4c. Because post-development flows are greater than pre development flows multiply the pre-development flows by the release rate to determine allowable post-development runoff peak flows

Allowable Post-Development Peak Flows (cfs) @ 75% Release Rate					
2yr	5yr	10yr	25yr	50yr	100yr
11.4	15.2	37.1	39.9	51.3	62.7

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

2.7 Economic Analysis of Implementation of the Five Phase Approach

It was determined that satisfaction of the 75% release rate criteria would require a basin with approximately 173,737 ft^3 of volume while detention of a traditional 100% release rate would require approximately 145,737 ft^3. This corresponds to a cost of approximately $130,300 for the pond to treat the 75% release rate and approximately $109,300 to treat the 100% release rate. Therefore, an additional $21,000 is required for construction of the detention facility associated with the 75% release rate. This detention facility will also be designed to satisfy the WQ_v and Cp_v requirements.

In addition, infiltration swales will be provided wherever practical, in lieu of curb and traditional pipe and inlet storm sewer, to satisfy the Re_v requirement. There are approximately 4200 feet of street frontage (2100 feet of street) associated with this project. If 80% of the street frontage could be treated with infiltration swales approximately 3360 feet of swale would be required. The remaining 840 feet would be treated with traditional curbs and storm sewers. The cost of this approach would be approximately $142,800. If the infiltration swales were not used and the curb and storm sewer were used over the entire site the cost would be approximately $176,400. Therefore, the use of infiltration swales could reduce the cost of the collection and conveyance facilities by approximately $33,600. The most significant savings comes from the reduction in amount of curb required on the site with the infiltration swales.

Stormwater management credits (see Appendix D) may also be utilized to reduce the amount of infrastructure required to meet the stormwater sizing criteria. Often these practices can come at no additional cost to the developer, however they must be integrated into the early stages of the design of the project. Some of the credits that might be applicable to this type of project are disconnection of rooftop and non-rooftop runoff and sheet flow to buffer credits. Construction costs may even be reduced slightly if the sheet flow to buffer credit is implemented, as less of the site will need to be cleared and graded.

In summary, this brief analysis indicates that the costs of constructing this development using the five-phase approach and selected BMPs is more cost effective when compared to the costs of traditional infrastructure. However, total project costs may vary due to differences in design costs, utilization of stormwater credits, and unique site conditions. For more information on sources of funding for the development and implementation of stormwater control requirements see Appendix I.

2.8 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/)
PA 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

2.9 Designation of Stormwater Hotspots

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. Table 2.5 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 2.5, 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 2.5 - 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 III – Drainage Problems and Proposed Solutions

3.0 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 Bull Run Watershed was provided with an opportunity to update the documentation of existing drainage problems within its borders.

Each of the municipalities in the watershed was contacted to solicit information, via questionnaires, relative to stormwater conditions that are perceived locally to be 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 21 problem areas were identified in the three municipalities in the watershed, see Plate 4. Of these problem areas, three had been previously reported as part of the original Bull Run Act 167 Plan. The distribution of identified problem types are presented in Plate 4: Stormwater Problem Areas. As is indicated on the Plate and as one would expect, the predominant problem type reported is flooding, with and without accompanying erosion and sedimentation.

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. 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."

3.1 Suggested Solutions

Several types of suggested solutions to recognized problems were offered. The suggested solutions include structural approaches such as increasing the capacity of storm sewers, constructing culverts and the construction of stormwater detention or ponding areas. Also included are such remedial actions as stream dredging for the removal of accumulated silt, the clearing of debris from culvert and bridge openings and the removal of obstructions from the stream bed. Refer to Appendix A for detailed information regarding previous studies and suggested solutions.

All of the suggested solutions offered 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.

3.2 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 pose a problem. 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 Bull Run Watershed Stormwater Management Plan, the following distinction, has been used:

> "Significant obstructions will be those that are identified in the municipal data questionnaires and which are identified as being areas where insufficient capacity exists for the necessary storm flows or those that would act as impoundments and affect watershed modeling."

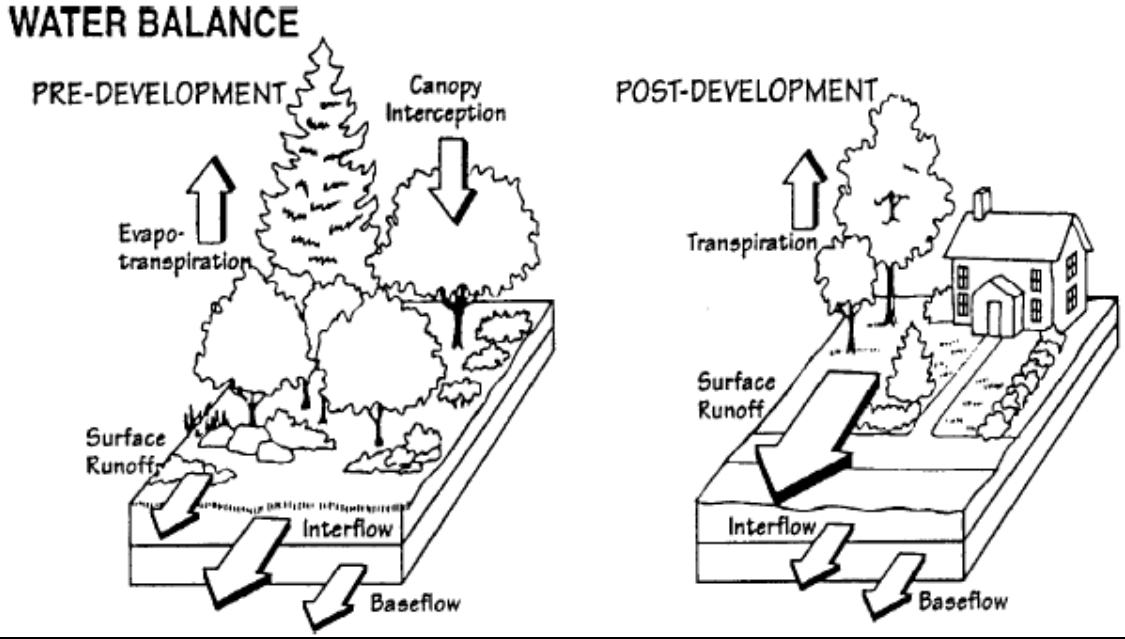
One of the goals of this Plan Update is to identify significant obstructions within the Miller Run Watershed, which is tributary to Bull Run. Using this definition, 25 significant obstructions have been identified within the Miller Run Watershed and are shown in Plate 5: Significant Obstructions. A list 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 Miller Run. 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 Update 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.

Section IV – Municipal Handbook

4.0 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 4.0). The hydrology of a site changes during the initial clearing and grading that occur during construction. Trees, meadow grasses, and agricultural crops that had intercepted and absorbed rainfall are removed and 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 4.0 - 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.

4.1 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.

4.2 Intent of the Act 167 Plan

The Bull Run 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.

4.3 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 4.0 lists the suggested BMPs that are described in the Plan and, in detail, in The Pennsylvania Handbook of Best Management Practices.

Table 4.0 - 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

4.4 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 facility must be available at all times because of the random nature of rainfall events and the impracticality of inspecting the facility and maintaining them immediately before a storm event. In addition, pollutant-removal efficiencies will decline over time if the BMP is 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 includes 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.

4.4.1 Overview of BMP Maintenance

Changes in downstream drainages 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 4.1.

Table 4.1 - 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 nontechnical 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 nonprofessional, a professional should be consulted periodically to ensure that all needs of the facility are met. Some developing problems may not be obvious to the untrained eye.

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

4.4.2 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 4.2. 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 4.2 - 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

4.4.3 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 need to 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, such as SEDCAD. 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, sometimes suspended sediment will 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.

4.4.4 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.

4.4.5 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.

4.4.6 Estimating Nonroutine Costs

Costs for nonroutine maintenance of BMPs also is 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.

4.4.7 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.

4.4.8 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.

4.4.9 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.

4.5 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.

4.5.1 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.

4.5.2 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.

4.5.3 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 developing 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.

Large areas of the Bull Run Watershed are underlain by limestone, dolomite, or marl carbonate rocks, which are potentially susceptible to the development of karst conditions. 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 rocks do occur, 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.

4.5.4 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 swales, 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 postdevelopment runoff rates, thereby minimizing needs for artificial conveyance and storage. To maintain predevelopment hydrologic conditions, opportunities 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.

4.5.5 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 nonstormwater 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.

4.5.6 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.

4.5.7 Protecting Natural Depressional 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.

4.6 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.

4.6.1 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.

4.6.2 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.

4.6.3 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.

4.6.4 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.

4.6.5 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 V – Runoff Control Techniques and Their Efficiencies

5.0 Introduction

As was discussed previously, the basic standard for stormwater management as established by Act 167 is that those involved in activities which can generate additional stormwater runoff, increase its velocity, or change the direction of its flow must be responsible for controlling and managing the runoff so that these changes will not cause harm to other persons or property throughout the watershed. This mandate requires comprehensive stormwater planning at a watershed level and the development of standards and criteria for managing stormwater to prevent adverse impacts, both at a particular site and anywhere downstream where the potential for harm can reasonably be identified.

Specifically, the primary prerequisite for effective stormwater management in the watershed is the development of standards which specify allowable stormwater discharges from land development activities. Standards must also be developed which address issues associated with the control of velocity, direction and quality, if appropriate. The standards must be accompanied by associated criteria which form the basis for the design and assessment of activities instituted to comply with those standards.

5.1 Runoff Control Standards

The basis for the establishment of runoff control standards is contained in the Stormwater Management Act. The statement of legislative findings contained in the Act (Section 2 of the Act) presents the following findings:

1. Inadequate management of accelerated runoff of stormwater resulting from development throughout a watershed increases flood flows and velocities, contributes to erosion and sedimentation, overtaxes the carrying capacity of streams and storm sewers, greatly increases the cost of public facilities to carry and control stormwater, undermines flood plain management and flood control efforts in downstream communities, reduces ground water recharge, and threatens public health and safety.

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

Section 3 of the Act defines the duty of persons engaged in the development of land as follows:

"Any landowner and any person engaged in the alteration or development of land which may affect stormwater runoff characteristics shall implement such measures consistent with the provisions of the applicable stormwater plan as are reasonably necessary to prevent injury to health, safety or other property. Such measures shall include such actions as are required:

1. To assure that the maximum rate of stormwater runoff is no greater after development than prior to development activities; or

2. To manage the quantity, velocity and direction of resulting stormwater runoff in a manner which otherwise adequately protects health and property from possible injury."

The most effective method means of satisfying the Act based upon the statements of legislative findings and definition of duty would be to control runoff from land development activities such that both the total volume and rate of runoff from new development are identical to that which occurred before development i.e., post-development runoff volume and rates identical to pre-development conditions. If this could be accomplished, stormwater runoff from the new development would not produce any effect on downstream flows, eliminating any concern relative to the creation of downstream damage potentials. Unfortunately, however, most land development activities involve the conversion of land use from a type which exhibits a relatively low runoff potential to a higher runoff potential type.

Often, stormwater management decisions for new development have predominantly been made based on conditions at the site in question. The difference between at-site runoff control philosophy and the Act 167 watershed-level philosophy is the consideration of downstream impacts. The objective of typical at-site design would only be to control post-development peak runoff rates to pre-development levels from the site itself, a watershed-level design would be geared towards maintaining existing peak flow rates in the entire drainage system. The latter requires knowledge of how the site relates 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 the site. The proposed watershed-level runoff control philosophy is based on the assumption that runoff volumes will increase with development and, rather than necessarily attempting to reduce post-development volume, seeks to "manage" the increase in volume such that peak rates of runoff throughout a watershed are not increased. The basic goal, therefore, of both the at-site and watershed-level philosophies is the same, i.e. no increase in the peak rate of runoff. However, simply controlling peak rates of runoff at-site does not guarantee an effective watershed-level control because the increase in total runoff volume could accumulate throughout the watershed and increase peak flows.

5.2 Application of the Assigned Release Rate Percentages

As indicated previously, the release rate percentage concept is a tool for watershed level stormwater management, developed to ensure that the application of runoff control plans for individual sites consider downstream stormwater runoff implications. As such, the release rate percentage functions as a performance standard; that is, it defines an end result which is to be attained. Under this approach, an individual developer can select and design those drainage control measures that are most appropriate to the site as long as the applicable release rate percentage for the subbasin is met. It is important to note that the assigned release rate percentages must be applied only to actions that control peak runoff through detention, retention or other methods which attenuate runoff discharges. Applicable stormwater control techniques are discussed in Section VII of this report.

To utilize the release rate for a particular site in one of the delineated release rate percentage areas, 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 increase infiltration and reduce impervious surfaces. Recompute the post-development runoff rate for the 2-, 10-, 25- and 100-year storms; and if the resulting post-development rate is less than or equal to the pre-development rate multiplied by the applicable release rate, the requirements of this Plan have been met. Otherwise, stormwater detention or retention will be required and the developer should proceed to Step 3.

3. Multiply the assigned release rate percentage for the area times the pre-development peak runoff rate to determine the allowable total peak runoff rate from the development. Design the necessary detention/retention facilities to meet the allowable peak runoff rate standard.

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.

Section VI – Plan Review Adoption and Updating Procedures

6.0 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 four parts, namely Watershed Advisory Committee review, Legal Advisory 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 Watershed Advisory Committee and Legal Advisory Committee. Presented below is a chronological listing and brief narrative of the required local review steps through County adoptions.

1. Watershed Advisory Committee Review - This body has been formed to assist in the development of the Bull Run 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 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 Advisory Committee review would 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 will meet one time to receive comments and direction in the development of the model ordinance. The output of the Municipal Engineers Committee review would 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 will meet one time to receive comments and direction in the development of the model ordinance. The output of the Legal Advisory Committee review would 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 *Bull Run Watershed - Act 167 - Stormwater Management Ordinance* which would implement the Plan through municipal adoption. The output of the municipal review would 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 Advisory 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.

6.1 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 Bull Run 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 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 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 Bull Run Watershed Stormwater Management Plan. Union County will review the recommendations of the Watershed 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 VII - Model Act 167 Stormwater Management Ordinance

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

BULL RUN WATERSHED

STORMWATER MANAGEMENT ORDINANCE

Implementing the Requirements of the

Bull Run 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

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 Bull Run 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 Bull Run Watershed, as delineated in Appendix E which is hereby adopted as part of this Ordinance.

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.

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 (PA DEP) Technical Manual for Sewage Enforcement Officers (as amended or replaced from time to time by PA 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.

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 Bull Run 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 (calibrated) - The computer-based hydrologic modeling technique adapted to the Bull Run Watershed for the Act 167 Plan. The model has been "calibrated" to reflect actual recorded flow values by adjoining key model input parameters.

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).

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 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 Bull Run Watershed adopted by Union County as required by the Act of October 4, 1978, P.L. 864, (Act 167), and known as the "Bull Run Watershed Action 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 Bull Run Watershed which do not fall under the exemption criteria shown in Section 402 shall submit a drainage plan consistent with the Bull Run Watershed Stormwater Management Plan Update 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. Also, maintenance, including mowing of vegetation within the easement shall be required, except as approved by the appropriate governing authority.

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 PA DEP through the Joint Permit Application process, or, where deemed appropriate by PA 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 PA DEP through the Joint Permit Application process, or, where deemed appropriate by PA 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 PA 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 Plan Update.

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 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:

$$WQ_v = \frac{(1.2)\,(R_v)(A)}{12}$$

P = 1.2 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 structural practices 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 non-structural practices 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 2.4 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. Stormwater Management Districts

A. Bull Run Watershed has been divided into stormwater management districts as shown in the original Bull Run Watershed Stormwater Management Plan. Miller Run has been further subdivided as shown on the plate in Appendix E.

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

Standards for managing runoff from each subarea in the Bull Run Watershed for the 2-, 10-, 25-, and 100-year design storms follow. Development sites located in each of the release rate districts must control post-development runoff rates to a percentage of pre-development runoff rates for the design storms as follows.

Table 305-1: Bull Run Watershed Release Rates

Subarea		Release Rate (%)
Bull Run Watershed	1	80
	2	50
	3	100
	4	100
	5	60
	6	60
	7	100
	8	70
	9	50
	10	60
Miller Run Watershed	37	100
	38	100
	39	100
	40	100
	42	100
	43	100
	44	100
	45	100
	46	75
	47	100
	49	100
	50	100
	51	100

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

A. General - Post-development rates of runoff from any regulated activity shall meet the peak release rates of runoff prior to development for the design storms specified on the Stormwater Management District Watershed Map (Ordinance Appendix E) and Section 305, of the Ordinance.

To utilize the release rate for a particular site in one of the delineated release rate percentage areas, 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 increase infiltration and reduce impervious surfaces. Recompute the post-development runoff rate for the 2-, 10-, 25- and 100-year storms; and if the resulting post-development rate is less than or equal to the pre-development rate multiplied by the applicable release rate, the requirements of this Plan have been met. Otherwise, stormwater detention or retention will be required and the developer should proceed to Step 3.

3. Multiply the assigned release rate percentage for the area times the pre-development peak runoff rate to determine the allowable total peak runoff rate from the development. Design the necessary detention/retention facilities to meet the allowable peak runoff rate standard.

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 at a reduced scale is included in the Ordinance Appendix E. 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. Sites Located in More Than One District - For a proposed development site located within two or more stormwater management district category subareas, the peak discharge rate from any subarea shall be the pre-development peak discharge for that subarea as indicated in Section 305. The calculated peak discharges shall apply regardless of whether the grading plan changes the drainage area by subarea. An exception to the above may be granted if discharges from multiple subareas recombine in proximity to the site. In this case, peak discharge in any direction may be a 100% release rate provided that the overall site discharge meets the weighted average release rate.

D. 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.

E. 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.

F. "No Harm" Option - For any proposed development site not located in a provisional direct discharge district, 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.G. 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 (2-, 5-, 10-, 25-, 50-, and 100-year) shall be the values from the calibrated model for the Bull Run 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.G.

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.

G. "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.

H. 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.

I. Hardship Option - The development of the plan and its standards and criteria was designed to maintain existing peak flows throughout the Bull Run 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 PA 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 PA DEP Chapter 105 regulations (as amended or replaced from time to time by PA DEP), shall be designed in accordance with Chapter 105 and will require a permit from PA 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 PA 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 PA 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 PA 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 PA DEP Joint Permit Application and regulated under Chapter 105 (Dam Safety and Waterway Management) or Chapter 106 (Floodplain Management) of PA 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 Bull Run 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 PA DEP Joint Permit Application, the Municipal Engineer shall notify PA 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. PA 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 PA 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 PA 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 PA 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 addressed, 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 guilty of a misdemeanor, and upon conviction 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.

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: NRCS (SCS) TR-55

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: NRCS (SCS) TR-55

Design Storm Frequency (years)	24 Hours Rainfall Amount (inches)
1	2.4
2	2.8
5	3.7
10	4.4
25	4.9
50	5.5
100	6.0

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

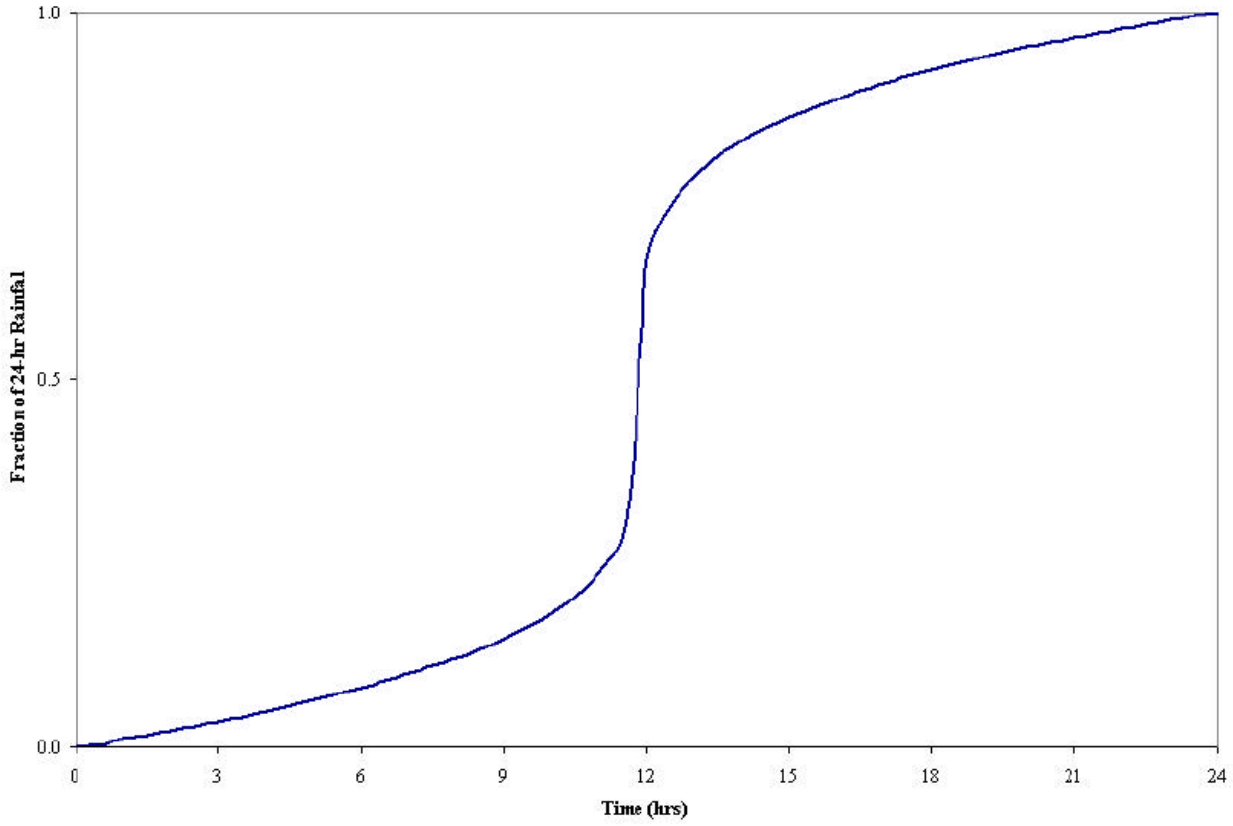


FIGURE B-2
PENNDOT STORM INTENSITY-DURATION-FREQUENCY CURVE
REGION 3
Source: "Field Manual of Pennsylvania Department of Transportation"
STORM INTENSITY-DURATION-FREQUENCY CHARTS
P D T - I D F" May 1986

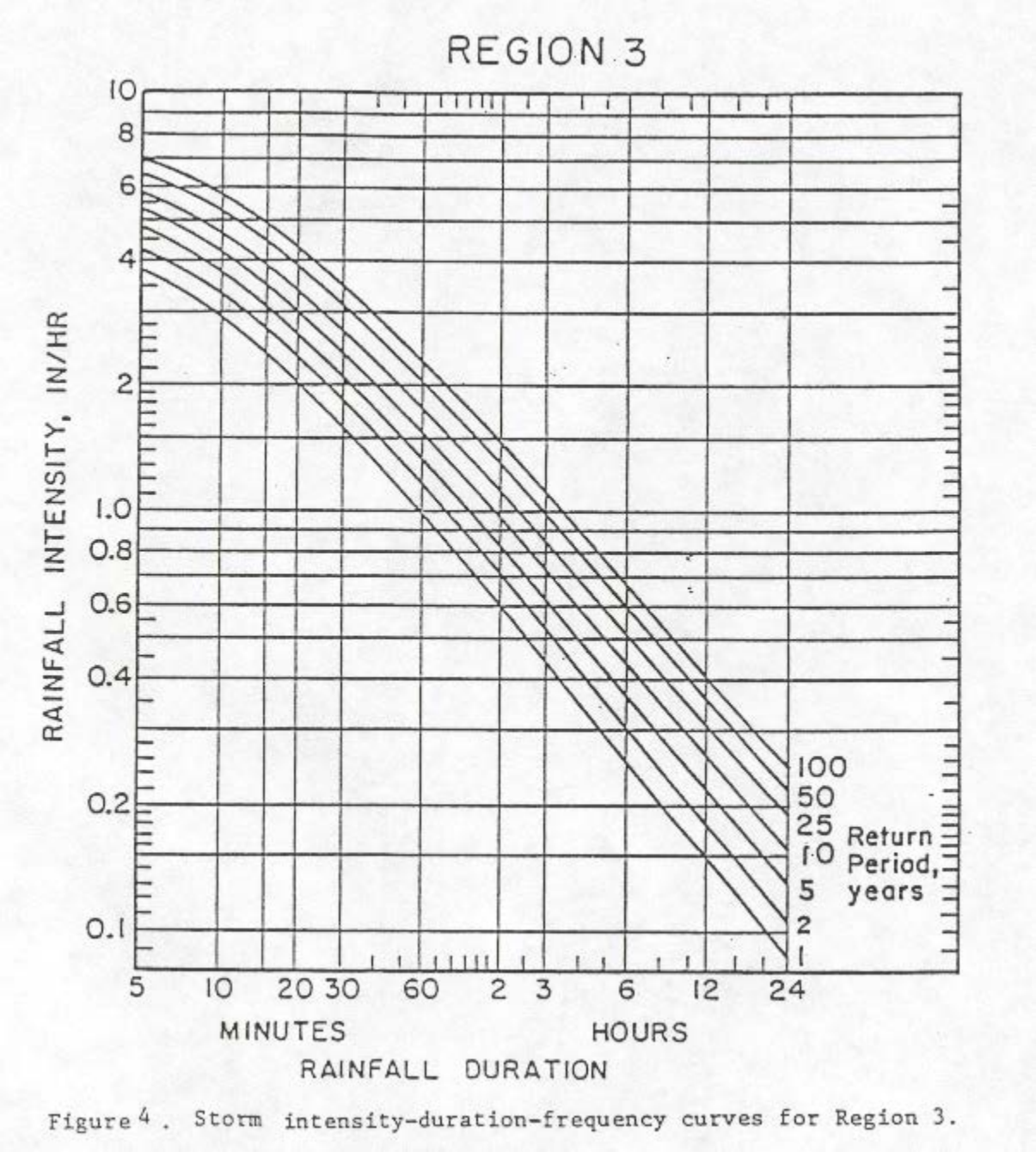


Figure 4. Storm intensity-duration-frequency curves for Region 3.

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

   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	$ _____
1-5 ac	$ _____
5-25 ac	$ _____
25-100 ac	$ _____
100-200 ac	$ _____
>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.

  $$Qa = \frac{(2.4 - Ia)^2}{(2.4 - Ia) + S}$$ where S = (1000/CN) - 10, Ia = (200/CN)-2

- Compute the ratio *Ia/2.4* where 2.4 is the one-year rainfall depth (Source: NRCS (SCS) TR-55.

- 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* ≤ 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

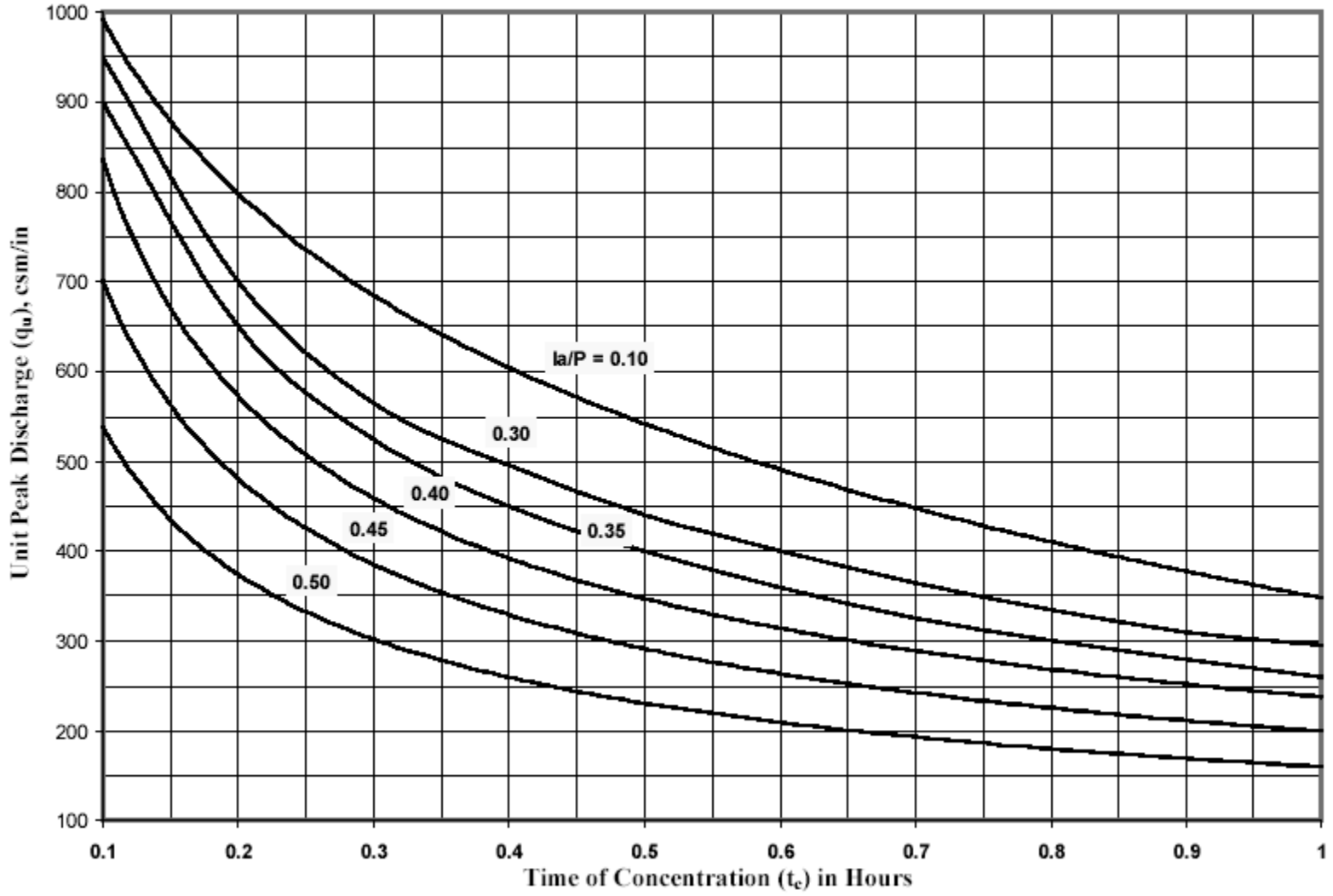
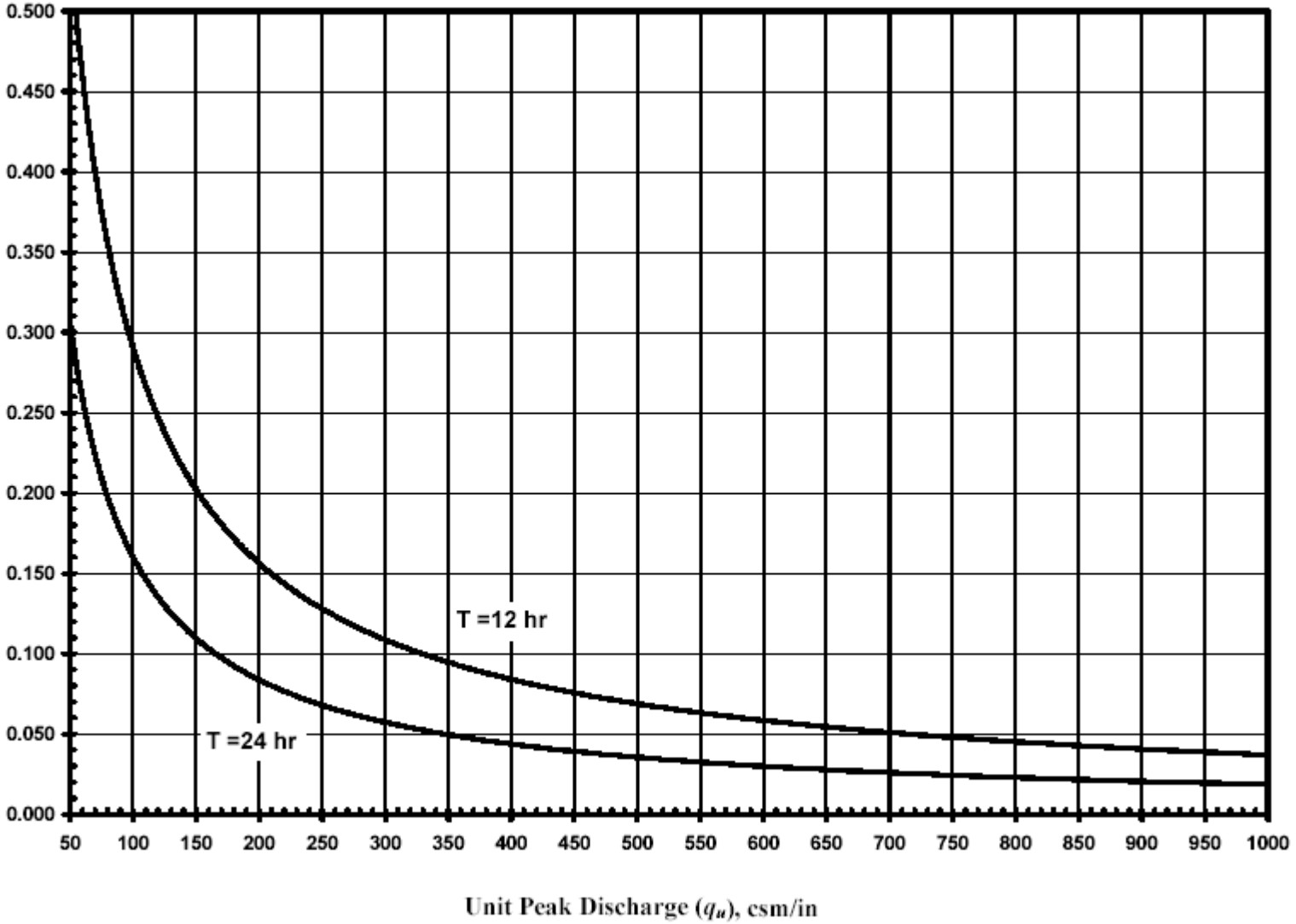


Figure D.2 Detention Time Versus Discharge Ratios (qo/qi)



Appendix A
Review of Related Documents

Appendix B
Review of Existing Municipal Ordinances

Appendix C
Union County Rainfall Data

Appendix D
Stormwater Credits for Effective Site Planning

Appendix E
Computation of Peak Discharge for Water Quality Storm

Appendix F
Computation of Channel Protection Storage Volume

Appendix G
Release Rate Concept and Computations

Appendix H
Repetitive-Loss Structures

Appendix I
Review of Funding Sources

Appendix J
References