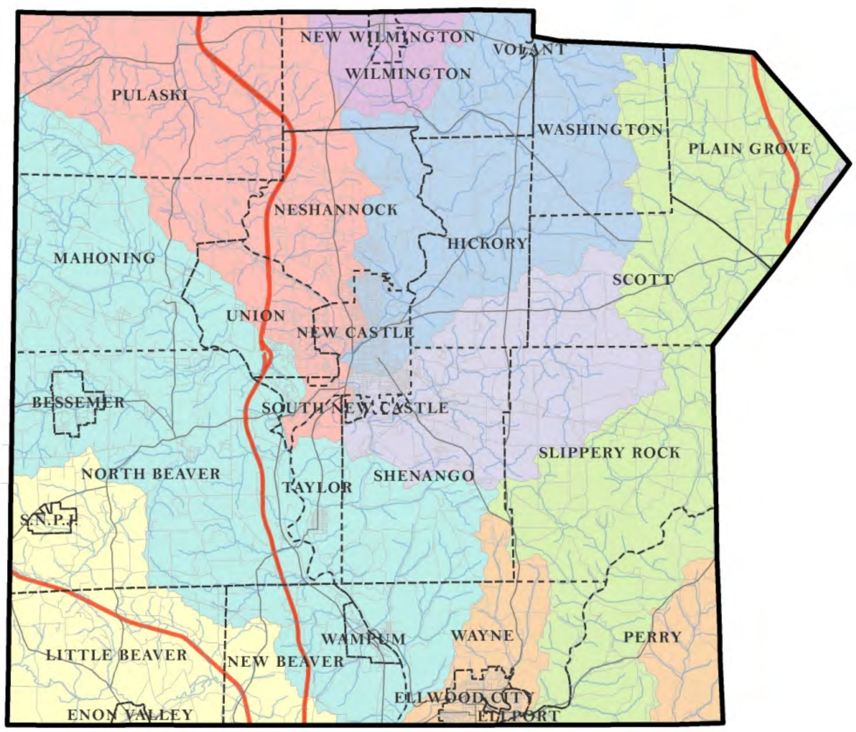
LAWRENCE COUNTY

ACT 167 PHASE 2

STORMWATER MANAGEMENT PLAN

VOLUME 2 – PLAN CONTENT



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Tamara Gibson	New Castle
	Boroughs
Head of Governing Body	Bessemer
Head of Governing Body	Ellport
Rohanda Zellhart	Ellwood City
Tyrone Petrich & Duane Clawson	Enon Valley
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	Townships
Head of Governing Body	Hickory
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Head of Governing Body	Shenango
Head of Governing Body	Slippery Rock
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LAWRENCE COUNTY PLANNING DEPARTMENT

LAWRENCE COUNTY GOVERNMENT CENTER
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NEW CASTLE, PENNSYLVANIA 16101

RESOLUTION R-2010-1

WHEREAS, the County of Lawrence has received funding from the Department of Environmental Protection to complete the Lawrence County Act 167 Stormwater Management Plan; and

WHEREAS, the Planning Commission of the County of Lawrence, Pennsylvania is the official advisory agent to the Board of Commissioners of Lawrence County on matters pertaining to the general planning of land use; and

WHEREAS, the Lawrence County Planning Commission recommends that the Board of Commissioners approves the Lawrence County Act 167 Phase 2 Stormwater Management Plan.

NOW, THEREFORE, BE IS RESOLVED, by the Lawrence County Planning Commission that the Lawrence County Act 167 Phase 2 Stormwater Management Plan be presented to the Board of Commissioners for their approval.

Adopted this 21st day of June 2010

Helen Jackson

Helen Jackson, Chairman

Everett Bleakney, Secretary

Attest:

Amy B. McKinney, Director

Mission Statement: The Lawrence County Planning Commission members and staff are committed to systematically organize, lead, direct, educate and administer planning as required by the Pennsylvania Municipalities Planning Code, so as to maximize the economic, environmental and social development of Lawrence County and the Commonwealth of Pennsylvania.

ORDINANCE NO. 2010 - # 2

AN ORDINANCE AUTHORIZING THE COUNTY OF LAWRENCE, PENNYSLVANIA TO PROVIDE FOR A COMPREHENSIVE PROGRAM OF STORMWATER MANAGEMENT, INCLUDING REGULATION OF DEVELOPMENT AND ACTIVITIES CAUSING ACCELERATED RUNOFF.

WHEREAS, the Stormwater Management Act 167 of 1978 provides for the regulations of land and water use for flood control and stormwater management, requires the Pennsylvania Department of Environmental Protection to designate watersheds, and provides for grants to be appropriated and administered by the Department for plan preparation and implementation costs, and provides that each county will prepare and adopt a watershed stormwater management plan for each designated watershed; and

WHEREAS, the Lawrence County Commissioners entered into a reimbursement agreement with the Pennsylvania Department of Environmental Protection to develop a County-wide watershed Stormwater Management Plan; and

WHEREAS, the purpose of the Stormwater Management Plan is to protect public health and safety and to prevent or mitigate the adverse impacts related to the conveyance of excessive rates and volumes of stormwater runoff by providing for the management of stormwater runoff and control of erosion and sedimentation; and

WHEREAS, design criteria and standards of stormwater management systems and facilities within the County shall use the criteria and standards as found in the Stormwater Management Plan;

NOW, THEREFORE, BE IT ORDAINED AND ENACTED by the Board of County Commissioners of the County of Lawrence, Pennsylvania, and it is hereby ordained and enacted by the same that the Lawrence County Commissioners hereby adopt the Stormwater Management Plan, including all volumes, figures, appendices, and Model Ordinance, and forward the Plan to the Stormwater Management Section of the Pennsylvania Department of Environmental Protection for approval.

CONTENTS

PLAN FORMAT

The format of the Lawrence County Stormwater Management Plan consists of three Volumes:

Volume 1 - Executive Summary

Provides an overview of Act 167 and a summary of the standards and criteria developed for the plan.

Volume 2 – Plan Content

Provides an overview of stormwater management, purpose of the study, data collection, all GIS maps, present conditions, projected land development patterns, calculation methodology, the Model Ordinance and implementation discussion.

Volume 3 – Appendices

Provides supporting data, watershed modeling parameters and modeling runs, peak flows, release rates, the existing municipal ordinance matrix, and obstructions inventory. Due to large volumes of data, one copy of Volume III will be on file at the Lawrence County Department of Planning.

SECTION I INTRODUCTION

A. Introduction

The purpose of this Act 167 Stormwater Management Plan is to:

1. Encourage planning and management of storm water runoff in each watershed which is consistent with sound water and land use practices.

2. Authorize a comprehensive program of storm water management designated to preserve and restore the flood carrying capacity of Commonwealth streams; to preserve to the maximum extent practicable natural storm water runoff regimes and natural course, current and cross-section of water of the Commonwealth; and to protect and conserve ground waters and ground-water recharge areas.

3. Encourage local administration and management of storm water consistent with the Commonwealth's duty as trustee of natural resources and the people's constitutional right to the preservation of natural, economic, scenic, aesthetic, recreational and historic values of the environment.

This Countywide Plan has been prepared for Lawrence County and applies to all areas located within the boundaries of Lawrence County, as well as all designated watersheds within the County. This Plan will assist in achieving the effective and efficient stormwater management of all major watersheds within Lawrence County and provide a single technical source for stormwater management across Lawrence County.

The need for this Act 167 plan is to assist in the achievement of Lawrence County's goal to create an overall stormwater management plan document, as well as to achieve compliance with the Pennsylvania Stormwater Management Act of 1978 (Act 167). Specific County goals are identified in Section I.C below. One of the primary objectives of Lawrence County's Act 167 planning process is to provide a countywide comprehensive program to assist in the planning and management of stormwater. With coordination from the twenty- seven (27) municipalities in Lawrence County, the resulting stormwater management ordinance will address severe and ongoing stormwater related problems in critical areas throughout the County. In accordance with Section 11.(b) of the Pennsylvania Stormwater management Act of 1978 the following is required:

> *"Within six months following adoption and approval of the watershed storm water plan, each municipality shall adopt or amend, and shall implement such ordinances and regulations, including zoning, subdivision and development, building code, and erosion and sedimentation ordinances, as are necessary to regulate development within the municipality in a manner consistent with the applicable watershed storm water plan and the provisions of this act."*

The watershed drainage system in Lawrence County consists of three (3) primary watershed groups:

1. Slippery Rock Creek / Connoquenessing Creek

   Connoquenessing Creek, a cold water fishery (with a very minor portion designated as a warm water stream), begins in northern Butler County and drains 838 square miles. The creek flows through only a small section of Lawrence County, but picks up a major tributary, Slippery Rock Creek in the process. Connoquenessing Creek is considered the second most polluted waterway in the United States, primarily due to the pollution from AK Steel. Other pollution comes from more typical sources such as agricultural runoff, sewage and siltation.

   Slippery Rock Creek starts in Butler County, drains 836 square miles and flows for forty-seven miles to Connoquenessing Creek. It is classed as a cold water fishery. Tributaries to the creek include Wolf Creek, Muddy Creek, Skunk Run, Grindstone Run, Hell Run and Taylor Run.

Hell Run is the only exceptional value (EV) stream in the county. It begins in Shenango Township, drains 6 square miles with a main branch length of 4.7 miles.

The upper sections of Slippery Rock Creek are affected by acid mine drainage, but current efforts by the Slippery Rock Watershed Coalition are underway to remediate the AMD. This is helping to improve the water quality in Lawrence County. Other problems include non-point siltation and light bank erosion.

2. Shenango/Mahoning/Beaver River Watersheds

The Mahoning River, also classified as a warm water stream, begins about 10 miles southeast of Alliance, Ohio, and flows through Pennsylvania for about 11 miles. The Mahoning River has been described as "one of the most polluted of any stream or river in Ohio" (OH EPA 1994), with the most polluted stretch located just downstream of Youngstown, Ohio. Dilution of the water makes the Pennsylvania section a little less polluted, but the sediment remains more contaminated than that found in Presque Isle Bay of Lake Erie. The Mahoning River's effects spread downstream into the Beaver River (see Beaver River description).

Major tributaries to the Mahoning River in Lawrence County include Coffee Run flowing from the north and Hickory Run, which joins the Mahoning River near the confluence of the Mahoning River and the Shenango River.

The Shenango River has its origin in Conneaut Township of Crawford County and flows more than 87 miles to its confluence with the Mahoning River to form the Beaver River. The drainage area is 1,062 square miles, of which 283 square miles are in Ohio (180,916 acres) and 779 square miles are in Pennsylvania (498,000 acres). The lower section from Shenango Lake to the Mahoning River confluence is considered the worse section. This section, in addition to receiving the pollutants from further upstream has effluents from industry, wastewater treatment plants and urban development.

Major tributaries of the Shenango River in Lawrence County include Neshannock Creek, Hottenbaugh Run, Big Run and Deer Creek.

3. North Fork Little Beaver Creek

North Fork Little Beaver Creek originates just north of New Springfield, Ohio, approximately 4.6 miles west of the Ohio-Pennsylvania border. Classed as a High quality-coldwater fishery, Little Beaver Creek flows for 30.6 miles to the Ohio River. This stream has numerous strip mines surrounding it in the upper reaches, and most of the mine drainage into the stream is alkaline. This AMD combined with the farm runoff contributes to water that has a high hardness and conductivity. Some industrial and municipal sewage discharges also affect water quality.

Honey Creek, the only major tributary to North Fork Little Beaver Creek in Lawrence County, joins upstream of Enon Valley Borough.

Figure I-1 below shows the seven watersheds designated under the Act 167 Program, as well as two additional watersheds of concern in Lawrence County.

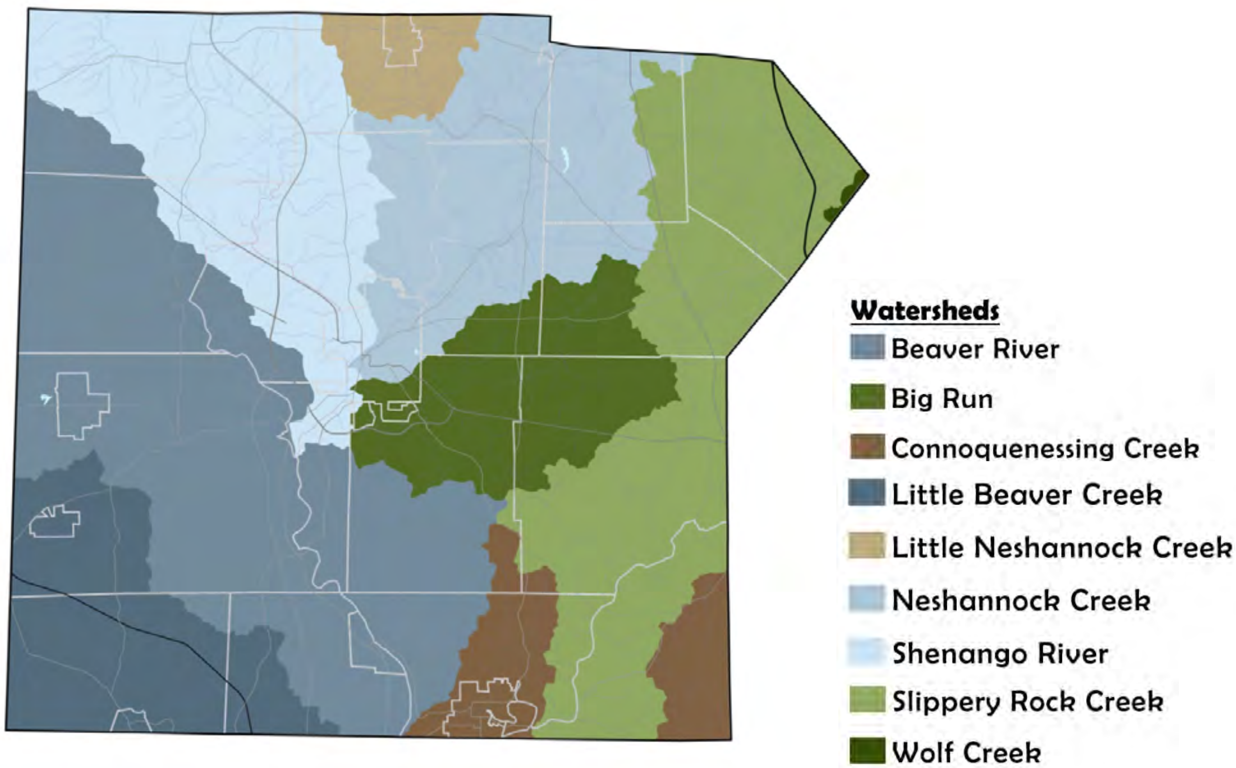


Figure I-1

As a requirement of the development of this plan, a model ordinance has been developed and is included in the Appendix section of this plan. Lawrence County and PADEP will then review and approve the final Plan document within the necessary timeframe. In accordance with Section 11.(b) of the Pennsylvania Stormwater management Act of 1978 the following is required:

> *"Within six months following adoption and approval of the watershed storm water plan, each municipality shall adopt or amend, and shall implement such ordinances and regulations, including zoning, subdivision and development, building code, and erosion and sedimentation ordinances, as are necessary to regulate development within the municipality in a manner consistent with the applicable watershed storm water plan and the provisions of this act."*

The County and municipalities must periodically review and revise the Plan at least every five years. PADEP may, for good cause shown, grant an extension of time to the County for the preparation and adoption of a watershed storm water management plan.

B. Stormwater Management

The water that runs off the land into surface waters of the Commonwealth during and immediately following a rainfall or snow/ice melt event is referred to as stormwater. In a watershed undergoing land use conversion or urban expansion, the volume of stormwater resulting from a particular rainfall event increases because of the reduction in pervious land area (i.e., natural land cover being changed to pavement, concrete, buildings, or unmanaged cropland). These surface changes can also substantially degrade stormwater runoff quality, increasing the pollutant load to the rivers and streams. The alteration of natural land cover and land contours to residential, commercial, industrial, and crop land uses results in decreased infiltration of rainfall, an increased rate and volume of runoff, and increased pollutant loadings to surface watercourses.

As the population of an area increases, land development is inevitable. As land disturbance and development increases, so does the problem of dealing with the increased quantity and decreased quality of stormwater runoff. Failure to properly manage this runoff results in greater flooding, stream channel erosion and siltation, degraded water quality, as well as reduced groundwater recharge. The cumulative effects of development in some areas of a watershed can result in flooding of natural watercourses with associated costly property damages. These impacts can be minimized if the land use and development incorporates appropriate runoff and stormwater management systems and designs.

Individual land disturbance/development projects have historically been viewed as independent or discrete events or impacts, rather than as part of a larger watershed process. This has also been the case when the individual land development projects are scattered throughout a watershed (and in many different municipalities). However, it is now being observed and verified that the cumulative nature of individual land surface changes dramatically affects runoff and flooding conditions. These cumulative effects of development and land disturbance in some areas have resulted in flooding of both small and large streams with associated property damages and even causing loss of life. Therefore, given the distributed and cumulative nature of the land alteration process, a comprehensive approach must be taken if a reasonable and practical management and implementation approach or strategy is to be successful.

C. Stormwater Management Plan Objectives

One of the County goals considered in the preparation of this plan is to produce a countywide model ordinance that will serve as a means of effectively implementing the results of the plan and providing measures that address technical, legal, and governmental issues, as well as achieving additional County-wide objectives noted below.

The final objectives for this plan were developed based on a review of the objectives within Section 3 of Act 167, a review of water quality impairments in the County, and a review of stormwater management problems identified by the WPAC and through the municipal survey process. Through analysis of the survey results, L.R. Kimball and County staff determined that the three primary stormwater problems within the County are stream corridor flooding, street flooding, and property flooding. No water quality issues or locations were identified by the WPAC or through the municipal survey process.

The original plan objectives included the following:

1. Encourage planning and management of storm water runoff in each watershed that is consistent with sound water and land use practices (Act 167, Section 3).
2. Establish a comprehensive program of storm water management policy to help preserve and restore stream flood carrying capacity, to help preserve as much as possible the natural storm water runoff regimes and natural course, current and cross-section of waters of the Commonwealth; and to protect and conserve ground waters and ground-water recharge areas (Act 167, Section 3).
3. Establish local administration and management of storm water (Act 167, Section 3).

4. Prepare detailed hydrologic analyses of the following watersheds in order to develop comprehensive approaches to stormwater management controls (as outlined in Table I-1)

Table I-1

Watershed	Rationale	Focus of Modeling Effort
Slippery Rock Creek	Bio-diversity Area threatened by development	Hell Run subwatershed
	Recurrent Flooding along Slippery Rock Creek identified in County Hazard Mitigation Plan	Lower Slippery Rock Creek in Perry and Wayne Townships
Connoquenessing Creek	Recurrent road flooding	Duck Creek subwatershed
	Recurrent road flooding	Squaw Creek subwatershed
	Recurrent road flooding	Connoquenessing Creek watershed in Ellwood City, Ellport, and Wayne Township
Little Beaver Creek	Recurrent urban flooding due to stream obstructions and development in floodplain.	Tributary in Enon Valley Borough
		Sugar Creek subwatershed
Beaver/Mahoning River	Recurrent stream corridor flooding, property damage	Hickory Run and Hickory Creek subwatersheds
	Recurrent stream corridor, property, and street flooding	Upper Mahoning River tributaries in Mahoning Township
	Recurrent street and property flooding	Lower Mahoning River tributaries in North Beaver Township
	Stream corridor flooding / obstruction(s)	Coffee Run subwatershed
	Recurrent street and property flooding, stream corridor flooding / obstruction(s)	Upper Beaver River/Jenkins Run/Edwards Run subwatersheds
	Obstructions, recurrent flooding due to increase in runoff	Unnamed tributary to Beaver River (Vinegar Valley) subwatershed in Wayne Township
	Recurrent street flooding in New Beaver Borough	Upper Eckles Run subwatershed
	Recurrent street and stream corridor flooding	Unnamed tributary to Beaver River (Possum Hollow) in New Beaver Borough

Shenango River	Growth areas, recurrent property flooding, water obstructions, urbanized areas	Select Tributaries
Big Run	Growth area, recurrent property flooding	Entire Watershed
Neshannock Creek	Growth area, urbanized areas, recurrent flooding and obstruction problems	Entire Watershed
Little Neshannock Creek	Recurrent flooding and obstruction problems in Wilmington Township	Entire Watershed

These original plan objectives were determined using the process summarized in Figure I-2.

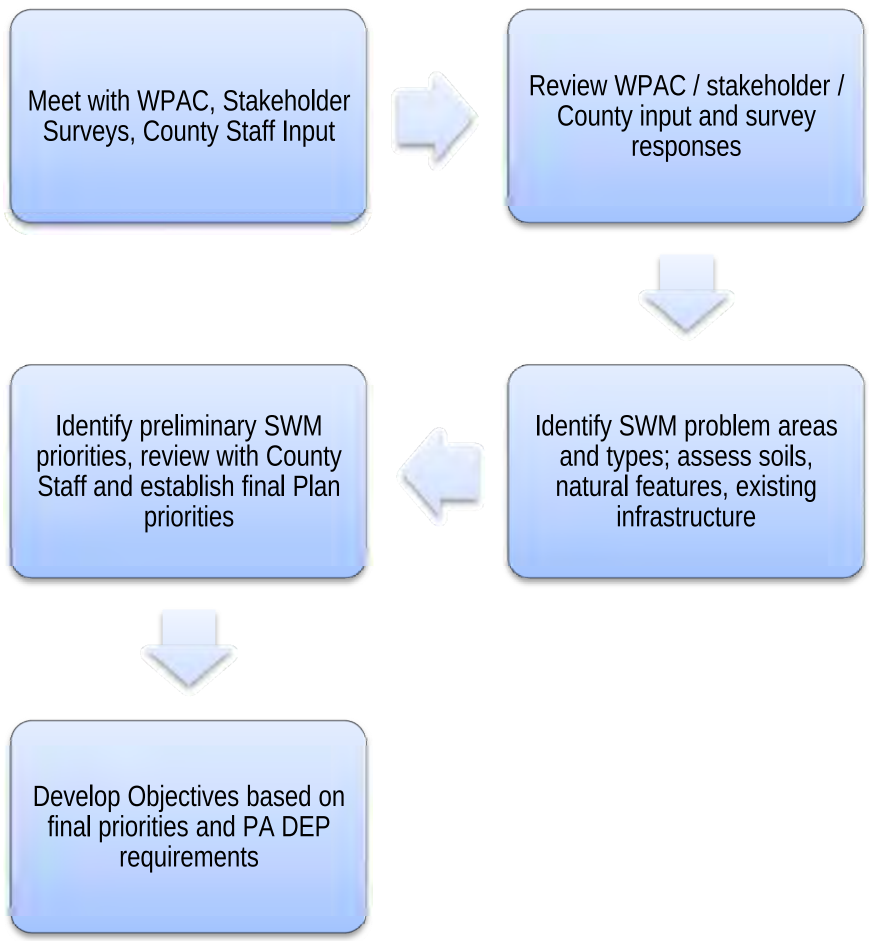


Figure I-2 Original Plan Objectives Setting Process

The final plan objectives for the current planning cycle take into account the Act 167 Program budget cuts and consequent cuts in funding for the Lawrence County Plan. These final objectives are based on the reduced funds available as well as the accelerated plan completion deadline. These changes forced a re-evaluation of the objectives for the current planning cycle, and the final plan objectives include the following:

1. Encourage planning and management of storm water runoff in each watershed that is consistent with sound water and land use practices (Act 167, Section 3).
2. Establish a comprehensive program of storm water management policy to help preserve and restore stream flood carrying capacity, to help preserve as much as possible the natural storm water runoff regimes and natural course, current and cross-section of waters of the Commonwealth; and to protect and conserve ground waters and ground-water recharge areas (Act 167, Section 3).
3. Establish local administration and management of storm water (Act 167, Section 3).
4. Prepare detailed hydrologic analyses of the following watersheds in order to evaluate more comprehensive approaches to stormwater management controls (as outlined in Table I-2):

Table I-2

Watershed	Rationale	Focus of Modeling Effort
Beaver/Mahoning River	Stream corridor flooding / obstruction(s), development pressure	Coffee Run subwatershed
	Development pressure	Marshall Run subwatershed

As noted above, these final plan objectives were determined by the County based on the amount of remaining funding available in the current state fiscal year for this planning project and based on the new plan approval deadline of June 30, 2010.

D. Stormwater Management Plan Strategy

Preferred Strategies:

1. Administrative / Policy
    a. Municipal adoption of the Model Ordinance language within this Plan.

       Municipalities may adopt a stand-alone ordinance, or may choose to incorporate the language within the Model Ordinance into their existing ordinances
    b. Municipal implementation and enforcement of the requirements of the Model Ordinance within this Plan. Specific implementation strategies are described in Section VII.
2. Technical (refer to technical discussion in Sections IV and V).
    a. Maintain groundwater recharge
    b. Maintain water quality
    c. Reduce channel erosion
    d. Manage overbank events

e. Manage extreme flood events

Alternative Strategies:

1. Administrative / Policy
    a. Municipal encouragement of clustered design practices to reduce overall development footprints
    b. Municipal or County support and funding of SWM BMP pilot projects for technical analysis as well as public education
    c. Public incentive programs related to Municipal-sponsored education activities
        i. Rain barrel programs
        ii. Public handbooks and technical guidance detailing residential BMP implementation
    d. The development of strategic partnerships between adjacent municipalities, key stakeholders and community interest groups.
2. Technical (refer to technical discussion in Sections IV and V).
    a. Correction of existing drainage problems – Individual problem corrections not addressed in the current plan due to additional technical analysis required. Refer to Section V for general discussion of non-achievable goals.
    b. Culvert retrofits – Individual retrofits not addressed in the current plan due to additional technical analysis required. Refer to Section V and the model ordinance for additional discussion of retrofits.
    c. Stormwater management basin retrofits - Individual retrofits not addressed in the current plan due to additional technical analysis required. Refer to Section V and the model ordinance for additional discussion of retrofits.
        i. Modification of outlet structures for additional outflow control
        ii. Combination of existing basin with new SWM BMPs
        iii. Addition of sediment forebays
        iv. Soil amendments for water quality
        v. Regrading/reshaping basin for more effective management and control of runoff
        vi. Incorporation of existing basins into surrounding landscaping to serve dual function of SWM practice and provide positive aesthetic and environmental habitat benefits
    d. Retrofit of existing landscaping and site design features - Individual retrofits not addressed in the current plan due to additional site investigation and technical analysis required. Refer to Section V and the model ordinance for additional discussion of retrofits.
        i. Modification of parking islands into bioretention areas
        ii. Replacement of impervious pavement/concrete with permeable paving and concrete
        iii. Modification of overflow parking areas into infiltration areas
        iv. Replacement of traditional tree planters to environmentally beneficial tree planter boxes in streetscape applications

SECTION II ACT 167

A. Stormwater Management Act 167

Recognizing the need to address the serious and growing problem of inadequate stormwater management, the Pennsylvania General Assembly enacted Act 167 of 1978. The statement of legislative findings at the beginning of the Pennsylvania Storm Water Management Act (Act 167) sums up the critical interrelationship among land development, accelerated runoff, and floodplain management. Specifically, this statement of legislative findings points out that:

1. Inadequate management of accelerated runoff of stormwater resulting from development throughout a watershed increases flood flows and velocity, 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 floodplain management and floodplain control efforts in downstream communities, reduces groundwater 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 their environment.

Until the enactment of Act 167, stormwater management had been oriented primarily towards addressing the increase in peak runoff rates discharging from individual land development sites to protect property immediately downstream. Management of stormwater throughout the state paid minimal attention to the effects on locations further downstream (frequently because they were located in another municipality) or to designing stormwater controls within the context of the entire watershed.

B. Purpose of the Study

Stormwater management has typically been regulated at the municipal level, with little or no design consistency (concerning the types or degree of storm runoff control to be practiced) between adjoining municipalities in the same watershed. Act 167 changed this approach by instituting a comprehensive program of watershed stormwater management planning. The Act requires Pennsylvania counties to prepare and adopt stormwater management plans for each designated watershed within the County. The County shall establish, in conjunction with each watershed storm water planning program, a watershed plan advisory committee composed of at least one representative from each municipality within the watershed, the County soil and water conservation district and such other agencies or groups as are necessary and proper to carry out the purposes of the committee. The plans are to provide uniform technical standards and criteria throughout the County's watersheds for the management of stormwater runoff, volume, and quality from new land development sites.

There also exists the opportunity for municipalities to retrofit existing sites to improve existing water quality impairments or existing sources of flooding problems. The types and degree of controls that are prescribed in the stormwater management plan must be based on the expected development pattern and hydrologic characteristics of each individual watershed. The standards and criteria contained within the plan are to be developed from the technical evaluations performed in the planning process in order to respond to the "cause and effect" nature of existing and potential storm runoff impacts in the watershed. The final product of the Act 167 watershed planning process is to be a comprehensive and practical implementation plan, developed with a firm sensitivity to the overall needs (e.g., financial, legal, political, technical, etc.) of the municipalities within Lawrence County.

SECTION III GENERAL DESCRIPTION OF WATERSHEDS

A. General County Description

Lawrence County covers 362 square miles and, according to the 2000 census, is ranked 29th out of the sixty-seven counties in Pennsylvania with a population of 94,643. The largest municipality in Lawrence County is the City of New Castle with a population of 28,334. Two townships in the New Castle vicinity follow with 8,373 people in Neshannock Township and 7,187 people in Shenango Township.

B. Political Jurisdictions

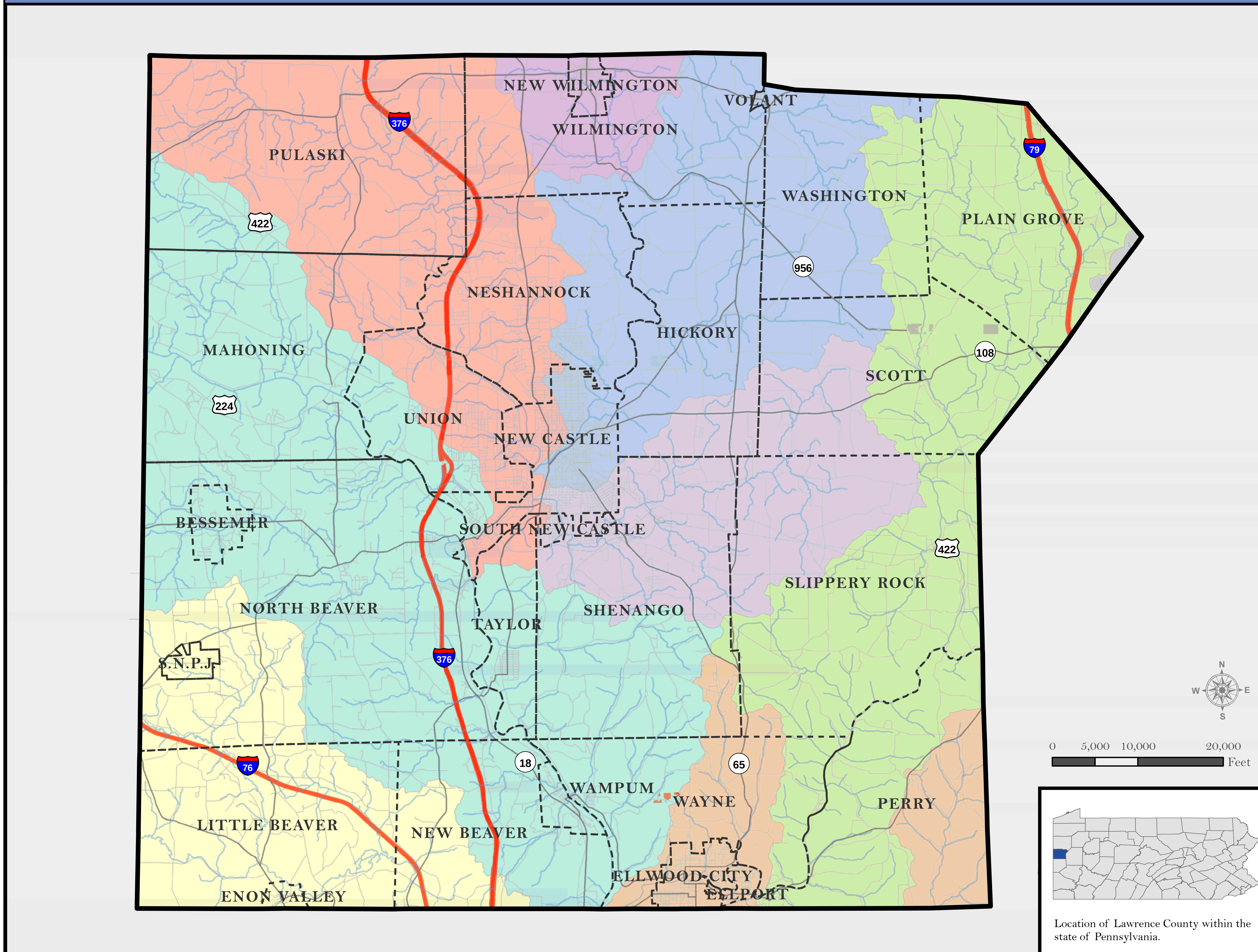
The County is comprised of twenty-seven municipalities. The political jurisdictions include sixteen townships, ten boroughs, and one city.

Table III-1

County Political Jurisdictions

Townships		Boroughs	Cities
Hickory	Taylor	Bessemer	New Castle
Little Beaver	Union	Ellport	
Mahoning	Washington	Ellwood City	
Neshannock	Wayne	Enon Valley	
North Beaver	Wilmington	New Beaver	
Perry		New Wilmington	
Plain Grove		S.N.P.J.	
Pulaski		South New Castle	
Scott		Volant	
Shenango		Wampum	
Slippery Rock			

Refer to Figure III-1 for a Base Map of Lawrence County.



Location of Lawrence County within the state of Pennsylvania.

Lawrence County

Stormwater Management Plan

Phase 2 Plan

FIGURE III-1

Base Map

- Lawrence County
- Municipal Boundary
- Stream

Other Features

- Interstate
- PA & US HWY
- Local Road

Watersheds

- Beaver River
- Big Run
- Connoquenessing Creek
- Little Beaver Creek
- Little Neshannock Creek
- Neshannock Creek
- Shenango River
- Slippery Rock Creek
- Wolf Creek

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Project Number: 08-1300-0135

File Location: G:\2008\Lawrence_County\ArcProjects\Phase 2_Figure III-1_BaseMap.mxd

C. NPDES Phase II Involvement

Ellwood City and Ellport Borough, and portions of Wayne and Perry Townships are included in the Pittsburgh Urbanized Area (UA) as designated by the U.S. Census 2000. Wayne and Perry Townships were granted waivers from the MS4 permitting requirements in 2003. Each municipality owning or operating a system of stormwater conveyance (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) within the designated UA is required to comply with the National Pollutant Discharge Elimination System (NPDES) Phase II requirements for operators of municipal separate storm sewer systems (MS4s), as specified by the U.S. Environmental Protection Agency (EPA). The City of New Castle is also classified as an MS-4 community.

NPDES Phase II requires owners of these MS4s to develop, implement, and enforce a stormwater management program designed to reduce the discharge of pollutants from their MS4s to the "maximum extent possible" to protect water quality. Each stormwater management program must address the following six minimum control measures (MCMs):

1. Public Education and Outreach
2. Public Participation / Involvement
3. Illicit Discharge Detection and Elimination (IDD&E)
4. Construction Site Runoff Control
5. Post-Construction Runoff Control
6. Pollution Prevention / Good Housekeeping

D. Data Collection

In order to evaluate hydrologic responses of the watersheds, data was collected on the physical features of the watersheds. Data collection varied depending on whether a hydrologic a detailed watershed model was to be developed and analyzed for a particular watershed.

1. Base Map: The base map was created using data from a variety of sources:

Data	Source
Designated watershed boundaries	PA DEP
USGS 1:24,000 Quadrangle Maps	USGS
Roads	The Pennsylvania Department of Transportation
Municipal and County Boundaries	The Pennsylvania Department of Transportation
Networked Streams	The Pennsylvania State University / Environmental Resources Research Institute

Data were reviewed against available aerial mapping and each other to check for consistency. Other various datasets were used for compilation of the GIS and stormwater models for analysis. A list of this additional information includes:

2. Topography: USGS digital raster graphic (DRG) formatted topographic maps (1:24,000, 7.5 minute quadrangles) were used to create a watershed-wide DRG. Corresponding 7.5-minute digital elevation models (DEM) were used to create a watershed-wide digital elevation model. Subwatersheds or subareas used in the watershed modeling process were derived from the watershed DEM using HEC-GeoHMS. Subareas, drainage courses, land slopes and lengths, and drainage element lengths and slopes were determined and calculated from the DEM using HEC-GeoHMS.

3. Soils: All soil data was obtained from the United States Department of Agriculture, Natural Resources Conservation Service (NRCS) in digital format. Generalized soils were obtained from the State Soil Geographic Database (STATSGO). STATSGO maps are statewide soil maps made by generalizing the detailed soil survey data. Soil mapping units with similar characteristics are grouped together. Data on hydrologic soil groups (HSG) was derived from the detailed Soil Survey Geographic Database (SSURGO) data. The spatial component of SSURGO data (the soil map) is provided as a GIS data layer. The attribute data (soil information) is provided as a relational Access database. Together the spatial data and relational database are referred to as National Soil Information System (NASIS) data. The NASIS data were processed to extract HSG classifications for the surface horizon of the soil-mapping units within the watershed.

4. Geology: The geology for the watershed was extracted from the statewide bedrock geology coverage produced by Pennsylvania Bureau of Topographic and Geologic Survey, Department of Conservation and Natural Resources (DCNR). The dataset obtained from the DCNR are not intended to be used at any scale finer than 1:250,000. The geology data are displayed for the watershed at a scale larger than 1:250,000. The geology information is provided for illustrative and general information only.

5. Land Cover: The land cover data was derived from the USGS National Land Cover Dataset. The National Land Cover Dataset (NLDC) was compiled from Landsat satellite TM imagery (circa 1992) with a spatial resolution of 30 meters and supplemented by various ancillary data (where available). The NLCD represents conditions in the early 1990s. This data is intended to provide a general overview of the watershed and to model stormwater runoff characteristics.

6. Wetlands: Wetlands were obtained from the United States Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) in digital format and incorporated into the overall GIS. NWI maps are compiled from photo interpreted aerial photography from the National Aerial Photography Program (NAPP) 1:40,000 Scale, and the National High Altitude Photography Program (NHAP) 1:58,000 or 1:80,000 Scale. Sources dates range from the 1970's to the present. The minimum mapping unit for treeless areas is 1/4 acres, 1 to 3 acres in general. The wetlands data is provided for illustrative purposes. Other wetland areas likely exist in the watershed that is not depicted on NWI maps.

7. Development in Floodplains: 100-year floodplain data, or special flood hazard areas, for Lawrence County was derived from the September 1996 Federal Emergency Management Agency (FEMA) National Flood Insurance Program Q3 Flood Data. The existing land cover was then clipped to these areas to depict the development in floodplains.

8. Obstructions: Bridges, culverts and pipes that convey streams and tributaries under roads, railroads and other similar infrastructure are referred to as obstructions. The obstruction locations and attribute information (size and shape) were determined during field investigations of the county and from Stakeholder Survey information.

9. Problem Areas: Stormwater problems include flooding, erosion, sedimentation, landslides, groundwater impacts, pollution and other potential issues. Data on the location of these problems in the watershed were collected from surveys sent to each municipality within the watersheds and incorporated into the watershed geodatabase. The municipalities were provided a topographic map of their township or borough and a collection of forms. They identified and plotted the locations of the known problem areas on paper maps or in digital format and completed the forms that describe the problems at each location

10. Stormwater Management Facilities: Stormwater management facilities may include detention/retention basins, underground storage and constructed wetlands. These types of facilities were also identified, plotted and described on forms by the municipalities.
11. Stormwater Sewer System Outfalls: Municipalities in urban areas (as defined by the US Census Bureau) are required to map the location of storm sewer outfalls as part of the PA DEP Municipal Separate Storm Sewer System (MS4) program. Based on budget and schedule restraints, appropriate outfall location information was not provided nor collected for Lawrence County. This data should be included in the next planning cycle.

E. General Development Patterns

The top ten municipalities in terms of subdivision activity over the twenty (20) year period studied for the latest Comprehensive Plan update are as follows:

1. Neshannock Township - 313 new lots
2. Slippery Rock Township - 235 new lots
3. Shenango Township - 201 new lots
4. North Beaver Township – 171 new lots
5. Wilmington Township - 158 new lots
6. Scott Township – 136 new lots
7. Pulaski Township – 130 new lots
8. Perry Township – 98 new lots
9. Hickory Township – 97 new lots
10. Mahoning Township – 93 new lots

Primary growth areas consist of those municipalities listed above, and include a new 1200-acre industrial park being planned for Neshannock Township. Major subdivisions are occurring in Union, Shenango, and Wayne townships.

Public water and sewer improvements are underway in Pulaski Township. The new infrastructure could induce development pressure, especially since this township is about equidistant from both Sharon and New Castle.

F. Physiography and Geology

Most of Lawrence County consists of undulating and rolling uplands, many poorly drained lowlands, rounded hills, and some steep ridges near the major streams. The southeast corner of Lawrence County consists primarily of rolling and hilly uplands and many narrow, steep-sided valleys. Here, the level and undulating areas are mainly on the broad ridge tops and in river valleys.

Elevations in the county range from a high of 1,440 feet just to the west of Slippery Rock Creek in Slippery Rock Township to a low of 740 feet at Rock Point where the Beaver River flows south out of the county in Wayne Township. Variations in aspect, slope, and elevation combine to create a number of different microenvironments throughout the county. Numerous soil types influenced by weathering of underlying bedrock, slope, organic material and climate and sometimes the bedrock itself create the ecological foundation for Lawrence County.

Lawrence County is divided into two geologic provinces. The Pittsburgh glaciated plateau prominently covers about 4/5 of the county. The un-glaciated Pittsburgh Plateau covers the rest of the county in the southeast delineated roughly by Slippery Rock Creek and Connoquenessing Creek. The underlying bedrock of the county is divided into four groups: the Pocono group underlies the steep slopes of the upper Mahoning and Shenango Rivers, and the Pottsville Group, Allegheny Group, and the Conemaugh Formation underlie the rest of the county.

Refer to Figure III-2 for a general geology map of Lawrence County.

G. Climate

Winters are cold and snowy at high elevations in the County. It is also frequently cold in the valleys, but intermittent thaws preclude a long-lasting snow cover. Summers are fairly warm on mountain slopes and very warm with occasional very hot days in the valleys. Rainfall is evenly distributed throughout the year, but it is appreciably heavier on the windward, west- facing slopes than in the valleys. Normal annual precipitation is adequate for all crops, although summer temperature and growing season length, particularly at higher elevations, may be inadequate.

In winter, the average temperature is 30 degrees F, and the average daily minimum temperature is 21 degrees. The lowest temperature on record, which occurred at New Castle on January 29, 1963, is -23 degrees. In summer, the average temperature is 70 degrees, and the average daily maximum temperature is 80 degrees. The highest recorded temperature, which occurred at New Castle on September 2, 1953, is 100 degrees.

The total annual precipitation is 38 inches. Of this, 22 inches, or 60 percent, usually falls in April through September, but in 2 years out of 10, the rainfall in April through September is less than 17 inches. The heaviest 1-day rainfall during the period of record was 3.70 inches at New Castle on October 16, 1954. Thunderstorms occur on about 36 days each year, and most occur in summer. Heavy rains, which occur at any time of the year, and severe thunderstorms in summer sometimes cause flash flooding, particularly in narrow valleys.

Average seasonal snowfall is 38 inches. The greatest snow depth at any one time during the period of record was 19 inches. On an average of 24 days, at least 1 inch of snow is on the ground. The number of such days varies greatly from year to year.

The average relative humidity in mid-afternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 60 percent of the time possible in summer and 35 percent in winter. The prevailing wind is from the southwest. Average wind- speed of 12 miles per hour is highest in winter.

H. Soils

Soil properties influence the runoff generation process. The USDA, Natural Resources Conservation Service (NRCS) has established a criterion determining how soils will affect runoff by placing all surface horizon soils into four Hydrologic Soil Groups (HSGs) – A through D, based on infiltration rate and depth. Hydrologic soil group A characteristics, which have a high infiltration rate and therefore low runoff potential, are found sporadically throughout Lawrence County. The majority of the surface horizon soils in the watershed fall in Group B and C. Group B is characterized as having moderate infiltration rates, and it consists primarily of moderately deep to deep, moderately well to well drained soils that exhibit a moderate rate of water transmission. Group C soils have slow infiltration rates when thoroughly wetted and contain fragipans, a layer that impedes downward movement of water and produces a slow rate of water transmission. Found throughout the watershed, D soils are tight, low permeable soils with high runoff potential and are typically clay soils.

Soils in the Pittsburgh Plateau section of Lawrence County are part of the Gilpin-Wharton-Wiekert Association. These level to steep soils, are well drained and formed in the residual material from acid shale, siltstone and sandstone.

Many different associations cover the glaciated part of the county. The Conotton-Chili-Holly association underlies the major rivers and streams, such as the Beaver, Shenango and Mahoning Rivers and North Fork Little Beaver and Slippery Rock Creeks. These soils formed from glacial outwash and alluvium and range from level to very steep, and from excessively drained to poorly drained.

The Ravenna-Canfield-Frenchtown and Canfield-Ravenna-Loudonville associations underlie the uplands. Both of these soils associations are formed in glacial till and range from level to very steep, and well drained to poorly drained. Plain Grove Township contains a small area of the Candice-Frenchtown-Holly Association formed from glacial lake sediment.

More descriptive breakdowns of each soil in the series can be found below. See soil map for additional information and location on the soils types.

Canadice Series: Soils of the Canadice Series are fine illitic, mesic type Ochraqualfs. They are deep and poorly drained and can be found on lake plains and along stream valleys. They were formed in glacial lake settlements. They range in slope between 0 and 3 percent. They have very slow permeability.

Conotton Series: Soils of the Conotton series are loamy skeletal mixed mesic type Hapludults. They are deep well drained, and somewhat excessively drained soils. The slope range is 3 to 50 percent. The saturated hydraulic conductivity is high is the mineral surface and high to very high in the subsoil and substratum.

Chili Series: Soils of the chili series are fine-loamy, mixed, mesic typic hapludalfs. They are deep and well-drained soils. The slope range is between 3 and 15 percent. The permeability is moderately rapid in the subsoil and rapid in the substratum.

Canfield Series: The Canfield series is made up of fine-loamy mixed mesic Aquic fragidaulfs. They are deep, moderately well drained soils and knolls and rides that were formed in glacial till material. The slope range is 3 to 25 percent. The permeability is moderate above the fragipan and slow within the fragipan.

Gilpin Series: Soils of the Gilpin series are fine-loamy mixed mesic typic Hapludults. They are moderately deep, well-drained soils on ridges and hillsides formed in residual material formed from acid shale and siltstone and they have a slope range of 3 to 70 percent. It has moderate permeability.

Frenchtown Series: Soils of the Frenchtown series are fine-loamy mixed mesic typic Fragiqualfs. They are deep, poorly drained soils on till plains and in minor drainageways and were formed in glacial till material. The slope range is 0 to 8 percent. The have moderate permeability above the fragipan and slow or very slow permeability within the fragipan.

Holly Series: Soils of the Holly series are fine-loamy, mixed non-acid, mesic type fluvaquents. They are deep, poorly drained soils on flood plains formed in alluvial material derived from glaciated uplands. Their slope range is between 0 and 3 percent.

Ravenna Series: Soils of the Ravenna series are fine-loamy mixed mesic aeric fragiqualfs. They are deep, somewhat poorly drained, nearly level and undulating soils on till plains formed in glacial till material. The slope range is 0 to 15 percent. The permeability is moderate above the fragipan and slow within the fragipan.

Loudonville Series: Soils of the Loudonville series are fine-loamy mixed mesic Ultic Hapludalfs. They are moderately deep and well drained soils that were formed in glacial till and in material from siltstone or shale bedrock. They have moderate permeability.

Wharton Series: Soils of the Wharton series are fine-loamy, mixed mesic Aquic Hapludults. They are deep and moderately well drained soils. They are found on broad ridge tops and side slopes. They were formed in residual material from interbedded acid shale and siltstone. The slope range is 0 to 25 percent. The permeability is slow to moderately slow.

Weikert Series: Soils of the Weikert Series are loamy-skeletal, mixed, mesic Lithic Dystrochrepts. They are shallow, well-drained soils on ridges and hillsides and were formed in residual material from interbedded acid shale, siltstone and some sandstone. The slope range is 3 to 80 percent. They have moderately rapid permeability.

County soils are shown in Figure III-3.

I. Water Resources

Various river and stream valleys cut through the landscape of Lawrence County. All of these either form or are tributaries to the Beaver River except for North Fork Little Beaver Creek, which flows directly to the Ohio River.

See Figure III-4 for watershed locations.

Slippery Rock Creek/Conoquenessing Creek Watersheds:

Connoquenessing Creek, a cold water fishery (with a very minor portion classified as a warm water stream), begins in northern Butler County and drains 838 square miles. The creek flows through only a small section of Lawrence County, but picks up a major tributary, Slippery Rock Creek in the process. Connoquenessing Creek is considered the second most polluted waterway in the United States, primarily due to the pollution from AK Steel. Other pollution comes from more typical sources such as agricultural runoff, sewage and siltation.

Slippery Rock Creek starts in Butler County, drains 836 square miles and flows for forty-seven miles to Connoquenessing Creek. It is classed as a cold-water fishery. Tributaries to the creek include Wolf Creek, Muddy Creek, Skunk Run, Grindstone Run, Hell Run and Taylor Run.

Hell Run is the only exceptional value (EV) stream in the county. It begins in Shenango Township, drains 6 square miles and has a main branch length of 4.7 miles.

The upper sections of Slippery Rock Creek are affected by acid mine drainage (AMD), but current efforts by the Slippery Rock Watershed Coalition are underway to remediate the AMD. This is helping to improve the water quality in Lawrence County. Other problems include non-point siltation and light bank erosion.

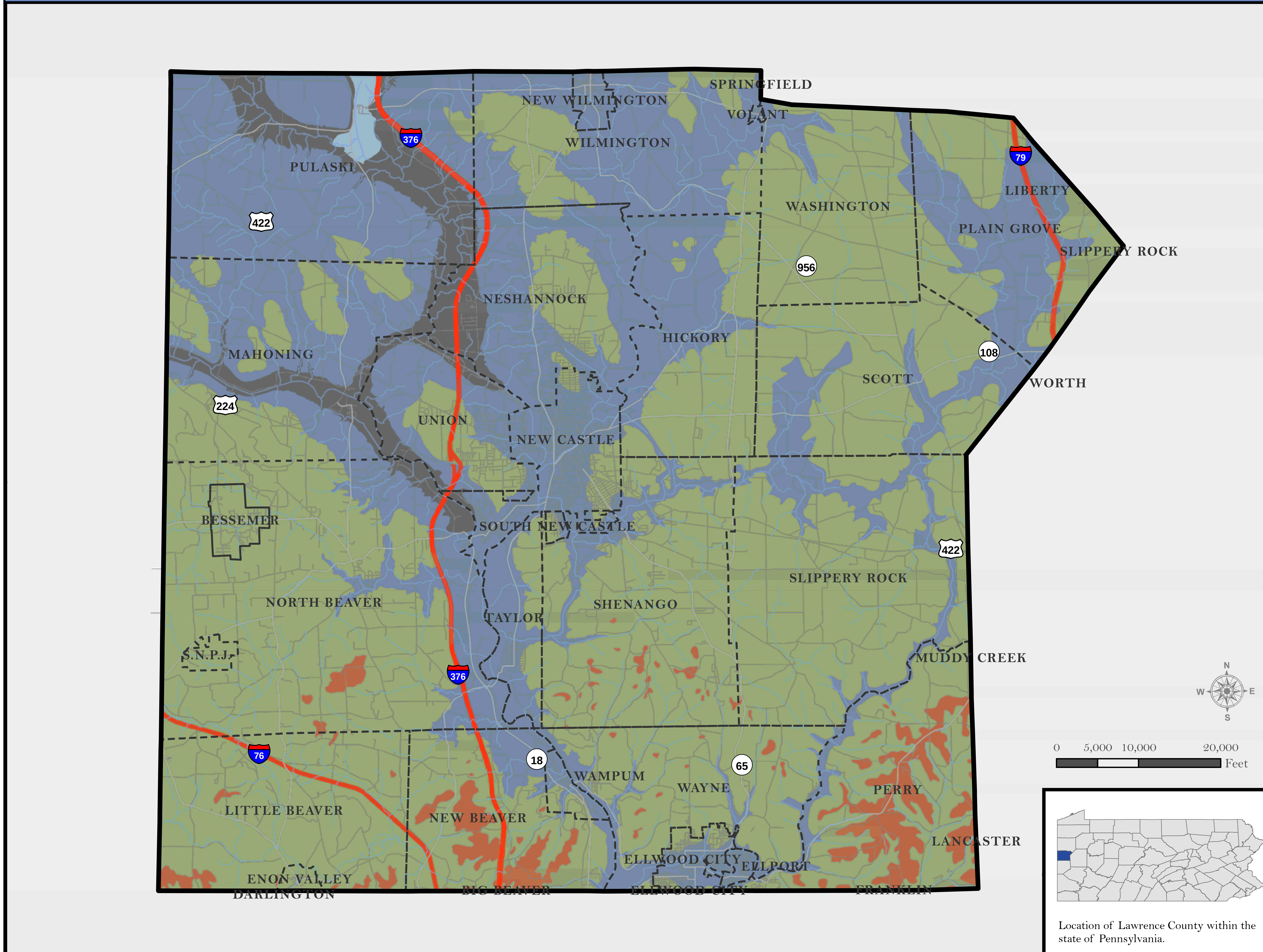
Lawrence County

Stormwater Management Plan

Phase 2 Plan

FIGURE III-2

Geology



Lawrence County

Municipal Boundary

Stream

Other Features

Interstate

PA & US HWY

Local Road

Bedrock

Glenshaw Formation

Allegheny Formation

Pottsville Formation

Cuyahoga Group

Shenango Formation

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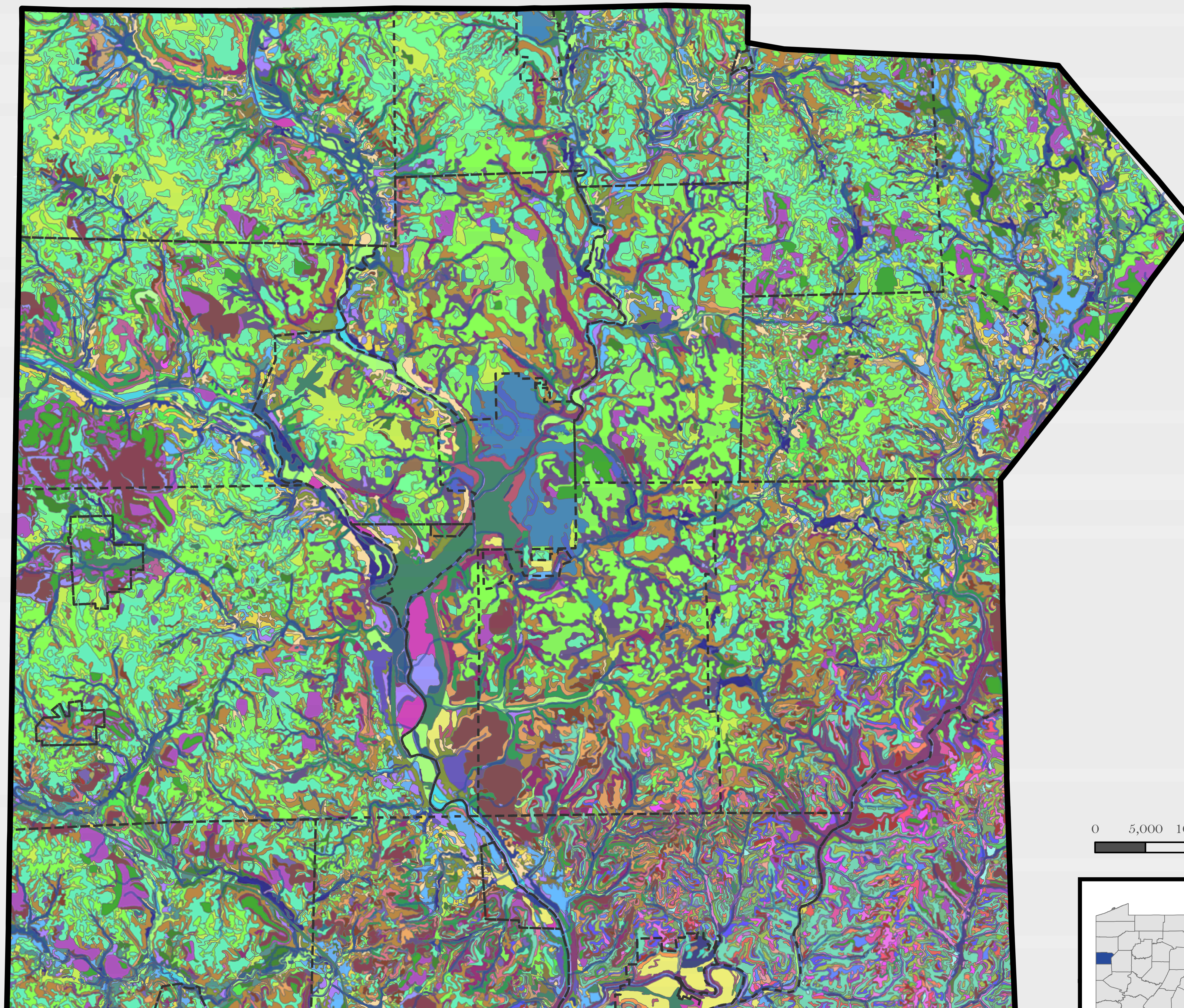
Lawrence County

Stormwater Management Plan

Phase 2 Plan

FIGURE III-3

County Soils



AgB	ChC	FnA	Lb	TsB	UwB
AgC	CmB	FnB	LoB	TsC	UwD
At	CmC	GnB	LoC	TyA	W
BcB	CmD	GnC	LoD	TyB	WeF
BcC	CoB	GnD	LoF	UAD	WhA
BkB	CoC	GsB	MoA	UaB	WhB
BkC	CoD	GsC	MoB	UaD	WhC
Ca	CoF	GsD	MoC	UaE	WnD
CdB	CuB	GsF	Ph	Ub	WoB
CdC	CuC	GtB	Pn	UcB	WoC
CdD	CuD	GtC	Po	UcD	WoD
CeB	Du	GvC	RaA	UfB	
CeC	ErB	HaB	RaB	UfD	
CeD	ErC	HaC	RaC	UgB	
Cg	ErD	HaD	ReB	UgD	
ChB	EsD	Ho	Sn	UnK	

N W E S

0 5,000 10,000 20,000 Feet

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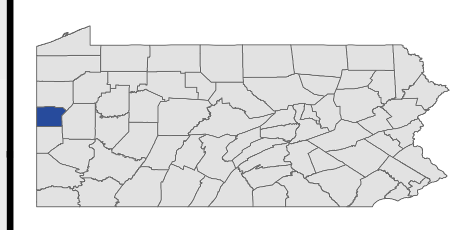

Location of Lawrence County within the state of Pennsylvania.

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Shenango/Mahoning/Beaver River Watersheds:

The Mahoning River, also classified as a warm water stream, begins about 10 miles southeast of Alliance, Ohio, and flows through Pennsylvania for about 11 miles. The Mahoning River has been described as "one of the most polluted of any stream or river in Ohio" (OH EPA 1994), with the most polluted stretch located just downstream of Youngstown, Ohio. Dilution of the water makes the Pennsylvania section a little less polluted, but the sediment remains more contaminated than that found in Presque Isle Bay of Lake Erie. The Mahoning River's effects spread downstream into the Beaver River (see Beaver River description).

Major tributaries to the Mahoning River in Lawrence County include Coffee Run flowing from the north and Hickory Run, which joins the Mahoning River near the confluence of the Mahoning River and the Shenango River.

The Shenango River has its origin in Conneaut Township of Crawford County and flows more than 87 miles to its confluence with the Mahoning River to form the Beaver River. The drainage area is 1,062 square miles, of which 283 square miles are in Ohio (180,916 acres) and 779 square miles are in Pennsylvania (498,000 acres). The lower section from Shenango Lake to the Mahoning River confluence is considered the worse section. This section, in addition to receiving the pollutants from further upstream has effluents from industry, wastewater treatment plants and urban development.

Major tributaries of the Shenango River in Lawrence County include Neshannock Creek, Hottenbaugh Run, Big Run and Deer Creek. Neshannock Creek is discussed in its own section because of its size.

North Fork Little Beaver Creek:

North Fork Little Beaver Creek originates just north of New Springfield, Ohio, approximately 4.6 miles west of the Ohio-Pennsylvania border. Classed as a High quality-coldwater fishery, Little Beaver Creek flows for 30.6 miles to the Ohio River. This stream has numerous strip mines surrounding it in the upper reaches, and most of the mine drainage into the stream is alkaline. This AMD combined with the farm runoff contributes to water that has a high hardness and conductivity. Some industrial and municipal sewage discharges also affect water quality.

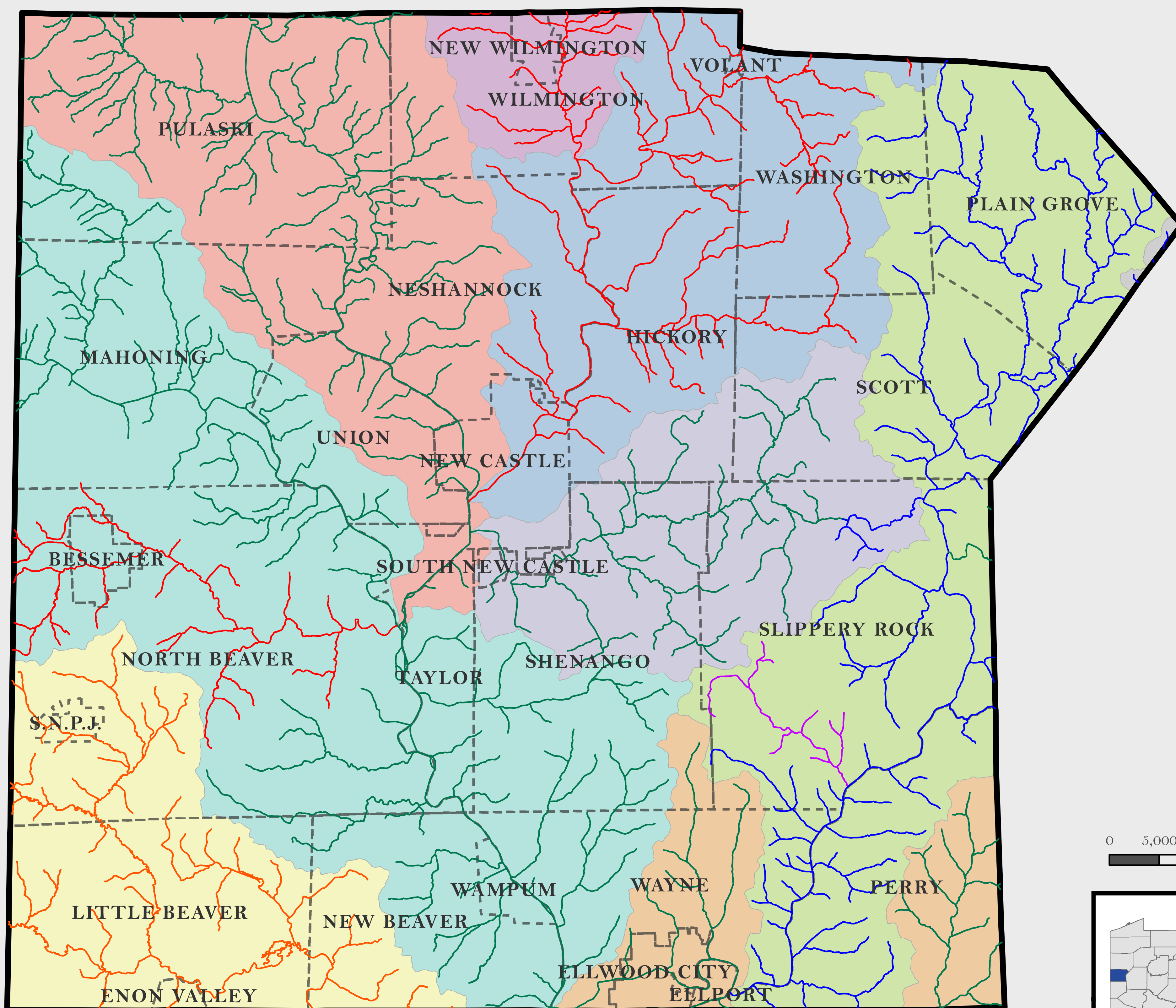
Honey Creek, the only major tributary to North Fork Little Beaver Creek in Lawrence County, joins upstream of Enon Valley Borough.

Designated Act 167 watersheds in Lawrence County include:

Beaver/Mahoning River
Shenango River
Little Beaver Creek
Conoquenessing Creek
Slippery Rock Creek
Neshannock Creek
Little Neshannock Creek

Lawrence County
Stormwater Management Plan
Phase 2 Plan

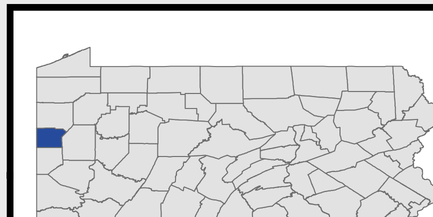
FIGURE III-4
Hydrology



Cold Water Fishes
Exceptional Value
High Quality Cold Water Fishes
Trout Stocking
Warm Water Fishes
Lawrence County
Municipal Boundary

Act 167 Watersheds

Beaver River
Big Run
Connoquenessing Creek
Little Beaver Creek
Little Neshannock Creek
Neshannock Creek
Shenango River
Slippery Rock Creek
Wolf Creek



Location of Lawrence County within the state of Pennsylvania.

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J. PA Chapter 93 Stream Classifications

Current (2008) PA Chapter 93 stream water quality classifications are shown on Figure III-4. A summary table of the streams in Lawrence County based on this data is presented below:

Table III-2

County Chapter 93 Stream Classification Summary

Classification	County Stream Miles	Percentage of Overall
Exceptional Value (EV)	8.99	1.3%
High Quality (HQ) Cold Water Fishery (CWF)	66.87	9.9%
Cold Water Fishery (CWF)	115.96	17.2%
Warm Water Fishery (WWF)	350.97	52.1%
Trout Stocking Fishery (TSF)	130.35	19.4%

K. Obstructions

Locations of significant waterway obstructions (i.e., culverts, bridges, etc.) were obtained by a number of methods. Methods used to properly verify the presence and to further address the integrity of the obstructions included:

1. Inspection of the United States Geologic Survey (USGS) topographic base mapping
2. Data from the Pennsylvania Department of Transportation (PADOT)
3. FEMA Flood Insurance Studies
4. Phase 1 Stormwater Problem Area survey results
5. Field verification work

The field verification portion of the project was completed by County Planning and the engineering Consultant. Using GIS data from the above sources, mapping was created from the direct intersection of roadway data and stream data. These intersections would indicate the likely location of a culvert or bridge structure. Field crews were then assigned to visually inspect and assess as many of the known structures as possible, as well as additional unknown structures that were discovered during the fieldwork. The type of information that was obtained through the field investigations were:

1. Verification that the structure is present
2. Type of structure
3. Physical characteristics and dimensions of structure
    a. Diameter/opening width
    b. Depth from thalweg of channel to top of opening or crown of pipe
    c. Depth from pipe crown or top of opening to approximate crown of road above
    d. Bridge piers and abutments
    e. Pipe/bridge material

4. Structural condition of structure
5. Observed deficiencies with the structure
    a. Damaged pipe or bridge
    b. Siltation/sedimentation
    c. Evidence of insufficient capacity (visual evidence of overtopping)
6. Photographs documenting structure

The field data that was collected at each structure was recorded on field survey forms that can be found in Volume III of the Plan.

The most common deficiencies discovered during field investigations were structural problems with the pipe/bridge and sedimentation at pipes and bridges. A significant number of structures have some form of structural damage. Damages most often included corroded or missing portions of pipe barrels, partially or near complete crushing of pipe barrels, occasional occurrences of spalling at bridges, reduced flow area (e.g. due to debris within pipe or opening) and damaged appurtenances (e.g. damaged or missing head/end walls). Sedimentation problems were also identified in a number of areas.

Any structure determined to be less than 18 inches in diameter was excluded from the field survey operations. Such structures were omitted from field collection activities due to the time constraints required to determine their locations and assess their physical and flow conveyance capabilities.

Based upon the limitations of the project due to the reduction in scope and schedule, obstruction hydraulic capacity calculations were not performed. Consequently, capacity calculations for the obstructions are not included as part of this plan. Plan updates should address capacity issues based upon the included field data in the appendix.

L. Dams and Impoundments

Existing dam locations are shown on Figure III-5 and are listed below. This list includes permitted PADEP dams, a United State Army Corps of Engineers dam, and two PA Fish and Boat Commission run-of-river dams.

Table III-3

Dams and Impoundments

Dam Number	Dam Name	Stream Name	Municipality
37-004	McConnell	Hettenbaugh Run	Hickory Township
37-011	Upper	Big Run	Shenango Township
37-012	Lower	Big Run	Shenango Township
37-016	Unnamed	Big Run	Shenango Township
37-019	McConnells Mill	Slippery Rock Creek	Slippery Rock Township
37-020	Kennedy Mill	Slippery Rock Creek	Slippery Rock Township
37-022	Volant Mill	Neshannock Creek	Washington Township
37-028	Boyer Dam	Eckles Run	New Beaver Borough
37-031	Fairless Murray	Slippery Rock Creek	Wayne Township

Table III-3

Dams and Impoundments

Dam Number	Dam Name	Stream Name	Municipality
37-032	Sarah Heinz House	Slippery Rock Creek	Wayne Township
37-039	Castleview Lower	Tr Shenango River	Neshannock Township
37-051	Unnamed Dam	Beaver River	Taylor Township
37-053	Mohawk Trails	Tr Mahoning River	Mahoning Township
37-054	Slippery Rock Dam - Wortemburg Pump	Slippery Rock Creek	Perry Township
37-055	Slovene Camp Dam	Tr Sugar Creek	North Beaver Township
37-056	Detention Basin No 1 (Section 43)	Tr Beaver River	North Beaver Township
37-057	Detention Basin No 3 (Section 43)	Tr Wampum Run	New Beaver Borough
37-058	Detention Basin No 4 (Section 43)	Tr Eckles Run	New Beaver Borough
37-059	Detention Basin No 8 (Section 43)	Tr Eckles Run	New Beaver Borough
37-060	Detention Basin No 6 (Section 44)	Tr Mahoning River	North Beaver Township
37-061	Fisher	Tr Hottenbaugh Run	Hickory Township
37-062	Reeher	Tr Neshannock Creek	Hickory Township
37-063	Unnamed	Tr Shenago River	Neshannock Township
37-064	Castleview Upper	Tr Shenango River	Neshannock Township
37-065	Castleview Middle	Tr Shenango River	Neshannock Township

M. Pollution and Stream Impairments

Table III-4 shows a summary of non-attaining segments of the Streams Integrated List representing stream assessments for the Clean Water Act Section 305(b) reporting and Section 303(d) listing.[1] PA DEP protects four (4) stream water uses: aquatic life, fish consumption, potable water supply, and recreation. If a stream segment is not attaining any one of its four uses, it is considered impaired. Based on the 303(d) data, the total number of impaired stream miles in Lawrence County caused by stormwater or urban runoff is approximately 62 miles.

[1] PA DEP Office of Water Management, Bureau of Water Supply & Wastewater Management, Water Quality Assessment and Standards Division, 2010

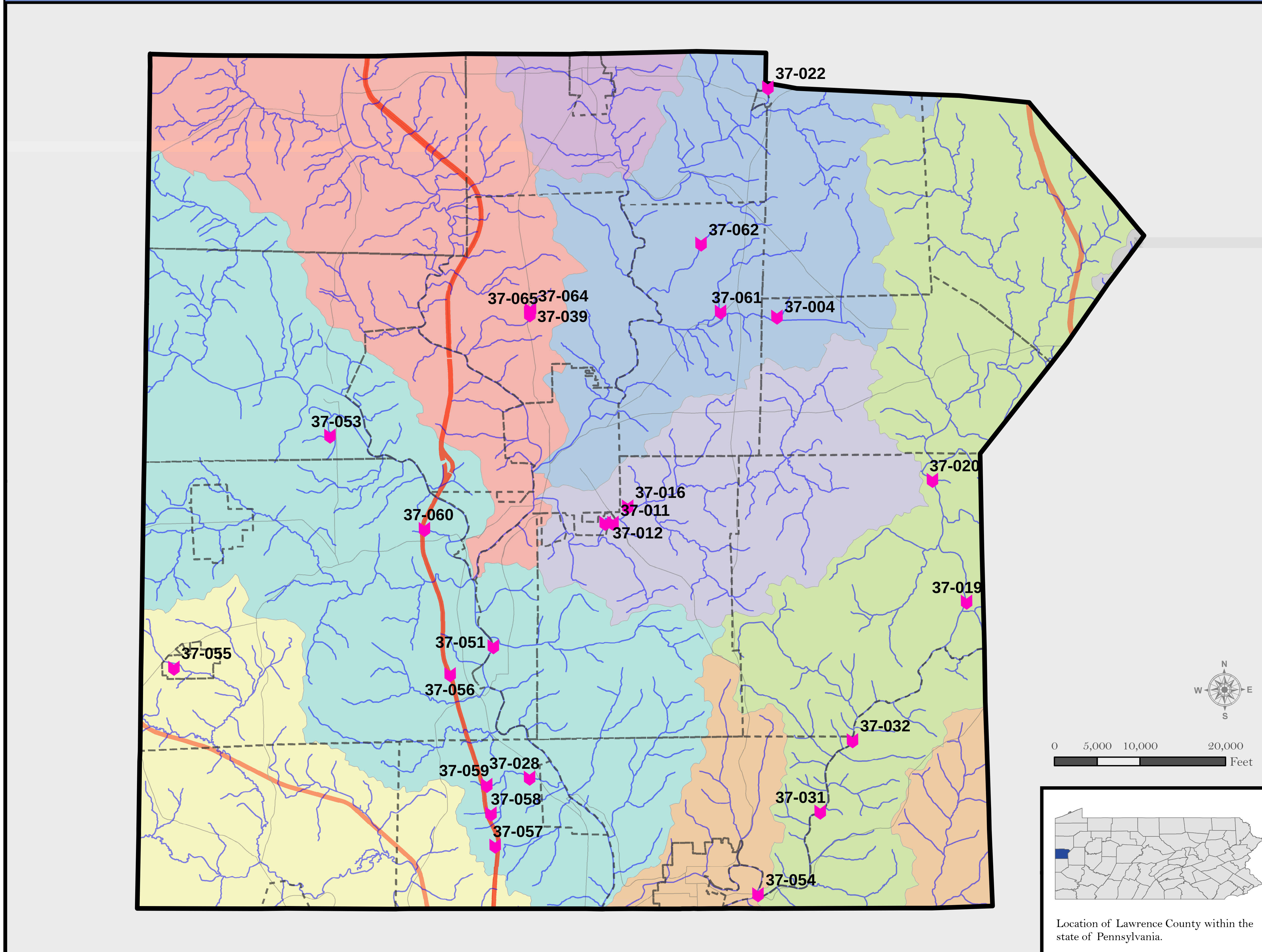
Lawrence County

Stormwater Management Plan

Phase 2 Plan

FIGURE III-5

Dams



Dams
Lawrence County
Municipal Boundary
Stream

Watersheds

- Beaver River
- Big Run
- Connoquenessing Creek
- Little Beaver Creek
- Little Neshannock Creek
- Neshannock Creek
- Shenango River
- Slippery Rock Creek
- Wolf Creek

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Table III-4

Non-attaining Impaired Stream Lengths

Impairment Source - Impairment Cause	Total (miles)
Abandoned Mine Drainage - Metals	16.17
Abandoned Mine Drainage - Metals ; Abandoned Mine Drainage - pH	0.61
Abandoned Mine Drainage - Metals ; Agriculture - Nutrients	12.66
Abandoned Mine Drainage - Metals ; Agriculture - Siltation	16.39
Abandoned Mine Drainage - Metals ; Road Runoff - Siltation	0.71
Abandoned Mine Drainage - Metals ; Urban Runoff/Storm Sewers - Siltation	2.51
Agriculture - Nutrients	3.08
Agriculture - Nutrients ; Abandoned Mine Drainage - Metals	5.44
Agriculture - Pathogens	2.99
Agriculture - Siltation	3.07
Agriculture - Siltation ; Agriculture - Nutrients	5.64
Channelization - Flow Alterations ; Road Runoff - Water/Flow Variability	2.60
Erosion from Derelict Land - Siltation	0.99
Grazing Related Agric - Siltation ; Animal Feeding Agric - Nutrients	1.18
Other - Nutrients ; Other - Metals	12.85
Package Plants - Nutrients	2.68
Package Plants - Unionized Ammonia	1.58
Road Runoff - Siltation	3.90
Road Runoff - Siltation ; Road Runoff - Metals	2.22
Source Unknown - Cause Unknown	24.99
Source Unknown - Pathogens	9.77
Source Unknown - PCB	20.74
Source Unknown - PCB ; Source Unknown - Chlordane	17.26
Surface Mining - Siltation	0.95
Urban Runoff/Storm Sewers - Cause Unknown	5.78
Urban Runoff/Storm Sewers - Nutrients	2.88
Urban Runoff/Storm Sewers - Siltation	1.60
Urban Runoff/Storm Sewers - Siltation ; Abandoned Mine Drainage - Metals	11.48
Urban Runoff/Storm Sewers - Siltation ; Urban Runoff/Storm Sewers - Nutrients	0.84
Total Impaired Stream Miles:	193.57

Additional discussion and detailed information pertaining to pollution and stream impairments are discussed in the water quality portions of the Plan.

N. Stormwater Problem Areas

Through analysis of survey results received from the County municipalities, it was determined that the three primary stormwater problem types are street flooding, property flooding, and stream corridor flooding.

More detailed information pertaining to problem areas and possible solution strategies are discussed later in this plan. While it is the initial intent of the Plan to focus on the primary stormwater problems identified above, the planning effort will also include further refinement and prioritization of stormwater problem solutions and strategies. Existing and potential problems caused by excessive stormwater runoff or pollution issues are indentified and addressed throughout the Plan. The Plan provides solutions and techniques to help better manage and mitigate existing problems and prevent future problems through proper management techniques and technologies. The problems identified in this section were further combined with other known issues within the County and then used to form the technological approach (discussed later in the Plan) for addressing the specific types of problems the County encounters.

The causes for the problems described above and listed on Figure III-6 range from increases in stormwater volume and velocity, inadequate infrastructure, obstructed waterways, AMD, excessive floodplain development, and illicit discharges. Refer to Figure III-7 for the location of problem causes.

A summary of the survey results indicating the types, frequency, and related severity of damage related to stormwater problems are shown in the table below:

Table III-5

Stormwater Management Problem Areas Identified in Survey

ID	Municipality	Problem Type	Problem Cause	Problem Frequency	Damage Type	Description / Comments
1	Ellwood City	8	1	2	3	Open storm culvert causing erosion
2	Ellwood City	8	1	2	3	Bank and yard erosion with debris accumulation. Possible AMD
3	Ellwood City	5	1	1	2	Ewing Park combined sewer system that is old
4	Ellwood City	8	1	2	3	Barry's run
5	Ellwood City	8	1	2	3	Bridge St. Run. Also possible AMD from Wayne TWP.
6	Ellwood City	5	-	-	2	WWTP storm steps. Old stormwater outfall is deteriorating.
55	Mahoning	1,2	-	-	-	Flooding in Edinburg, Coffee Run prior to entering Mahoning
37	New Beaver	3	1,6	1	-	Private road-Freed's camp
38	New Beaver	2	1	1	-	Haggerty Road

Table III-5

Stormwater Management Problem Areas Identified in Survey

ID	Municipality	Problem Type	Problem Cause	Problem Frequency	Damage Type	Description / Comments
39	New Beaver	2	1	1	-	Glenkirk Rd.
40	New Beaver	3,8	1	1	-	McBride Rd
41	New Beaver	2	1	1	-	Mallory Rd.
42	New Beaver	1,2	1	1	-	Possum Hollow Run
32	New Castle	8	1	1	2	-
33	New Castle	13	1,5	3	2	-
34	New Castle	2,3	1	4	2	-
35	New Castle	2,3	1	3	2	-
36	New Castle	8,2	1	1	2	-
11	North Beaver	1	1	-	2	Mallory/Halltown Rd.
14	North Beaver	1	1	-	2	Galilec/Wampum Rd.
15	North Beaver	1	1	-	2	Willow Grove
16	North Beaver	3	3	-	2	Jackson Knolls
17	North Beaver	1,3	1,3	-	2	Hickory View
18	North Beaver	3	1	-	2	Westfield Rd/Pond overflow
19	North Beaver	1	1	-	2	Moravia Rd.
20	North Beaver	1	1	-	2	Moravia Rd.
21	North Beaver	1	1	-	2	Moravia/Musser Rd
22	North Beaver	1	1	-	2	McClain Rd
25	North Beaver	1	1	-	2	Enon Rd./culvert
26	North Beaver	1	1	-	2	Smalls Ferry Rd
27	North Beaver	2,3	1,3	-	2	Smalls Ferry/Columbiana Rd.
28	North Beaver	1,3	1	-	2	East Beechwood Rd
29	North Beaver	1,3	1,5	-	2	Len Ann Dr.
30	North Beaver	2,3	1	-	2	Covert Rd./run off from Rt. 60 overpass

Table III-5

Stormwater Management Problem Areas Identified in Survey

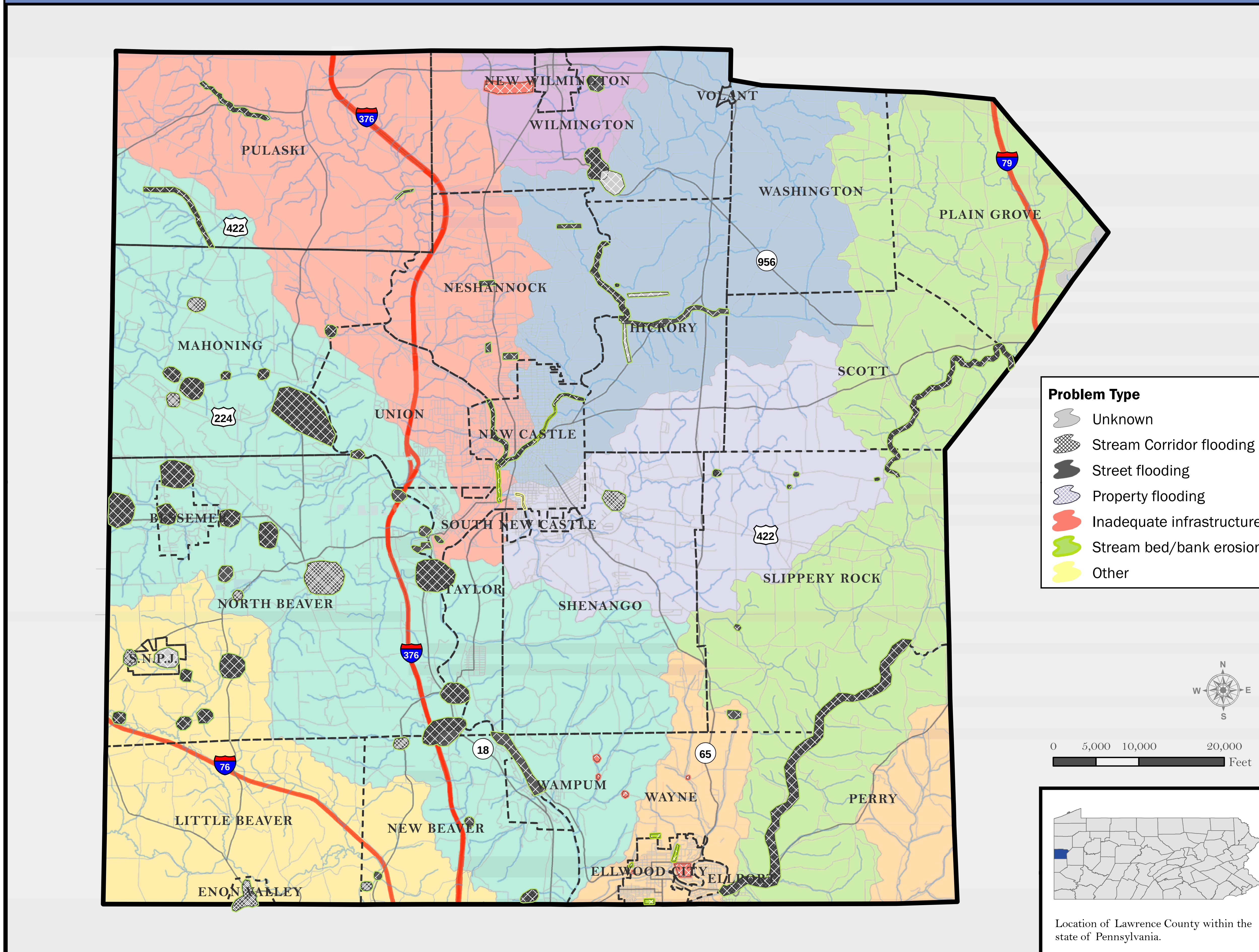
ID	Municipality	Problem Type	Problem Cause	Problem Frequency	Damage Type	Description / Comments
31	North Beaver	2	1,3	-	2	Mt. Jackson Rd./Mahoning Town swamp overflow
43	Pulaski	2	-	-	-	Prone to flooding
44	Pulaski	1	-	-	-	Prone to flooding
23	SNPJ	-	1	-	2	SNPJ surface water washed out culverts
24	SNPJ	3	1	-	2	SNPJ lake overflow
45	Wayne	5	3	1	-	Friday Hill Rd
46	Wayne	5	1	1	-	Smiley Stop
47	Wayne	5	1	4	-	Green House Rd
48	Wayne	5	1	4	-	Green House Rd
49	Wilmington	1	-	4	3	Little Neshannock Creek floods when we get lots of rain
50	Wilmington	2	1	1	-	Riding stable area, floods road and basements
51	Wilmington	-	-	-	-	Big Neshannock Creek
52	Wilmington	5	5	4	-	Beechwood Rd. 3ft culvert plugs up and needs replaced

Description Codes

Problem Type:	Description:	Problem Frequency:	Description:
1	Stream corridor flooding	1	Occurs > 1 per year
2	Street flooding	2	Occurs every 1 to 3 years
3	Property flooding	3	Occurs every 4 to 8 years
4	Surface water pollution	4	Occurs during flood events
5	Inadequate infrastructure		
6	Accelerated soil erosion		
7	Sediment in streams		
8	Stream bed/bank erosion		
9	Storm sewer outfall erosion		
10	Habitat/water resources loss or damage		
11	Other		
Problem Cause:	**Description:**	**Damage Type:**	**Description**
1	Increase in the amount of stormwater (volume)	1	Loss of life
2	Velocity of stormwater	2	Loss of vital services
3	Poor drainage	3	Property damage
4	Discharge location (direction of flow)		
5	Water obstructions		
6	Floodplain development		
7	Other		

Lawrence County
Stormwater Management Plan
Phase 2 Plan

FIGURE III-6
Problem Areas: Problem Types



Watersheds

- Beaver River
- Big Run
- Connoquenessing Creek
- Little Beaver Creek
- Little Neshannock Creek
- Neshannock Creek
- Shenango River
- Slippery Rock Creek
- Wolf Creek

Other Features

- Interstate
- PA & US HWY
- Local Road
- Stream
- Municipal Boundary
- Lawrence County

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Date: 04/16/2010

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File Location: G:\2008\Lawrence_County\ArcProjects\Phase 2_Figure III-6_Problem Areas.mxd

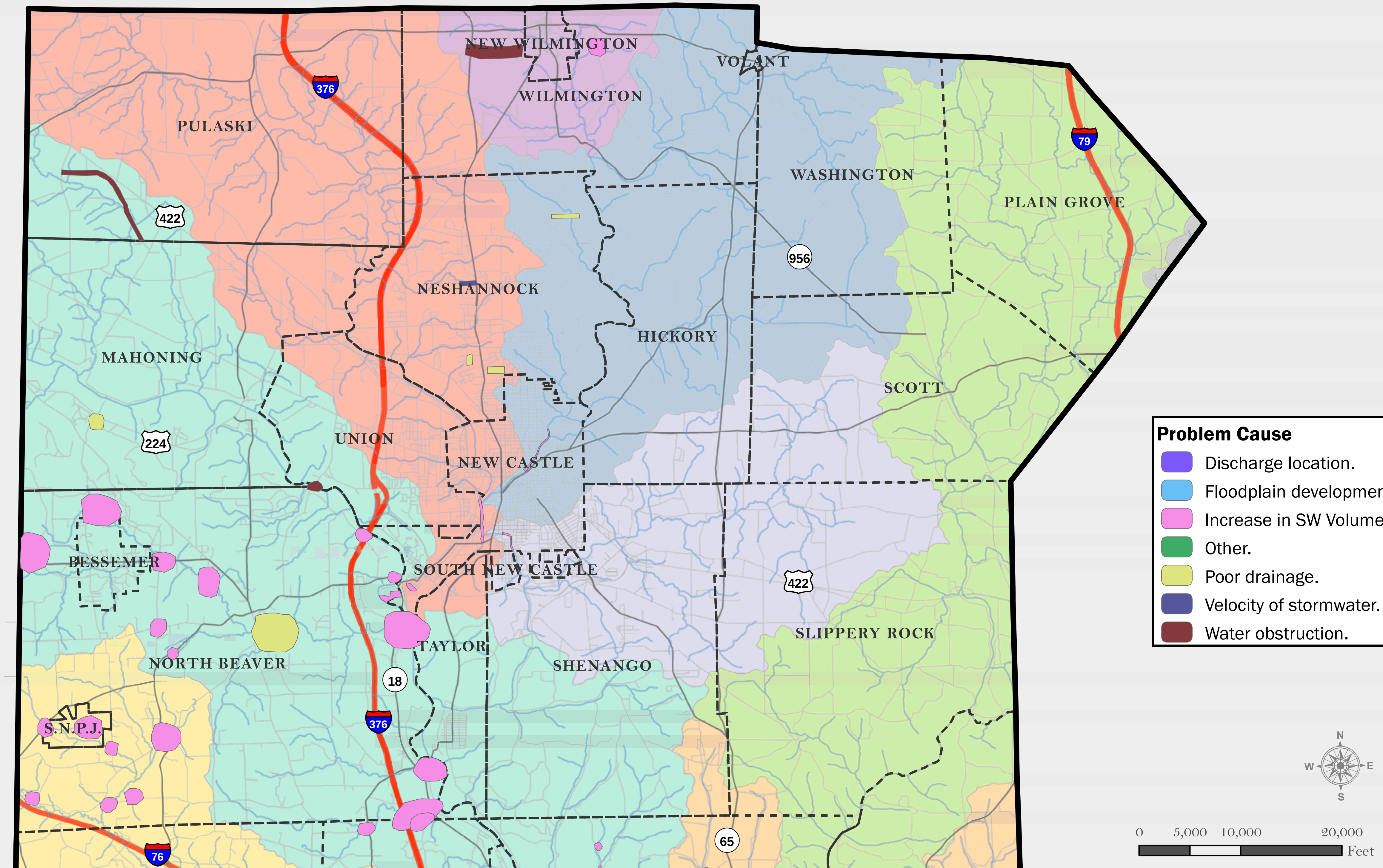
Lawrence County

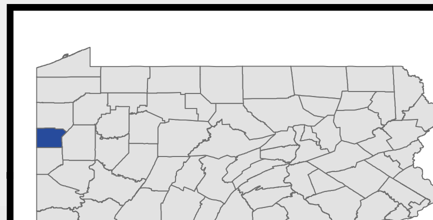
Stormwater Management Plan

Phase 2 Plan

FIGURE III-7

Problem Areas: Problem Causes





Location of Lawrence County within the state of Pennsylvania.

Watersheds

- Beaver River
- Big Run
- Connoquenessing Creek
- Little Beaver Creek
- Little Neshannock Creek
- Neshannock Creek
- Shenango River
- Slippery Rock Creek
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Other Features

- Interstate
- PA & US HWY
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O. Land Use

Lawrence County contains three major watersheds: Slippery Rock Creek/ Connoquenessing Creek, the Shenango/Mahoning/Beaver River watershed complex, and North Fork Little Beaver Creek.

Slippery Rock Creek / Connoquenessing Creek: Land uses in these watersheds include the urban areas of Ellwood City, Ellport and Wayne Township, as well as agricultural, forestry, industrial and light residential land uses in the Slippery Rock Creek watershed.

Shenango/Mahoning/Beaver River Watersheds: Land uses in these watersheds include the heavily urbanized and industrial areas around New Castle, strip mining and gravel quarries in floodplain areas, agricultural, low density and medium density residential, and natural areas.

North Fork Little Beaver Creek: Land uses in this watershed include agriculture, rural residential and strip mine uses.

The factors which influence the growth and development of communities, are very complex and interrelated. These factors are variable in nature and include such items as economy, cultural rate of growth, and technology. Furthermore, these factors are beyond the control of governmental agencies responsible for land use regulations. Local government can however, stimulate, retard, control, and guide development patterns to productively enhance those variables: growth, cultural enhancement, economy.

It is not the intent of this plan to analyze land use from a growth impact standpoint, but to consider existing and potential future land use to properly analyze the impacts land use has on the existing hydrology of the County. It is also necessary to identify those areas which currently are adversely impacted by stormwater. The hydrologic modeling done within the County takes into account the existing land uses to accomplish this.

Land uses are identified and grouped below:

Table III-6

Land Use

Land Use	Overall Area (Acres)	Overall Area (Square Miles)	Percentage of County[2]
Commercial and industrial areas	4,424.21	6.913	1.91%
Rangeland Areas[3]	27,071.89	3.1804	0.88%
Forested Areas[4]	94,598.21	147.81	40.74%
Row crops, pastures, golf courses	90,557.97	141.49	39.00%
Reservoirs/water	4,467.56	6.98	1.92%
Residential	16,164.68	25.25	6.96%
Strip Mines, Quarries and Gravel Pits	14,481.06	23.189	6.39%
Transportation, Communications and Services	5,106.67	7.97	2.20%
Totals:	533,118	362.78	100%

[2] Based on approximately 362.78 square miles

[3] Includes areas classified as croplands, pastures, and shrub-brush land

[4] Includes areas classified as deciduous, evergreen, mixed forest, and forested wetlands

Refer to Figure III-8 for Lawrence County Land Uses.

P. Existing Development in the Flood Hazard Areas

The U.S. Department of Housing and Urban Development, Federal Insurance Administration, and Federal Emergency Management Agency (FEMA) prepare Flood Insurance Studies (FISs) and floodplain mapping for the municipalities in Lawrence County. This activity is now a responsibility of the U.S. Department of Homeland Security. Municipalities and the Pennsylvania Department of Community and Economic Development (PADCED) should be contacted as to the latest FIS studies before use.

There are two types of studies conducted in the FIS program: detailed and approximate. Detailed methods included hydrologic computations and detailed HEC-2 or HEC-RAS backwater computations. The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development and proposed construction. Areas studied by the approximate methods were areas having low development potential or minimal flood hazards. Map III-9 shows the 100-year floodplains classified as detailed and approximate as taken from the FEMA mapping for the entirety of Lawrence County.

Encroachments of residential, industrial, urban, transitional, transportation infrastructure, and commercial land covers are shown by overlaying these areas on the floodplain in the GIS.

Approximately 55,955 acres (24%) of the County are within floodplains.

The following table provides a summary of the total amount of developed floodplain area.

Table III-7

Floodplain Land Use

Land Use	Area (Acres)	Area (Square Miles)
Residential Areas	2,617	4.09
Forested Areas	37,667	58.86
Industrial	1,334	2.08
Mines, Quarries and Gravel Pits	2,698	4.21
Row Crops, Pastures, Golf Courses	11,639	18.27
Totals:	55,955	87.51

Refer to Figure III-10 for mapping that overlays the existing, 100-year flood plain locations with the Lawrence County Land Uses. This map will show the degree to which urbanized development has occurred within the flood plain boundaries.

The evaluation of the returned municipal questionnaires shows occurrences of stream flooding throughout several of the more urbanized areas of the County during major storm events, resulting in property damages. Urbanized development of any kind within delineated flood plain areas is highly discouraged by this Plan. Restoration of existing flood plains and their eventual return to their natural occurring conditions is key to improving the overall County stream conditions and flood-flow capacities.

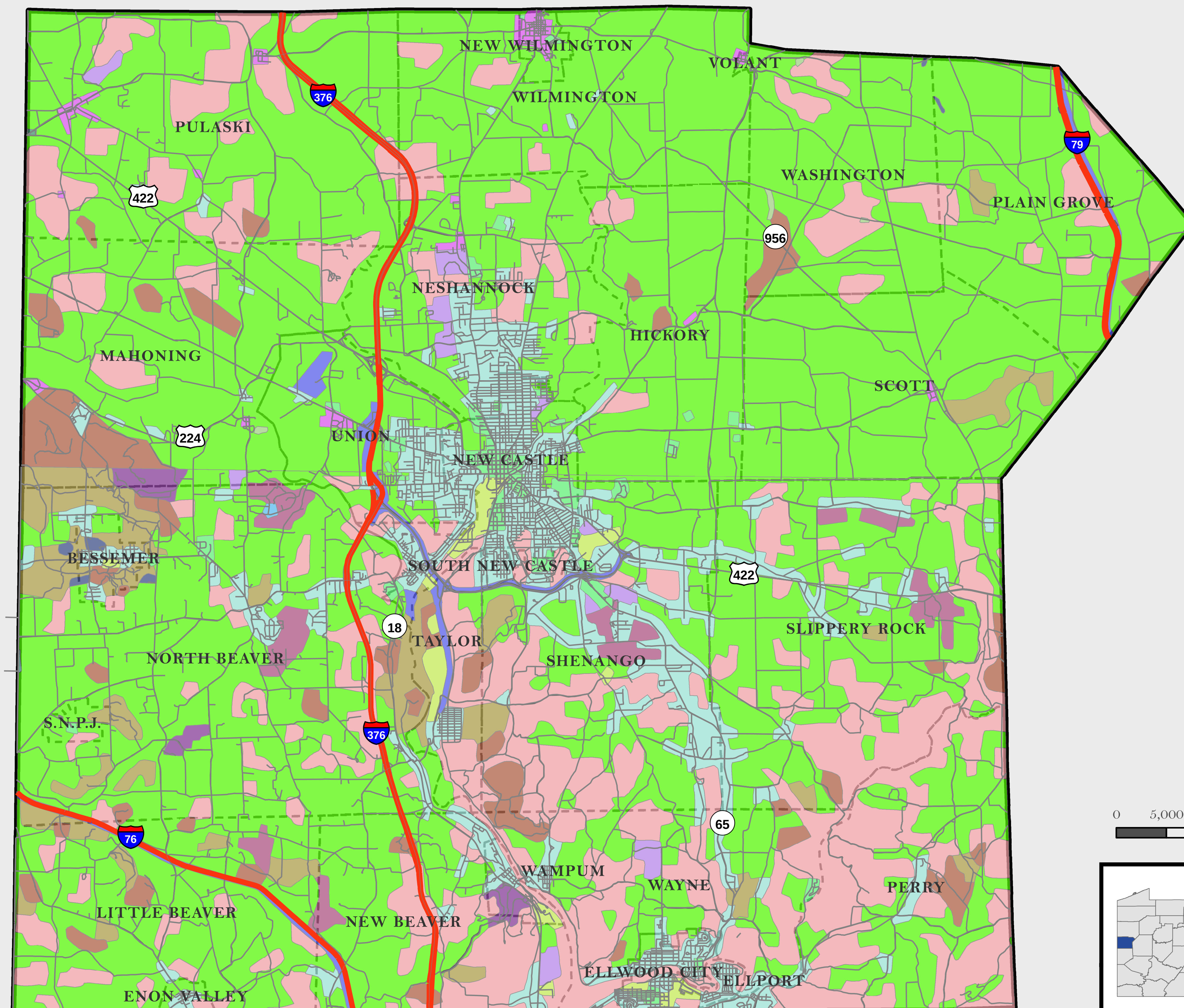
Lawrence County

Stormwater Management Plan

Phase 2 Plan

FIGURE III-8

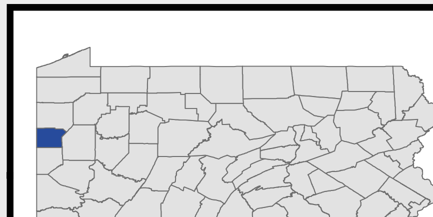
Existing Land Use



0 5,000 10,000 20,000 Feet

Existing Land Use

- Commercial and Services
- Confined feeding operations
- Cropland and pasture
- Deciduous forest land
- Evergreen forest land
- Industrial
- Lakes
- Mixed forest land
- Mixed urban or built-up land
- Orchards, groves, vineyards, nurseries..
- Other urban or built-up land
- Reservoirs
- Residential
- Strip mines, quarries and gravel pits
- Transitional areas
- Transportation, communications and services
- Municipal Boundary
- Lawrence County
- StateRoads



Location of Lawrence County within the state of Pennsylvania.

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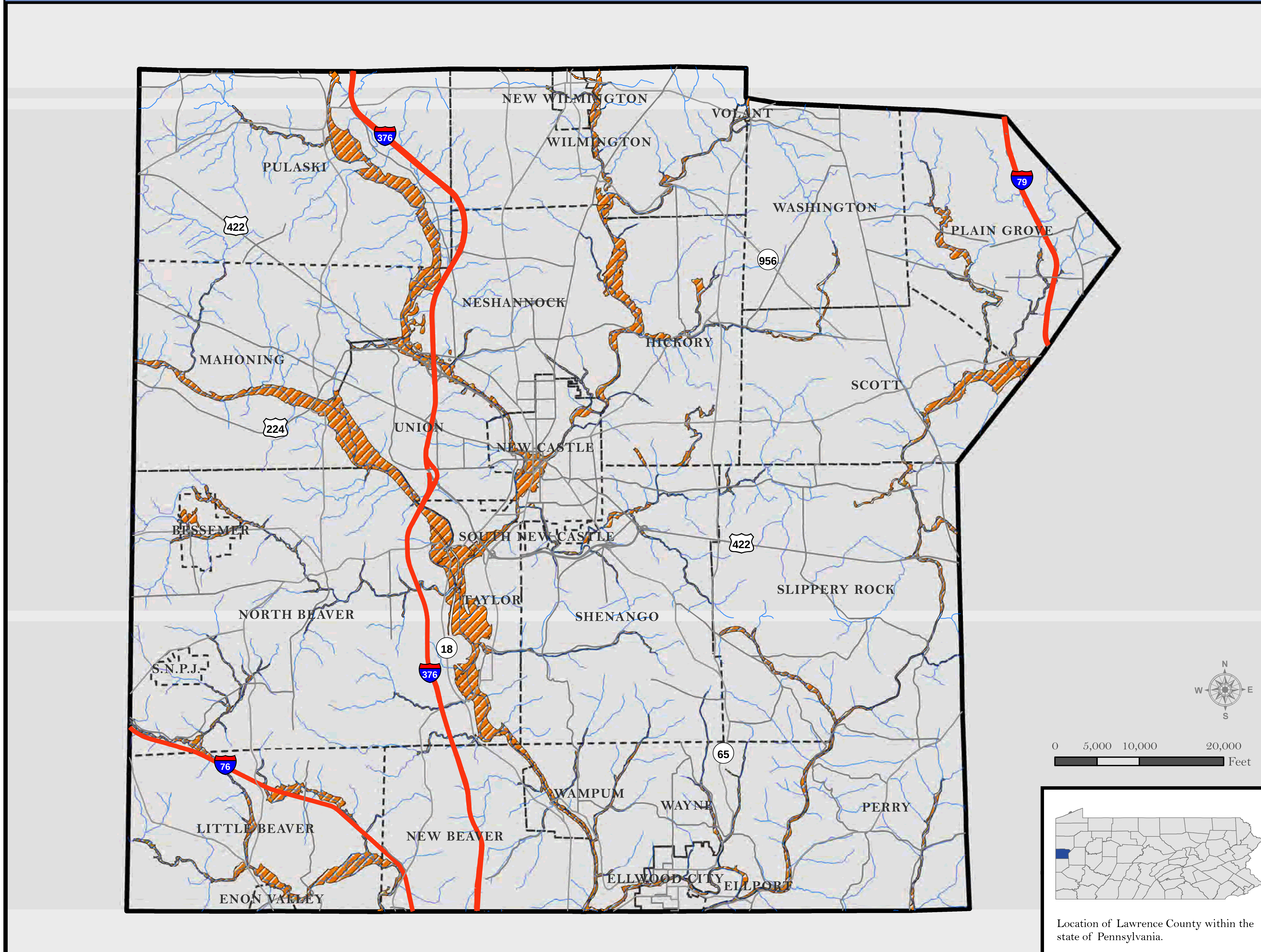
Stormwater Management Plan

Phase 2 Plan

FIGURE III-9

100-Year Flood Plains



100-Year Flood Plain
Streams
Municipal Boundary
Lawrence County
State Roads

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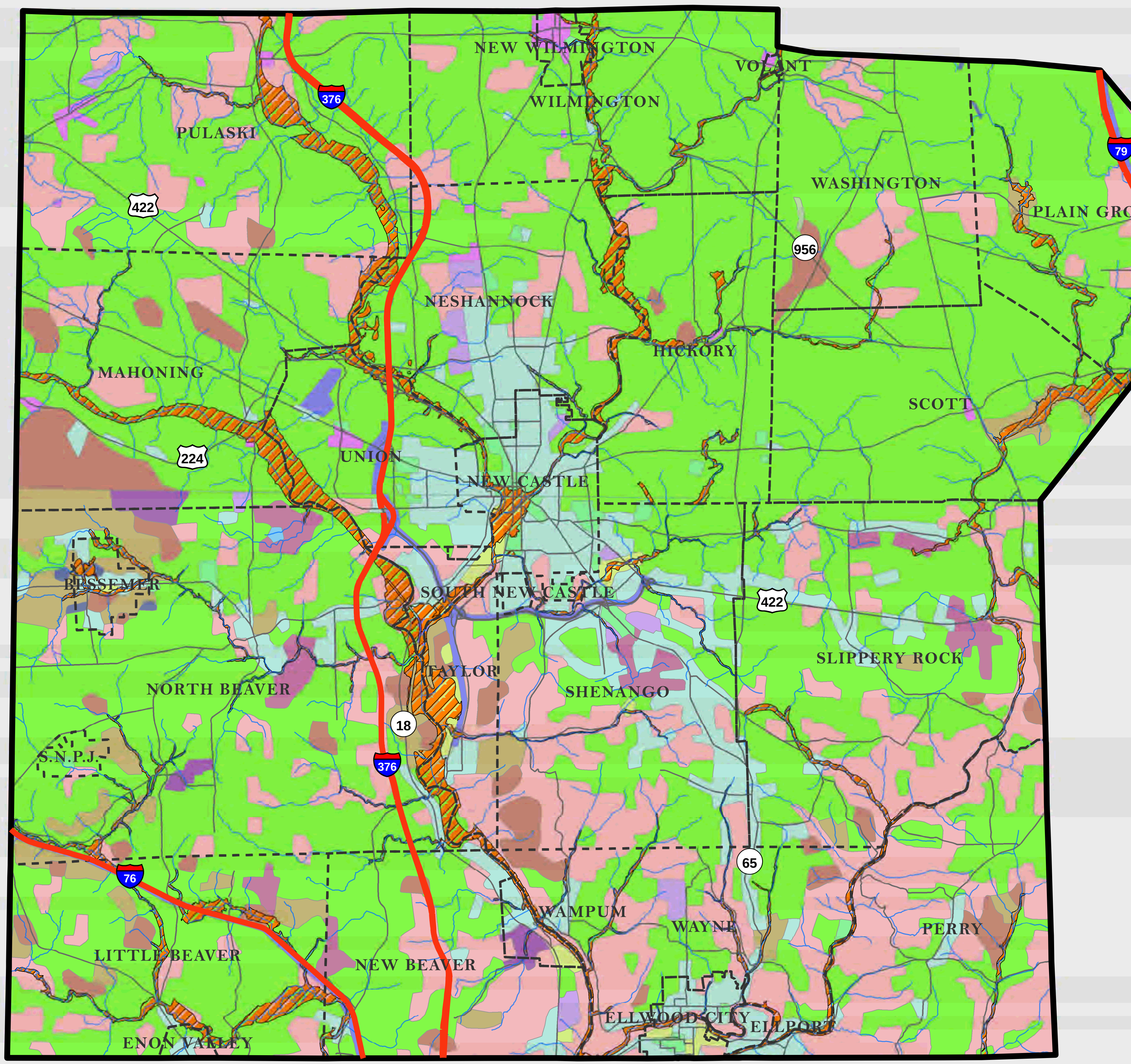
Lawrence County

Stormwater Management Plan

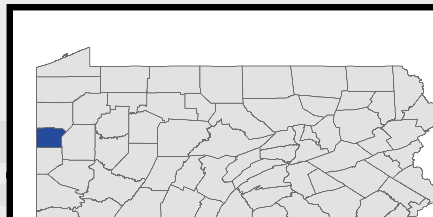
Phase 2 Plan

FIGURE III-10

Existing Land Use and 100-Year Flood Plains



Lawrence County
Municipal Boundary
Streams
State Roads
100-Year Flood Plain
Commercial and Services
Confined feeding operations
Cropland and pasture
Deciduous forest land
Evergreen forest land
Industrial
Lakes
Mixed forest land
Mixed urban or built-up land
Orchards, groves, vineyards, nurseries..
Other urban or built-up land
Reservoirs
Residential
Strip mines, quarries and gravel pits
Transitional areas
Transportation, communications and services



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Project Number: 08-1300-0135

File Location: G:\2008\Lawrence_County\ArcProjects\Phase 2_Figure III-9_Land Uses and Flood Plains.mxd

SECTION IV WATERSHED TECHNICAL ANALYSIS

1. Watershed Modeling

In planning the Act 167 Stormwater Management Phase 2 effort, one of the initial steps was the selection of a computer simulation package that could accurately and efficiently model the county's watersheds.

The selected modeling method and program needed to provide many capabilities related to stormwater modeling, but most importantly, it needed to achieve the following:

- Produce realistic and dependable results, while not requiring a disproportionate amount of input information
- Produce realistic simulations and results in comparison to the overall size of the study area
- Accurately and efficiently account for all pertinent physical properties of the naturally occurring hydrologic process
- Evaluate a variety of rainfall events, durations, and frequencies to generate outflow hydrographs which represented an accurate and realistic representation of the hydrologic conditions in all watersheds being studied

The model chosen for use on this plan was the U. S. Army Corps of Engineers (USACE), Hydrologic Engineering Center, Hydrologic Modeling System (HEC-HMS). The standalone HEC-HMS program was supplemented with the use of the USACE GeoHMS software package in order to take better advantage of the growing amount of countywide Geographic Information System (GIS) data available. The selection of the HEC-HMS and GeoHMS modeling software was based upon the following[5]:

- It is accepted by the Pennsylvania Department of Environmental Protection
- Provides the ability for combination modeling of the hydrology of natural watersheds as well as developed urban areas
- Provides the ability to represent engineered structures (e.g. pumps, diversions, reservoirs, etc.)
- The software places an equal value on both natural and urban watersheds (one of few software packages available that can model hydrology in watersheds with a mixture of conditions)
- The finalized model can easily be adapted for use in additional applications such as: estimating flood damage reduction, consideration of environmental restoration, future flexibility, and the ability to apply new methods that represent infiltration, new reservoir outlets, and several other components of the hydrologic cycle
- The use of the software allows for integration with other Federal, local, and private entities that are using compatible models produced from USACE software packages

While other commercially and freely developed software packages are available and possess the ability to provide similar results, HEC-HMS was chosen for the reasons outlined above as well HMS's ability to calculate flows for specific sub-watersheds along the stream/river route and then compare these flows with the overall watershed flows.

HEC-HMS has the ability to calculate runoff amounts for each specified storm or return period based on several physical, geological, and meteorological characteristics of the watershed. This flow is then generated and routed through the watershed system based on the stream's hydraulic parameters. This is one of the benefits of using the

[5] The list is partially adapted from reference material published by the United States Army Corp of Engineers

GeoHMS package in conjunction with HEC-HMS. The watershed's characteristics (listed above) are often available in GIS datasets from the County or other acceptable location. This greatly aids in streamlining the modeling process, increases the modeler's efficiency in producing the results, and helps to diminish the potential for "human error" by reducing the number of calculations that the modeler has to perform without the benefit of the software.

In essence, the amount of flow generated from any watershed is a result of the following contributing factors:

- Basin Slope
- Hydraulic Flow Parameters of Related Streams/Rivers
- Soil Type/Hydrologic Soil Conditions (used for determination of the Soil Conservation Service (SCS) soil curve number)
- Land Use within the Basin (e.g. wooded cover, grassy areas, urbanized areas, open fields, etc.)

Composite SCS curve numbers (CN) are then generated by the software using the available soils and land use information. This information, along with flow travel times, basin slopes, and available rainfall data, are the basis for the resulting watershed and sub-watershed model results.

The map shown in Figure IV-1 shows the overall watershed areas including the sub-watershed areas that were analyzed and modeled for this plan.

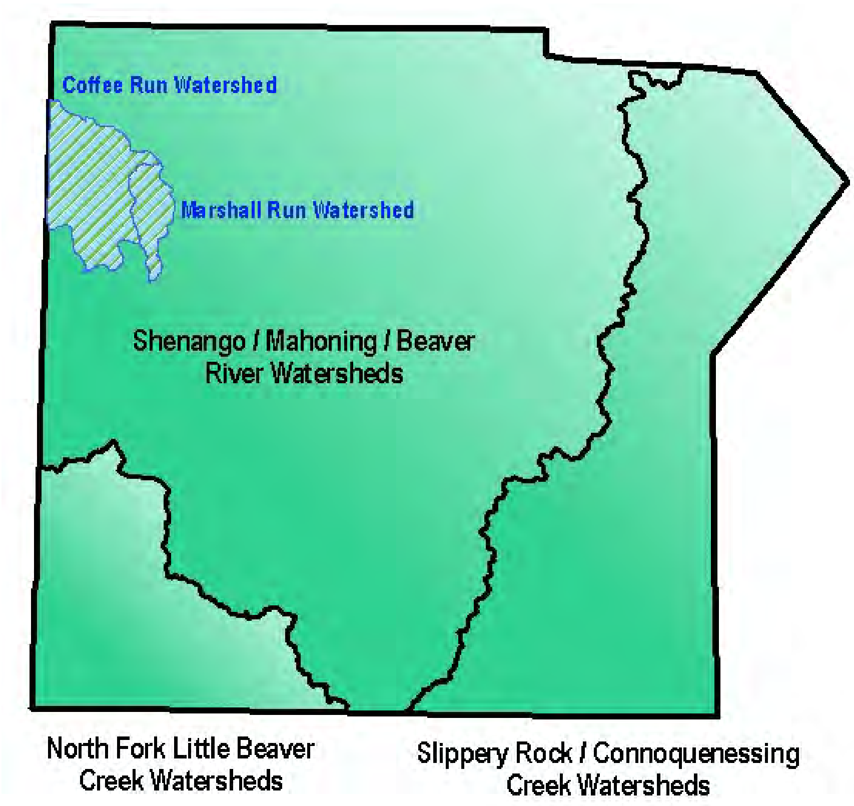


Figure IV-1

As noted in Section I, only two of the watersheds originally identified in the Phase 1 Scope of Study were modeled in Phase 2. The two watersheds modeled in this planning cycle are:

- Marshall Run
- Coffee Run

These two watersheds are located in the northwestern corner of the County and are both tributary to the Mahoning River. Both of these watersheds are located in portions of Pulaski and Mahoning Township. They flow from north to south, with their headwaters originating in Pulaski Township.

2. Modeling Process

After delineation of the major watersheds within Lawrence County based upon the natural topography of the study areas and using the available GIS data, these major watersheds were then further sub-divided into sub-watersheds for further study and analysis.

The determination of sub-watershed boundaries was based on a number of factors. Obstructions (e.g. bridges, culverts, and dams), reported problem areas (e.g. flooding, water-quality issues, excessive sedimentation, stream capacity issues, etc.), and confluence points between sub-watersheds were among the factors used in the selection of sub-watershed areas.

The most downstream point of any sub-watershed, the point where the water will leave the sub-watershed and enter another sub-watershed is known as the point of interest (POI). This is the point within each sub-watershed where the most significant results from the model are calculated. This is the point where the overall flow from the sub-watershed is determined. All areas upstream of this point are used to help determine the overall flow at any point of interest.

The point of interest is also selected as a reasonable location for considering how to best and most effectively manage and control the runoff within the watershed contributing to the POI. The watersheds POI acts as a management point, where a specific runoff rate can be determined and upstream management policies can be formulated around this quantifiable number. It also acts as a measurement point in determining any downstream impacts the overall watershed has on adjacent watersheds to which that watershed eventually drains.

All watersheds and sub-watersheds were then modeled to determine the overall runoff amounts for the following 24 -hour storm events:

- 2-year
- 10-year
- 25-year
- 50-year
- 100-year

It is the opinion of the County that the 5-year, 24-hour duration storm event adds very little value to the hydrologic evaluation of a watershed. Therefore, the County proposed to PA DEP that this duration storm be eliminated from hydrologic evaluation. The PA DEP reviewed and agreed with this decision.

An Applicant may still analyze and evaluate the 5-year storm event at their discretion. If the 5-year storm event is included however, it must meet the requirements of Article III – Stormwater Management Standards of the Municipality's local ordinance.

The factors addressed during the modeling process include:

- The peak discharge/overall runoff values at various locations along the stream and its tributaries within each modeled watershed
- The time at which the above mentioned peak discharge is reached (time to peak), and the overall timing of flow through the watershed
- Runoff contributions of individual sub-watersheds and sub-areas within those sub-watersheds at various downstream locations

The results for each individual watershed and the return periods shown can be found in the Technical Appendix of the Volume III document. This document is available at the Lawrence County Planning Department offices in New Castle.

3. Calibration

The most appropriate and accurate way to model any watershed is through the proper calibration of the model. The model should be calibrated against known field data and accurate, recent rainfall events collected within the analysis area. An acceptable alternative to the use of known physical and meteorological data is the use of statistical analysis or regression models (Paul A. DeBarry, 2004).

In its simplest form, calibration is the adjustment of model input parameters to converge upon and provide a realistic representation of the actual runoff and time conditions of the watershed based upon known, historical data.

Figure IV-2 shows a theoretical comparison between known, plotted data and the data provided by the model. An acceptably calibrated model will be one that reduces the amount of error between the plotted data when compared to one another. The information in Figure IV-2 is a simple stormwater hydrograph (flow versus time). As the two hydrographs come closer and closer together, and near a point of convergence, the model becomes more representative of realistic conditions within the watershed being modeled.

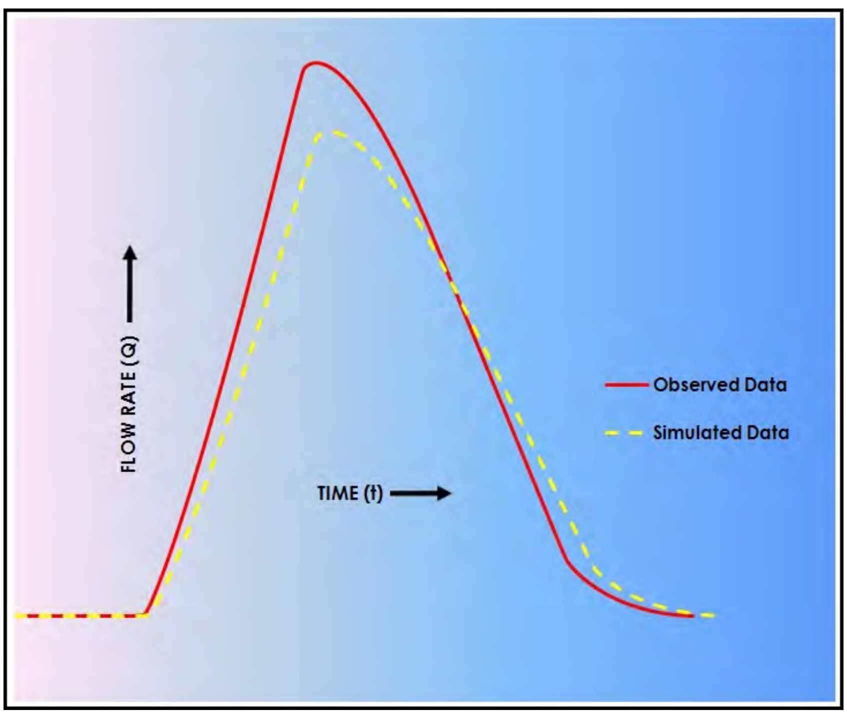


Figure IV-2

Hydrologic model calibration often uses the following procedures:

Table IV-1

Calibration Methods and Priority of Application (Paul A. DeBarry, 2004)

Priority	Data	Advantages	Disadvantages
1	Actual (historically recorded) stream flow data and rainfall hyetographs	Can adequately calibrate peak runoff, watershed timing, and runoff volumes	Historical and recorded data is often not available, especially in more rural areas; method of application is time-consuming
2	Statistical Frequency Analysis	Based on historically recorded data	Can only be used for the calibration of peak runoff amounts only; runoff volumes and watershed timing cannot be calculated
3	Regression Analysis (Regionally Derived)	Fast and not time-consuming for the modeler	The watershed in question may not fit the "regional trend[6]" Can only be used for the calibration of peak runoff amounts only; runoff volumes and watershed timing cannot be calculated

When historical precipitation and stream flow data is available, by way of recorded rain gage and stream flow information, the model can then be properly be set up to simulate hydrographs of the watershed.

If the modeler seeks to simulate a specific rainfall event, the model input needs to include information concerning the relative wetness and dryness of the watershed (antecedent moisture content) and the accurate distribution of rainfall throughout the watershed. The flow through any given watershed can be significantly impacted by the continuously changing antecedent moisture content.

Additional modifications to the simulation model are then also made in an effort to replicate the outflow hydrograph (shape and peak flow rates) at various measurement points within the watershed. The use of stream flow and rain gage data during the calibration process can only be used if the data is sufficient in amount as well as being geographically near the watershed. Since watershed distribution can vary quite significantly over relatively small areas, it is imperative that the rain and stream gages are numerous and as close as possible to the watershed in question.

The inclusion of more localized events and occurrences, such as snowmelt conditions, are typically not reliable sources of data for calibration efforts. This is because such data is not historically consistent and can often be unique to the area in question. The variation of this data over time makes it somewhat unreliable to yield realistic model simulation results.

[6] Regional trend is meant to indicate the varying flow conditions that can occur from watershed to watershed. Known rainfall data has proven that there is a possibility that precipitation conditions in one portion of a watershed can vary from that of another portion of the same watershed. This can even occur in very small watershed areas.

Lawrence County Calibration Effort

As noted previously, the two watersheds modeled during this Phase 2 planning cycle are Marshall and Coffee Runs. No existing stream gage data or other recorded information is available for either stream, so comparison of the model runs with recorded or statistically analyzed historical data are not options. There is also no detailed FEMA Flood Insurance Study peak flow information available for either of these watersheds. Therefore, the use of a regression analysis was used to properly calibrate the computer modeling efforts.

Current State of Regression Analysis Methodlogy in Pennsylvania

The most current regression analysis method for Pennsylvania is the *Regression Equations for Estimating Flood Flows at Selected Recurrence Intervals for Ungaged Streams in Pennsylvania*, (Roland & Stuckey, 2008), (Scientific Investigation Report 2008-5102), commonly referred to as USGS 5102. This method was published in 2008, after the planning effort for Lawrence County had already started. USGS 5102 presents regression equations developed for estimating flood flows at selected recurrence intervals for ungaged streams in Pennsylvania with drainage areas less than 2,000 square miles. These equations were developed using peak-flow data from 322 streamflow-gaging stations within Pennsylvania and surrounding states. All stations used in the development of the equations had 10 or more years of record data and included active and discontinued continuous-record as well as crest-stage partial-record stations. The state was divided into four regions, and regional regression equations were developed to estimate the 2-, 5-, 10-, 50-, 100-, and 500-year recurrence-interval flood flows. The equations were developed by means of a regression analysis that used basin characteristics and flow data associated with the stations. This method established equation variables for the following basin characteristics: drainage area; mean basin elevation; and the percentages of carbonate bedrock, urban area, and storage within a basin. The regression equations can be used to predict the magnitude of flood flows for specified recurrence intervals for most streams in the state; however, they are not valid for streams with drainage areas generally greater than 2,000 square miles or with substantial flow regulation, diversion, or mining activity within the basin.

Regression Analysis Methodology Used During the Current Planning Cycle

Since the Lawrence County Plan effort started prior to the release of USGS 5102, the calibration efforts described below are based on its predecessor, *Techniques for estimating magnitude and frequency of peak flows for Pennsylvania streams*" (Stuckey and Reed, 2000) USGS 4189. This method is still accepted by PennDOT and consequently is still useful for projects requiring that PennDOT standards be followed.

We recommend, however, that future design projects or calibration efforts use USGS 5102.

Lawrence County Calibration Results

In order to calibrate the watersheds, a validated flow result within the watershed would need to be known for each event. In this event, consistent stream gage data was unavailable for the entire County. For this reason, the watersheds were calibrated by comparing the un-calibrated model results to a regression analysis. The regression analysis that was used was "*Techniques for estimating magnitude and frequency of peak flows for Pennsylvania streams*" (Stuckey and Reed, 2000). This commonly accepted form of regression analysis presents equations that predict flood frequencies with return intervals or 10, 25, 50, 100, and 500-year intervals for un-gauged streams in Pennsylvania.

Specific basin characteristics were used in the regression analysis formulas depending upon how the watershed being studied correlates with one of two delegated regions within Pennsylvania. These regions were delineated based upon technical evaluations that reveal the flooding within Region A seems hydrologically unrelated to the flooding in Region B. See Figure IV-3 below for the Region map.

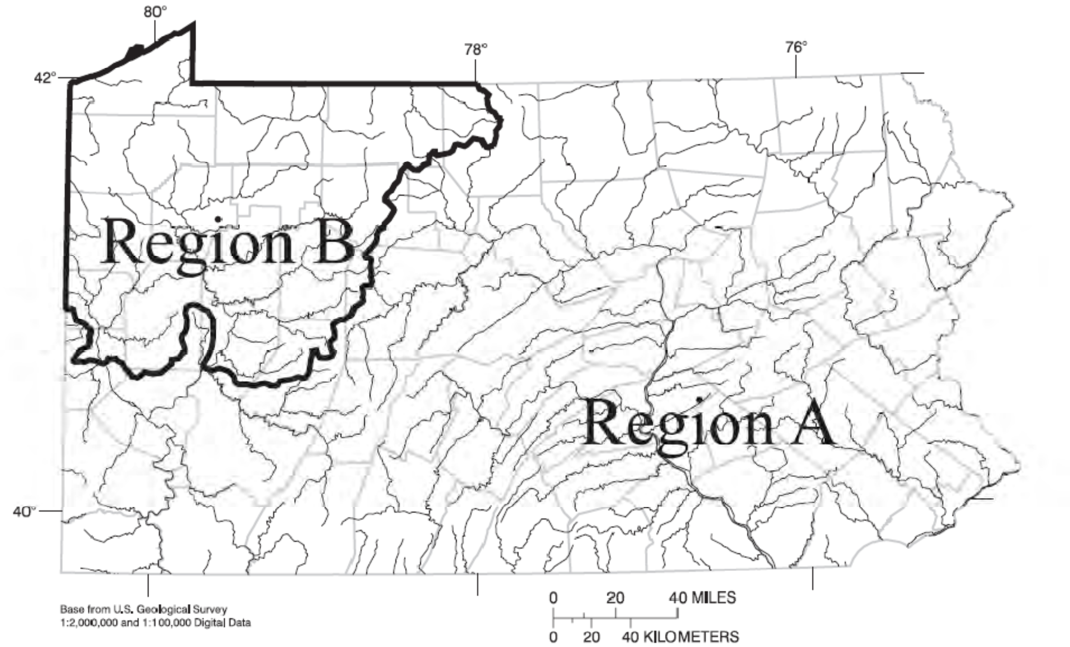


Figure IV-3
(Stuckey and Reed, 2000)

The County falls mainly within Region B. A small area in the Southwestern corner of the County falls within Region A. However, based on the goals of the plan, this specific area of the County was not designated for further study. Regression equations for Region B were developed from 54 stream flow-gauging station records and have two (2) variables, drainage area and the percentage of basin controlled by lakes, swamps, and reservoirs. The area of the State that comprises Region B does not contain any significant areas of carbonate rock coverage (Figure IV-4). The percentage of urban area coverage is consistently low for stream flow-gauging stations in Region B. An overall lack of urban area coverage results in un-meaningful results during analysis. The percentage of forest-type coverage was also not a significant variable and was therefore omitted from the analysis. From this information, each sub-basin area was analyzed utilizing the equations shown in Figure IV-4 below. It was also assumed that CA, or the percentage of basin controlled by lakes, swaps or reservoirs was zero.

Q_T return flow (ft^3/s)	Basin characteristic coefficients						Residual standard error		Coefficient of determination (R^2)
	Intercept (A)	Drainage area (b)	Percentage forested area (c)	Percentage urban development (d)	Percentage carbonate area (e)	Percentage controlled area (f)	Log units	Percent	
Region A									
Q_{10}	2.5243	0.7770	-0.9712	1.0217	-1.7184	-0.5719	0.18	43	0.93
Q_{25}	2.7145	.7556	-1.0324	.7608	-1.5302	-.5302	.19	45	.91
Q_{50}	2.8441	.7414	-1.0821	.5785	-1.3955	-.4980	.21	50	.89
Q_{100}	2.9665	.7278	-1.1342	.4040	-1.2691	-.4637	.23	55	.87
Q_{500}	3.2294	.6994	-1.2666	.0208	-.9877	-.3834	.27	66	.82
Region B									
Q_{10}	2.3105	.7255	---	---	---	-1.2425	.12	28	.96
Q_{25}	2.4418	.7108	---	---	---	-1.3700	.13	30	.95
Q_{50}	2.5276	.7017	---	---	---	-1.4695	.14	33	.94
Q_{100}	2.6069	.6932				1.5677	.16	38	.92
Q_{500}	2.7673	.6776	---	---	---	-1.8055	.19	45	.89

OR

Region A

$$Q_{10} = 334.4\,DA^{.7770}(1+.01F)^{-.9712}(1+.01U)^{1.0217}(1+.01C)^{-1.7184}(1+.01CA)^{-.5719}$$

$$Q_{25} = 518.2\,DA^{.7556}(1+.01F)^{-1.0324}(1+.01U)^{.7608}(1+.01C)^{-1.5302}(1+.01CA)^{-.5302}$$

$$Q_{50} = 698.4\,DA^{.7414}(1+.01F)^{-1.0821}(1+.01U)^{.5785}(1+.01C)^{-1.3955}(1+.01CA)^{-.4980}$$

$$Q_{100} = 925.8\,DA^{.7278}(1+.01F)^{1.1342}(1+.01U)^{.4040}(1+.01C)^{1.2691}(1+.01CA)^{.4637}$$

$$Q_{500} = 1{,}696\,DA^{.6994}(1+.01F)^{-1.2666}(1+.01U)^{.0208}(1+.01C)^{-.9877}(1+.01CA)^{-.3834}$$

Region B

$$Q_{10} = 204.4\,DA^{.7255}(1+.01CA)^{-1.2425}$$

$$Q_{25} = 276.6\,DA^{.7108}(1+.01CA)^{-1.3700}$$

$$Q_{50} = 337.0\,DA^{.7017}(1+.01CA)^{-1.4695}$$

$$Q_{100} = 404.5\,DA^{.5932}(1+.01CA)^{-1.5677}$$

$$Q_{500} = 585.2\,DA^{.6776}(1+.01CA)^{-1.8055}$$

DA is drainage area, in square miles;
F is percentage of forest cover, in percent;
U is percentage of urban development, in percent;
C is percentage of basin underlain by carbonate rock, in percent;
CA is percentage of basin controlled by lakes, swamps, or reservoirs, in percent; and
b, c, d, e, f are basin characteristic coefficients of regression.

Figure IV-4
(Stuckey and Reed, 2000)

Calibration results for Coffee and Marshall Runs can be found in Tables IV-2 and IV-3.

Table IV-2
Coffee Run Calibration Results

Node or Reach ID	Tributary Drainage Area (mi^2)	10-year Event: Regression Peak Flow (CFS)	10-year Event: Calibrated Model Peak Flow (CFS)	10-year Event: % Difference	25-year Event: Regression Peak Flow (CFS)	25-year Event: Calibrated Model Peak Flow (CFS)	25-year Event: % Difference	100-year Event: Regression Peak Flow (CFS)	100-year Event: Calibrated Model Peak Flow (CFS)	100-year Event: % Difference
W690/reach 1	0.85473	182.40	181.5	0%	247.40	250.2	1%	362.80	369.2	2%
W720/reach 2	0.17018	56.56	51.1	10%	78.56	73.6	6%	118.52	113.9	4%
J259	1.02491	208.08	207	1%	281.48	286.8	2%	411.46	426.2	4%
W700/reach 3	0.16166	54.49	59.8	10%	75.74	81.1	7%	114.37	117.4	3%
J251	1.18657	231.41	237	2%	312.36	315.8	1%	455.43	469.1	3%
W740/reach 5	0.33454	92.36	93.6	1%	127.01	128.3	1%	189.35	187.9	1%
W750/reach 4	0.20823	65.48	63.4	3%	90.67	89	2%	136.31	133.5	2%
W870/reach 7	0.37711	100.74	98.3	2%	138.29	136	2%	205.74	201.1	2%
J242	0.58534	138.59	133.1	4%	189.03	178.8	5%	279.05	256.9	8%
W820/reach 8	0.205	64.74	66.1	2%	89.67	92.4	3%	134.84	138.3	3%
W840/reach 9	0.19292	61.95	67.8	9%	85.88	91	6%	129.28	130.7	1%
J229	0.98326	201.91	200.9	1%	273.30	275.3	1%	399.79	403.6	1%
J245	2.50437	397.87	390.5	2%	531.19	533.3	0%	764.36	773.6	1%
W760/reach 11	0.16028	54.15	56.3	4%	75.28	77.1	2%	113.69	113.11	1%
W860/reach 10	0.34312	94.07	108	15%	129.31	142	10%	192.70	198.3	3%
J239	3.00777	454.41	450.1	1%	605.05	597.4	1%	867.84	842.8	3%
W800/reach 13	0.31165	87.73	93.8	7%	120.77	125.2	4%	180.27	178	1%
J226	3.31942	488.10	494.5	1%	648.97	651.8	0%	929.22	917.3	1%
W930/reach 14	0.10938	41.04	46.8	14%	57.38	61.8	8%	87.24	87.2	0%
J220	3.4288	499.72	504.1	1%	664.10	663.6	0%	950.34	932.9	2%
W1090/reach 15	1.2868	245.43	249.7	2%	330.90	334.5	1%	481.76	479.1	1%
J274	4.7156	629.70	639.2	2%	832.92	848.4	2%	1185.26	1199.4	1%
W1120/reach 16	0.15383	52.56	62.7	19%	73.11	81.8	12%	110.50	113.8	3%
J212	4.86943	644.53	644.4	0%	852.14	856	0%	1211.93	1209.5	0%
W1150/reach 21	0.46884	117.98	124.4	5%	161.44	167.6	4%	239.26	240.7	1%
W1180/reach 25	0.10855	40.82	46.5	14%	57.07	61.8	8%	86.78	88	1%
W1220/reach 26	0.29186	83.65	96	15%	115.27	125.7	9%	172.26	175	2%
J236	0.40041	105.22	137.2	30%	144.32	180.6	25%	214.47	253.3	18%
J254	5.73868	726.10	714.3	2%	957.67	947.7	1%	1358.09	1338.3	1%
W970/reach 23	2.1762	359.32	342.5	5%	480.72	460.5	4%	693.44	690.5	0%
W1200/reach 22	1.3408	252.86	219	13%	340.71	317	7%	495.69	493.3	0%
outlet	9.25568	1027.09	967.4	6%	1345.16	1295.3	4%	1891.62	1878.5	1%

Table IV-3 Marshall Run Calibration Results										
		10-year Event			25-year Event			100-year Event		
Node or Reach ID	Tributary Drainage Area (mi^2)	Regression Peak Flow (CFS)	Calibrated Model Peak Flow (CFS)	% Difference	Regression Peak Flow (CFS)	Calibrated Model Peak Flow (CFS)	% Difference	Regression Peak Flow (CFS)	Calibrated Model Peak Flow (CFS)	% Difference
W190/reach 2	0.10846	40.79	45.7	12%	57.03	59.9	5%	86.73	83.6	4%
W220/reach 1	0.26645	78.30	85.1	9%	108.04	111.3	3%	161.72	155.2	4%
J35	0.37491	100.31	129.8	29%	137.72	169.8	23%	204.91	237	16%
W230/reach 9	0.51407	126.13	138.8	10%	172.36	185.3	8%	255.03	264.1	4%
W240/reach 3	0.25653	76.17	71.8	6%	105.16	103.2	2%	157.52	159	1%
J30	1.14551	225.57	224	1%	304.64	303.4	0%	444.44	440.2	1%
W270/reach 10	1.0397	210.26	224.8	7%	284.36	300.6	6%	415.57	429.7	3%
W260/reach 7	0.61753	144.08	140.7	2%	196.36	192.1	2%	289.60	280.6	3%
outlet	2.80274	431.72	424.8	2%	575.43	577.8	0%	826.39	836.6	1%

SECTION V STANDARDS AND CRITERIA FOR STORMWATER CONTROL

A. Watershed Level Control Philosophy

Within any watershed, an increase in development or disturbance to the natural hydrology results in an overall increase in peak runoff rates, stormwater runoff volumes, and in many cases, a decrease in overall stormwater runoff quality.

The traditional approach to stormwater management has been the site specific or on-site control approach. The goal was to create a situation where the post-development peak runoff rates did not exceed those of the pre-development rates. This was often done through on-site collection and then conveyance to a large detention basin (or system of basins), located somewhere on the low point of the site. For many years, this was the methodology and philosophy behind managing stormwater.

However, new regulations (the result of new research) have begun to dictate the mitigation of not only peak runoff rates, but also runoff volumes and the issue of water quality. On-site stormwater management is still a key factor in overall watershed management; however, these new limiting factors can complicate the management process and make the traditional methods of managing stormwater a way of the past. New technologies and implementation practices are becoming the norm and no longer the anomaly.

The management of runoff volumes from a developed site is becoming a very important contributing factor, not only to on-site stormwater management, but also in overall watershed management. On-site volume controls (through various methods such as infiltration, stormwater re-use, bio-retention, limiting the source of runoff, etc.) are greatly reducing the volume of water (and the timing of its conveyance) that needs to be transported by streams through the watershed. This aids significantly in reducing excessive flows and volumes that can result in stream bank erosion and destructive flooding. On-site volume control also helps in the recharge of groundwater tables and aquifers by keeping the water within the watershed, instead of simply releasing it at a slower rate through the water shed and into adjacent, downstream watersheds. This methodology also helps in the management of water quality, an increasingly important issue. By allowing the natural characteristics of the watershed the ability to filter and treat runoff naturally, overall water quality can be greatly improved.

B. National Pollutant Discharge Elimination System (NPDES), Phase II Requirement

"In 1990, the US Environmental Protection Agency (EPA) promulgated federal National Pollutant Discharge Elimination System (NPDES) regulations for stormwater discharges under the Clean Water Act. These regulations, among other discharge requirements, established the federal Phase I NPDES stormwater discharge program that requires permit coverage for all operators of large construction activities proposing to disturb five or more acres of land. Effective October 10, 1992, operators of large construction activities required NPDES permit coverage in Pennsylvania for such activities. In December 1999, EPA promulgated NPDES Phase II regulations that require permit coverage for small construction activities that disturb one to less than five acres, which result in a point source discharge to waters of the United States. Effective December 7, 2002, the Pennsylvania Department of Environmental Protection (DEP) integrated the federal Phase II NPDES requirements into the existing Pennsylvania Phase I NPDES permit for stormwater discharges associated with construction activities (NPDES Construction Permit). An important distinction between Phase I and II is that the small construction activities only require permit coverage when the activity disturbs one to less than five acres and will result in a point source discharge to surface waters of the Commonwealth" (Pennsylvania DEP, 2007).

The National Pollutant Discharge Elimination System (NPDES) Stormwater Program regulates stormwater discharges from three potential sources: municipal separate storm sewer systems (MS4s), construction activities, and industrial activities. Most stormwater discharges are considered point sources, and operators of these sources may be required to receive an NPDES permit before they can discharge. This permitting mechanism is designed to prevent stormwater runoff from washing harmful pollutants into local surface waters such as streams, rivers, lakes or coastal waters.

The Pennsylvania Department of Environmental Protection (DEP) is responsible for administering the state's stormwater management program. Pennsylvania's stormwater program is closely modeled after the federal NPDES program, which requires stormwater be treated to the maximum extent practicable. Pennsylvania's NPDES stormwater program establishes permitting requirements for construction sites disturbing more than one acre, industrial sites, and MS4s. All MS4s should currently be permitted, or in the permit process. Each permitted MS4 will be responsible for establishing a Stormwater Management Program (SWMP).

This program affects all municipalities in "urbanized areas" of the state. This definition applies to all Lawrence County municipalities as listed in Table V-1.

Table V-1

County Name	Municipality Name	Urbanized Area Name (UA)
Lawrence	Ellport Borough	Pittsburgh
Lawrence	Ellwood City Borough	Pittsburgh
Lawrence	Perry Twp.	Pittsburgh
Lawrence	Wayne Twp.	Pittsburgh
Lawrence[7]	New Castle City	N/A

The Phase II Rule defines a small MS4 stormwater management program consisting of six elements that when implemented together, are expected to result in significant reductions of pollutants discharged into receiving water bodies (United States Environmental Protection Agency, Revised, 2005).

All municipalities that are required to implement the MS4 program are required to address the following six minimum control measures (MCM's):

1. Public Education and Outreach
2. Public Involvement/Participation
3. Illicit Discharge Detection and Elimination
4. Construction Site Stormwater Runoff Control
5. Post-Construction Stormwater Management in New Development and Redevelopment
6. Pollution Prevention/Good Housekeeping for Municipal Operations

At a minimum, municipal entities regulated under MS4 must:

- Specify BMPs and implement them to the "maximum extent practicable"
- Identify measurable goals for control measures

[7] MS4s outside UAs may be designated by PADEP for inclusion in the Phase II Program

- Develop an implementation schedule of activities or frequency of activities, and
- Define the entity responsible for implementation

All municipalities must adopt, amend, and implement such ordinances and regulations, including zoning, subdivision and development, building code, and erosion and sedimentation ordinances, as are necessary to regulate development within the municipality in a manner consistent with the Plan and the provisions of Act 167.

The adoption of the Lawrence County Stormwater Management Plan and model ordinance by Lawrence County Officials and by all Local Municipalities will successfully satisfy the basic requirements noted above. Acceptance by all necessary stakeholders and parties will also satisfy at least one of the six required MCMs of the NPDES II program, specifically, post-construction stormwater management in new development and redevelopment.

There are no exemptions to the guidelines set forth by the NPDES program and therefore all impacted municipalities will need to comply with any additional measures and guidelines of the plan and ordinance. The additional requirements concerning water quantity and water quality control guidelines shall be strictly implemented and enforced, regardless of project size. All necessary BMPs that address and mitigate stormwater runoff peak runoff, runoff volume, and water quality must all be met in order to be considered in compliance.

Any applicants proposing development in a given NPDES municipality would be required to provide BMP design information to the municipality in order to prove the municipality's compliance with at least one of the required NPDES Phase II regulations.

C. Standards and Criteria

The purpose of the Act 167 plan is to ensure the proper management of stormwater runoff and associated issues. The plan is intended to provide information and guidance to allow the design professional to manage stormwater in a manner that is consistent with proven, acceptable, and effective engineering practices; and to protect the public welfare through the protection of environmental resources. This would include acceptable land-use management practices as well as additional measures that will conserve and protect existing water sources and all other surface waters of the Commonwealth.

The plan is also intended to reduce destructive and potentially dangerous flow conditions caused by accelerated surface runoff (due to excessive development) by reducing overall peak flow rates and volumes and return existing stream capacities to a quantity more conducive to their size. The restoration of the flood capacity of such streams is of paramount importance to protecting existing natural features as well as protecting the public and property.

The provisions that shall be implemented concerning the recharging and infiltration of stormwater runoff will not only help to achieve the goal of returning streams to their natural flow capacities, but also to help recharge groundwater tables and aquifers that have been diminishing in recent years.

The easiest way to accomplish the goals of the Act 167 plan is by the implementation of BMPs that will help to return the hydrological flow characteristics of a given watershed to a state comparable to its natural capacity and capabilities. This is the driving force behind the Act 167 Plan's concept of watershed-wide stormwater management and maintenance.

In order to achieve the desired results of the Act 167 plan, the following five objectives should be implemented so that the watersheds can be properly conserved and protected:

1. Maintain groundwater recharge
2. Maintain or improve water quality
3. Reduce channel erosion
4. Manage overbank flood events

5. Manage extreme flood events

Refer to Figure V-1 for a schematic approach on how each of the five objectives can be accomplished and how their implementation can be achieved.

The standards were developed to take into account a number of land use and development activities. The standards provide the design professional with proven and common stormwater management methods and guidelines for their implementation.

The standards also incorporate information from the following tasks or assessments completed during both Phase 1 and Phase 2 activities:

<u>Mapping of physical characteristics</u>

- Maps depicting the characteristics of soils and land use have been included in this Plan. These areas were identified using existing spatial data. This information can then be streamlined and used as specific impact parameters for the computer model used for analysis of the necessary watersheds. The results of these model analyses can then be used to formulate rate release district maps as well as rate release values in these watersheds.

<u>Obstruction Locations</u>

- Mapping depicting the location of known structures and obstructions has been included in this Plan. These obstructions were identified by way of surveys sent to each municipality, through available spatial data, and through field visits. Based on the limited scope of the project and Plan, the identified obstructions have not been analyzed for capacity or potential impacts because of future development. This task will be addressed in more detail during the next planning cycle.

<u>Land Development Patterns</u>

- Mapping depicting the areas most likely poised for future growth has been included in this Plan. These areas were identified by way of surveys sent to each municipality and by the County Planning Department. Potential strategies for negative impact mitigation are addressed in various locations within this Plan.

<u>Flood Hazard Areas</u>

- Based on the reduced scope of the project and Plan development and based on limited historical and future planning, a detailed review of such areas and their impacts on flooding or stormwater runoff has not been included in this plan. Section III of this Plan identifies areas those areas that lie within floodplains and the specific land use of those areas. This task will be addressed in more detail during the next planning cycle.

<u>Drainage problems and Solutions</u>

- Mapping depicting the current known problem areas and their location within the county are included within the Plan. Mapping is based on municipal and stakeholder surveys conducted during Phase 1. The means for addressing these problems are addressed in various locations throughout the Plan and with a detailed description and breakdown of specific BMP measures that can be implemented in order to alleviate a specific problem area's impact on the watershed(s) in which it is located. The most common problems were identified and specific criteria for alleviating their impacts are included in this Plan.

<u>Stormwater Collection and Conveyance Systems</u>

- Based on the reduced scope of the project and Plan development and based on limited historical information pertaining to existing collection and conveyance systems, a detailed review of such systems and their impacts on flooding or stormwater runoff has not been included in this plan. This task will be addressed in more detail during the next planning cycle.

Alternative Runoff Control Techniques

- Based on the reduced scope of the project and Plan development, specific criteria for identifying alternative runoff control techniques on a watershed-by-watershed basis has not been included in this plan. These criteria should be considered for future revisions of the plan. In lieu of prioritization of localized implementation criteria, the Plan shall be used in broader terms and currently contains information on addressing several factors that may or may not be present in each specific watershed. This task will be addressed in more detail during the next planning cycle.

Federal, State, and Local Flood Control Projects

- As of the publication of this Plan, no known flood control projects exist or are intended for implementation. Future revisions of the Plan should incorporate any new flood control projects and their potential impacts on the watershed(s) in which they reside.

Identification of Areas for Future Stormwater Collection and Conveyance Systems

- Growth in Lawrence County is slow and sporadic enough that the County and municipalities are primarily in a reactive mode regarding extension of stormwater collection and control facilities. Based on the reduced scope of the project and Plan development, specific criteria designating areas to be served by stormwater collection and control facilities have not been included. Consequently, estimates relating to the design capacity and cost of such facilities are not included in this planning cycle. The Model Stormwater Ordinance within this Plan, and required to be adopted by each municipality (in its simplest form) does contain information and guidelines related to financing, construction and operation, and institutional arrangements to implement and operate the facilities. The information provided is intended as guidance information only. This task will be addressed in more detail during the next planning cycle.

Location of Flood Plains

- Mapping depicting the current FEMA flood plain and flood hazard areas and their location within the county is included within the Plan.

Criteria and Standards for Stormwater Control

- The Model Stormwater Management Ordinance contained within this Plan contains specific criteria and standards for the control of stormwater runoff from existing and new developments that are necessary to minimize dangers to property and life and carry out the purposes of the Plan. At its most basic structure, this Model Ordinance is required to be adopted by each municipality (more stringent measures can be enacted on a municipality-by-municipality basis).

Plan Implementation Priorities

- Only Marshall and Coffee Runs are addressed in this planning cycle. All other watersheds identified in the Phase 1 Scope of Study were excluded from this planning cycle. Based on the limited scope of the project and Plan development, specific criteria for implementation on a watershed-by-watershed basis have not been included in this plan. These criteria should be considered for future revisions of the Plan. In lieu of prioritization of specific implementation factors, the Plan shall be used in broader terms and currently contains information on addressing several factors that may or may not be present in each specific watershed. This task will be addressed in more detail during the next planning cycle.

It is required that the plan be reviewed and revised in five (5) year cycles in order to identify and address the relevance of the plan as well as addressing the following items that may not be included in the current plan and are related to mitigation of future problems and consistency with other land use plans:

- This allows for the identification of new problems or areas within the watershed that require attention and potential strategies for alleviating them. Plan revision also allows for the implementation of newer and more efficient technical strategies and procedures for the management of stormwater runoff.
- This allows for the implementation of new regulatory practices and resolutions that may have been enacted at the local, State and Federal levels that influence the management and future management of stormwater runoff. This includes new regulatory guidance and land use plans that impact future development and stormwater runoff management methods and technology.

Detailed stormwater management measures and BMP information can be found in the Pennsylvania Stormwater Best Management Practices Manual, (Document #363-0300-002), prepared by the Pennsylvania Department of Environmental Protection (PADEP BMP Manual). Such information includes:

- Selection Criteria
- Sizing and Computational Information
- Maintenance
- Construction Specifications
- Applicability
- Safety Procedures

The PADEP BMP Manual is the key source for information concerning acceptable and applicable stormwater management BMP measures in Pennsylvania that will allow the designer to achieve conformance with Control Guideline – 1 (CG-1) or Control Guideline -2 (CG-2), which is outlined within the manual.

In addition, the department shall, in consultation with the Department of Community Affairs, review all watershed storm water plans and revisions or amendments thereto. It shall approve the plan if it determines:

- That the plan is consistent with municipal flood plain management plans, State programs which regulate dams, encroachments, and water obstructions, and State and Federal flood control programs; and
- That the plan is compatible with other watershed storm water plans for the basin in which the watershed is located, and is consistent with the policies and purposes of this act.

PennDOT and Pennsylvania Turnpike Commission Projects

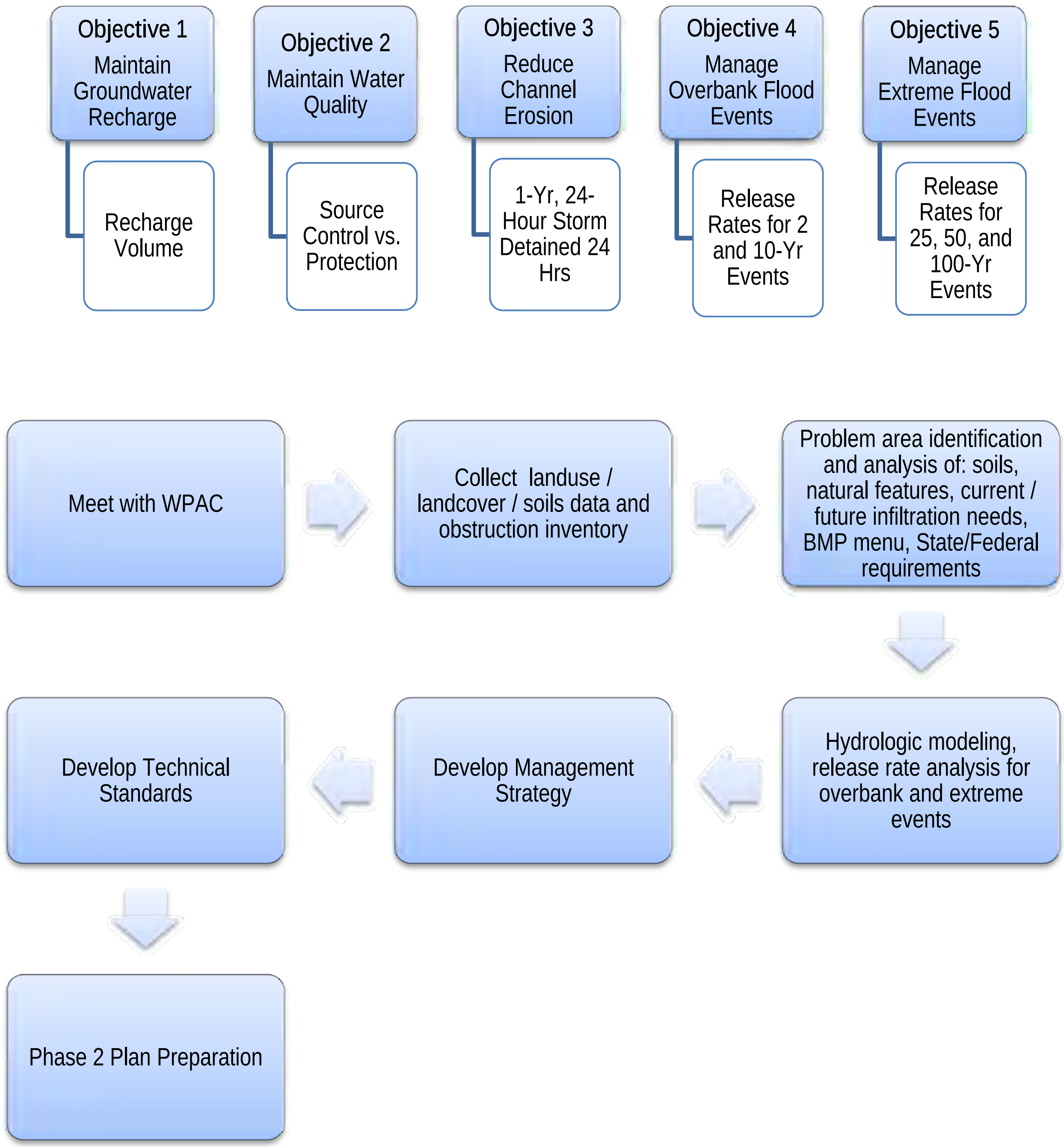
In addition to the information contained herein, for projects regulated by PennDOT or the Pennsylvania Turnpike Commission (PTC), the following shall govern their administration:

For purposes of Act 167 Stormwater Management Plans (Plans), design policy pertaining to stormwater management facilities for PennDOT and PTC roadways and associated facilities are provided in Sections 13.7 (Anti-degradation and Post Construction Stormwater Management Policy) of PennDOT Publication No. 13M, Design Manual Part 2 (August 2009), as developed, updated, and amended in consultation with PADEP. As stated in DM-2.13.7.D (Act 167 and Municipal Ordinances), PennDOT and PTC roadways and associated facilities shall be consistent with Act 167 Plans. DM-2.13.7.B (Policy on Anti-degradation and Post Construction Stormwater Management) was developed as a cooperative effort between PennDOT and PADEP. DM-2.13.7.C (Project Categories) discusses the anticipated impact on the quality, volume, and rate of stormwater runoff.

Where standards in Act 167 Plans are impracticable, PennDOT or PTC may request assistance from DEP, in consultation with the county, to develop an alternative strategy for meeting state water quality requirements and the goals and objectives of the Act 167 Plans.

For purposes of this Act 167 Plan, road maintenance activities are regulated under 25 Pa Code Chapter 102.

Figure V-1
Five Comprehensive Management Objectives and Analysis Process



Objective 1 – Maintain Groundwater Recharge

Surface water reaches the ground surface and then sheet flows to adjacent streams or water bodies. A portion of this surface water returns to the atmosphere through evapotranspiration or sublimation. Yet another percentage of the water returns to the soil through infiltration and groundwater recharge. Typically, water infiltrates through the soil until it is transferred through the evapotranspiration process or it reaches the groundwater table and replenishes the local aquifer.

The movement of water through the sub-surface is complex, and less permeable soils, clay layers, and rock strata are often encountered, especially in areas in the central and western portions of Pennsylvania. This water moving through the soil is typically referred to as one of the following:

- Gravitational water or drainage water
- Capillary Water (water held in soil pores by surface attraction, sometimes called "capillary action")
- Hygroscopic Water (water tightly held within soil particles and removable only through the physical drying process of the soil)

While capillary water does play a role in evaporation processes, gravitational/drainage water is the primary concern from a stormwater management perspective. Figure V-2 provides an illustrative representation of the water cycle process.

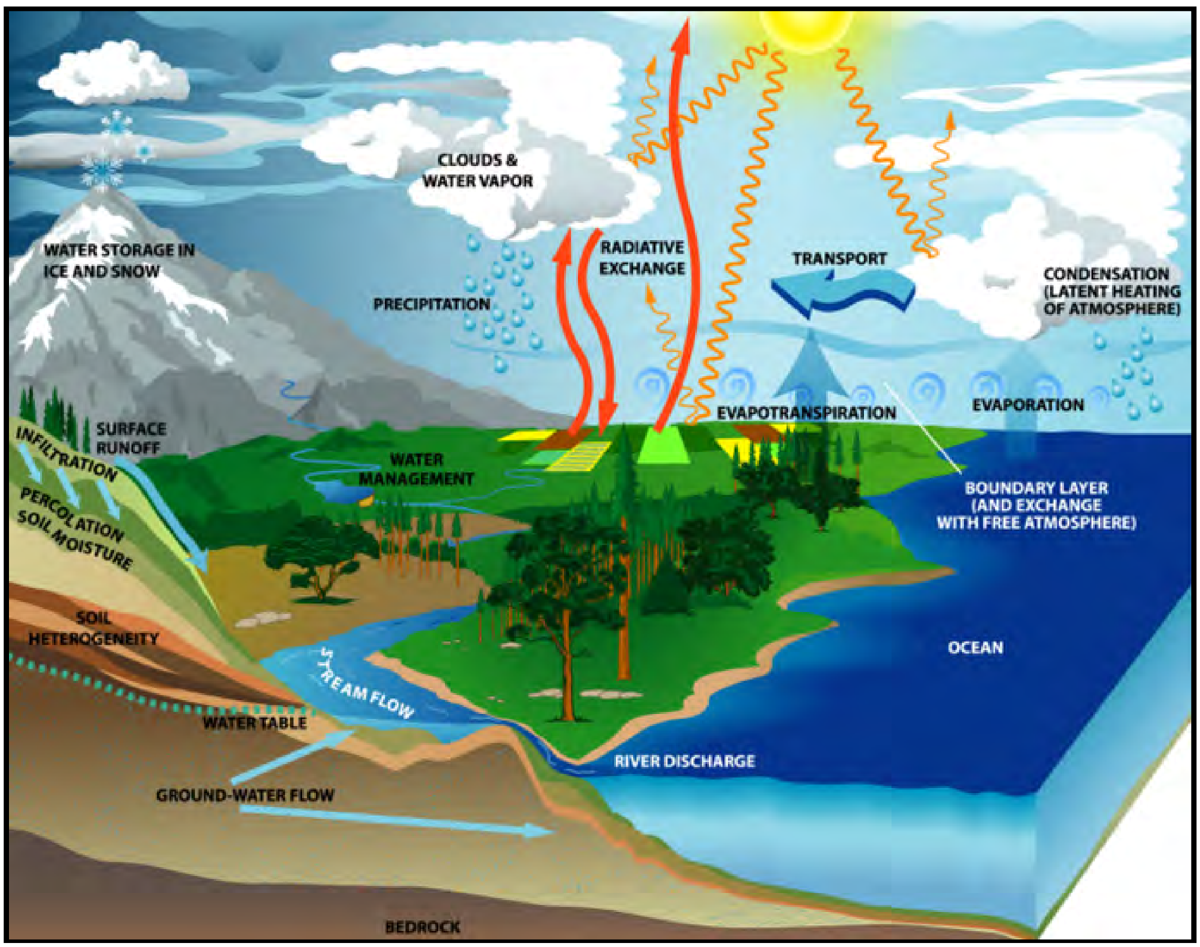


Figure V-2
(US Climate Change Science Program, 2003)

The process and ease by which gravitation water is transmitted through soil layers is based upon several factors. These factors include:

- Layering
- Structure
- Texture
- Presence of macropores (flow pathways within the soil)

The texture of a soil is based upon the ratio of sand, clay, and silt present in the soil. The permeability and hydraulic conductivity of a soil layer is significantly affected by the grain size of the soil layer. In general, these flow characteristics decrease as the grain size of the soil layer decreases. Gravitation or drainage water moves more easily through sand than it does through silty or clay-based soils. The texture of an individual soil layer also influences the shape of the wetting front as water travels through it due to the cohesive forces of both the water and the soil particles themselves.

One of the most critical components of understanding the methods and practice by which the designer will recharge the existing groundwater aquifer is by gaining an understanding of the specific soils on a project site and how their individual characteristics will influence the infiltration and absorption of excess stormwater runoff.

Maintaining groundwater recharge helps maintain watershed hydrology and is a method of meeting specific stormwater management regulations for volume control, peak-rate control, and even water quality.

There are many acceptable and practical methods for infiltrating water and thereby meeting the requirements for ground water recharge. The PADEP BMP Manual breaks BMPs down by the desired function of the designer as well as by structural or non-structural methods. Non-structural methods can be a cost effective means of addressing the infiltration/recharge issue, as well as the other necessary technical objectives when dealing with stormwater runoff. However, there are times when non-structural methods are not practical or cannot provide the necessary results from a quantitative standpoint. Some of the more common structural and non-structural BMP applications are listed in Table V-2.

Table V-2[8]

Recommended BMPs for Groundwater Recharge/Infiltration

Non-Structural BMPs	Structural BMPs
Protection of Sensitive Areas	Infiltration Basins and Trenches
Site Clustering	Subsurface Infiltration Beds
Minimize Soil Compaction	Drywells/Seepage Pits
Reduce Street/Parking Imperviousness	Constructed Filters
Minimize Total Disturbed Area	Rain Gardens
Rooftop Disconnection	Floodplain Restoration Practices

[8] BMP methods are taken directly from the Pennsylvania DEP's, *Pennsylvania Stormwater Best Management Practices Manual*, and are intended for use in the most commonly encountered site conditions. Specialized BMPs should be used as necessary.

A comprehensive list of non-structural and structural BMPs and their applicability towards a specific technical objective can be found in Figures V-7 and V-8 at the end of this chapter.

The requirements pertaining to the proper and adequate design, sizing and application of stormwater BMPs shall be in strict accordance with local and Commonwealth regulations, as well as the design information contained in the PADEP BMP Manual. The PADEP BMP Manual provides comprehensive information concerning the applicability of specific BMPs as well as other necessary requirements concerning soil testing, case studies, available resources, design formulas, information pertaining to vegetative covers, and other necessary guidance materials. It should be noted however, that while the PADEP BMP Manual is the preeminent source for proper BMP design in Pennsylvania, it is intended to be used as a guide and should not discourage the experienced design professional from using additional BMPs or to curtail the innovative process and application of stormwater management methods that may not be listed in the current BMP Manual version. While the manual does contain specific guidelines and criteria that must be followed, it is not intended to be the sole source for stormwater management design. Additional and hybrid management methods will be considered by the proper regulatory agency on a case-by-case basis.

Another additional factor to consider during the implementation of recharge/infiltration BMP usage is the surrounding site conditions. Not all sites chosen for development will be sites that have been untouched and undisturbed for several years. There are also specific sites within the Commonwealth that have been identified for their special contribution to the waters of the Commonwealth or have been deemed environmentally sensitive areas. The PADEP BMP Manual refers to these specific types of sites as "special management areas." The following list identifies some of the more commonly encountered special management areas:

- Karst Areas
- Brownfields
- Previously Mined Areas
- Surface and Well Water Supply Areas
- Highways and Roads
- Special Protection Watersheds (High-Quality and Exceptional Value Watersheds)

Special care and consideration must be taken when these types of sites are encountered. The presence of such sites does not necessarily prohibit the designer from using infiltration practices. However, specific guidelines and overall environmentally sensitive decisions should be exercised when these types of sites are encountered. These types of sites are extremely prevalent in western Pennsylvania, with the possible exception of karst areas, which tend to occur more often in central and southeastern Pennsylvania.

Karst Areas: Karst is the description given to areas underlain by substantial areas of carbonate bedrock (limestone and dolomite) that have been partially dissolved. The movement and shifting motion this specific type of strata over millions of years have caused fractures and faults to develop. These fractures have also undergone substantial chemical weathering by weakly acidic water. This has caused the bedrock to dissolve, leaving behind voids and severely weakened areas. These voids are a major contributor to such anomalies as sinkholes, caves, and surface depressions. These areas are also often related with significant variations in the depth to bedrock and groundwater tables, as well as streams that "disappear" into the subsurface. A decision concerning the use or non-use of infiltration in these areas is a critical one. While infiltration is recommended, it must be done only after careful consideration and selective decision-making has taken place. Extensive subsurface investigation is recommended in these areas and special care should be used when selecting the areas on the development in which to attempt infiltration. The presence of karst topography does not need necessarily need to be a prohibitive factor in the decision to infiltrate. Source control (reducing surface runoff at the point it is created) is another important factor. Reducing the overall amount of runoff generated will greatly aid in the design required for the infiltration process.

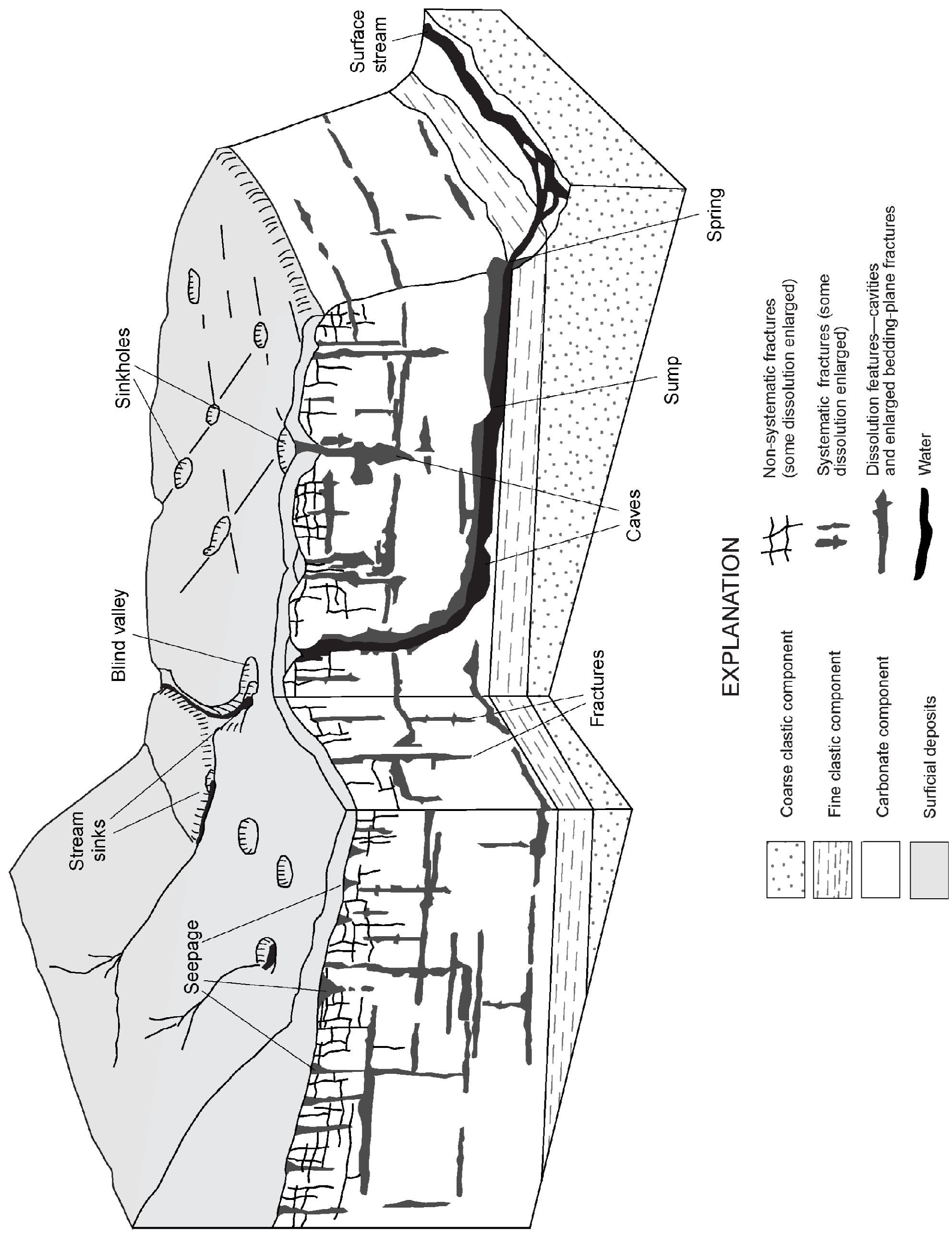


Figure V-3
(Lively, 1995)

The PADEP BMP Manual suggests some of the following BMPs for application in karst areas:

Table V-3[9]

Recommended BMPs for Karst Areas

Increased Storage	Increased Infiltration	Decreased Velocity	Pollution Control / Water Quality
Dry Detention Ponds	Runoff/Level Spreaders	Increased Vegetation Density	Filter Berms
Wet Retention with Lined Settling Ponds	Porous Pavement	Vegetated Swales	Gravel or Sand Filtration Systems
Shallow Detention Ponds	Improved Sinkholes / Class V Injection Wells[10]	Terraced Slopes	Peat Moss or Activated Carbon Filtration Systems
Vegetated Roofs	Perforated Pipes	Rip Rap (preferably using carbonate rock, e.g. limestone)	Constructed Wetlands (Lined)
	Bioretention Cells/Rain Gardens		Increased Vegetation Density/Rain Gardens
			Compost

Brownfield Areas: Brownfields are areas within the Commonwealth where the potential presence of hazardous materials and pollutants could hinder future development. Applicable laws concerning the classification of brownfields should be consulted prior to beginning the process of any potential development work; however, brownfields can often be found in areas (though not limited to) that fall into the following categories:

- Abandoned steel mill facilities or sites
- Abandoned industrial facilities or sites
- Areas where petroleum or petroleum by-products were stored (e.g. fueling stations)
- Areas related to specific mining activities
- Abandoned commercial facilities or parking facilities

Areas such as these pose a threat to the environment by being contaminated with a number of possible pollutants.

However, while these areas are often deemed a blight on the community, they are prime locations for the use of smart-growth technologies. The redevelopment of these sites can help revitalize depressed areas, contribute to environmental clean up through mitigation of the hazardous materials, and serve the public interest by providing a mixed-use environment to help the community thrive.

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[9] BMP methods are taken directly from the Pennsylvania DEP's, *Pennsylvania Stormwater Best Management Practices Manual*.
[10] Class V Injection wells are used to inject non-hazardous fluids underground. The more common types of injection wells include simplistic, gravity-based systems (e.g. stormwater drainage wells, cesspools, septic tanks) and more sophisticated systems such as aquifer storage/recovery wells and geothermal electric power wells. (United States Environmental Protection Agency, 2007)

When applying for any permits for a site deemed as a brownfields site, it is important to disclose the following information, as well as any other necessary or requested information, per the PADEP BMP Manual:

- Existing and previous land uses
- Potential pollutants, along with a summary of sampling data.
- Source and location of the potential pollutant(s) on the Erosion and Sediment Control (E&S) Plan drawings,
- A description of what measures are proposed to manage and control discharges of these pollutants to eliminate the potential for pollution to surface waters of the Commonwealth.

Table V-4[11]

Recommended BMPs for Brownfields

Soil Contact Areas	Non-Soil Contact Areas
Bio-Retention in areas where soil has been remediated or pollutants are NON-SOLUBLE in nature. Soils containing soluble pollutants should be filtered through the bio-retention areas and then allowed to exit via by-pass piping. Infiltration in these areas should not be permitted.	Stormwater Collection/Re-Use • Vegetated Roofs • Cisterns • Rain Barrels

Stormwater management options are available for use on brownfield sites where the contaminated soil has been completely removed from the site. These options include minimizing earth disturbance and soil compaction, minimizing impervious areas, maximizing stormwater infiltration (where applicable), and dispersing runoff to BMPs scattered across the site rather than concentrating runoff to just a few locations.

With the exception of structural stormwater infiltration BMPs, the stormwater management BMP measures listed in PADEP BMP Manual are also available for use on brownfield sites where potentially contaminated soil is isolated and sealed, or the contaminated soil was blended with clean soil. Since soil contaminants are still present at these sites, the use of structural stormwater infiltration BMPs should be used only if the residual soil contaminants are non-soluble pollutants.

Refer to the PADEP BMP Manual and supporting documentation for additional information on stormwater management, remediation, and environmental due diligence concerning the development of brownfield sites.

Highways and Roads: Highways and roadways within the Commonwealth have the potential to severely affect the hydrologic integrity of any watershed. The increase of impervious area (a near certainty in new roadway construction) results in excessive peak runoff rates and volumes. The other key issue concerning highway and roadway construction in relationship to stormwater management is that of water quality. The potential for heavy metals, de-icing salts and chemicals, petroleum pollutants, hazardous materials from vehicular spills, as well as thermal impacts during hot-weather months, can all contribute to de-graded water quality. The following table taken from the PADEP BMP Manual lists suggested BMPs available for roadway and highway applications:

[11] BMP methods are taken directly from the Pennsylvania DEP's, *Pennsylvania Stormwater Best Management Practices Manual*, and are intended for use in the most commonly encountered site conditions. Specialized BMPs should be used as necessary.

Table V-5[12]

Recommended BMPs for Highway and Roadway Applications

Non-Structural BMPs	Structural BMPs
Reduced roadway/cartway widths (as applicable, and in accordance with all local and Federal regulations)	Vegetated Swales and Infiltration Trenches along contours perpendicular to the road and along the right-of-way
Reduction or elimination of curbs and gutters	Bioretention areas along the roadway
Reduction of stormwater collection/conveyance infrastructure (as applicable, and in accordance with all local and Federal regulations)	Bioretention and Bio-Infiltration in cul-de-sac areas
	Catch Basin Inserts and Treatment Devices

Mined Areas: Areas of proposed development that have been previously mined should be treated with special care. Areas that have been strip/ surface mined or are underlain by deep wall mining facilities are an extremely difficult location in which to apply stormwater BMPs. Acid mine drainage caused by previously (and presently) mined areas is one of the largest environmental problems in Pennsylvania. The infiltration and percolation of water through mined areas has resulted in thousands of miles of contaminated streams and waterways. Infiltration and groundwater recharge BMPs are prohibited in such areas, thus rendering most available structural BMPs unusable for development in these areas. There are only a few acceptable and practical structural BMP methods available for use in these areas. BMPs such as vegetated roofs and capture/re-use (e.g. rain barrels) methods are applicable. Limiting and prohibiting infiltration or percolation of stormwater runoff into previously mined sites is of the utmost importance.

The most reasonable solution for the management of runoff is through the re-direction of stormwater runoff from areas contaminated with mine wastes. If this is not entirely feasible then the use of lined BMPs should be considered to separate the runoff from the contaminated soils. Lined detention basins for rate mitigation are an option for storage. Volume reduction in these areas is specifically difficult to achieve. Rate mitigation and water quality should be the primary factors for the designer. The most important item to consider when proposing a plan for development is to provide for the protection and restoration of native vegetative cover to the greatest extent possible. Natural vegetative cover provides the best method of treating and restoring these soils back to their native conditions (Pennsylvania Department of Environmental Protection, 2006).

Groundwater Supply Areas: Any stormwater management practice in areas adjacent to ground water supply sources is of critical importance. It is estimated that approximately half of Pennsylvania's residents receive their drinking water from ground water supply sources (Pennsylvania Department of Environmental Protection, 2006)

In relationship to the protection of groundwater supplies, three (3) zones must be taken into consideration when proposing the use of infiltration practices for new development:

- Zone 1 – The innermost protective zone surrounding a well, spring, or existing infiltrative gallery. This zone ranges from 100 to 400 feet depending on the site-specific source and characteristics of the aquifer (Pennsylvania Department of Environmental Protection, 2006). Proposed infiltration BMPs should not be located in Zone 1 protection areas (Pennsylvania Department of Environmental Protection, 2006).

[12] BMP methods are taken directly from the Pennsylvania DEP's, *Pennsylvania Stormwater Best Management Practices Manual*, and are intended for use in the most commonly encountered site conditions. Specialized BMPs should be used as necessary.

- Zone 2 – The capture zone that encompasses the area of the aquifer through which it supplies water to a well, spring, or existing infiltration gallery. This zone is determined to be a one-half mile radius around the source unless more extensive hydrogeological testing is done. Extreme care should be used when implementing infiltration BMPs in Zone 2 areas. Aquifers can become easily contaminated, and therefore extensive pretreatment measures should be used to filter and diminish pollutants (Pennsylvania Department of Environmental Protection, 2006).
- Zone 3 – The area beyond the capture zone and contributes significant recharge to the capture zone aquifer in Zone 2 (Pennsylvania Department of Environmental Protection, 2006).

  A minimum distance of 50 feet should be used when placing infiltration BMPs adjacent to privately owned wells and water sources serving non-community supply systems (Pennsylvania Department of Environmental Protection, 2006).

As in nearly all instances, some of the best measures available for adequately managing stormwater runoff are to eliminate or reduce the amount of runoff at its source of generation. This can be done by reducing impervious areas or through the capture and re-use of stormwater runoff. Another recommended practice is the scattering of stormwater BMPs across the entire development site. The measure of dispersing stormwater runoff more evenly helps to maintain the hydrological balance within the watershed and helps to prevent the concentration of runoff quantities and pollutants at only a few points within the watershed. The pre-treatment of stormwater runoff prior to dispersing it can make water quality mitigation much easier and more effective.

Table V-6[13]

Recommended BMPs for Areas Adjacent to Ground Water Supply Areas

Non-Infiltrative BMPs
Reduce Parking Imperviousness
Rooftop Disconnection
Vegetated Roof
Rain Gardens/Bioretention
Capture and Re-Use
Wet Ponds
De-icing alternatives consisting of sand or other inert materials

Surface Water Supply Areas and Special Protection Watersheds: Stormwater management practice in areas adjacent to surface water supply sources and special protection watersheds (exceptional value, EV and high quality, HQ, as determined by the PA DEP) is of critical importance. The PA DEP anti-degradation requirements can be met in these watersheds by infiltrating a volume in the post-development conditions that is equal or greater than that of the pre-development infiltration volume. Another component of this requirement is that the post-development runoff is pre-treated and managed so that it will not degrade the physical, chemical, or biological characteristics of the receiving water body (Pennsylvania Department of Environmental Protection, 2006).

The project should be designed and constructed in a manner that will minimize the amount of impervious area. Any post-development runoff that is generated should then be infiltrated to the maximum extent possible. Water quality BMPs should be implemented across the site for adequate treatment but also to help in spreading the water across

[13] BMP methods are taken directly from the Pennsylvania DEP's, *Pennsylvania Stormwater Best Management Practices Manual*, and are intended for use in the most commonly encountered site conditions. Specialized BMPs should be used as necessary.

the watershed and not concentrating it at only a few points. The last component is that the final volume and rate of any stormwater discharge must be properly managed to prevent the physical degradation of the receiving waterway, including scour and stream bank stabilization. Appropriate BMPs for pre-treatment and for addressing water quality issues can be found in Table V-7, later in this chapter.

While infiltration is a key factor in stormwater management in areas adjacent to surface water supply areas and special protection watersheds, care must be taken during the design process. Any proposed infiltration BMPs within two miles on either side of surface water supply areas or special protection waters must be designed and constructed to provide maximum pollutant removal prior to the runoff being infiltrated or discharged to the receiving stream.

The proximity of infiltration areas and adjacent surface water areas and special protection waters should follow the following guidelines:

- Zone A – Represents a 1/4 mile buffer on either side of the river or stream extending from the area 1/4 mile downstream of the intake upstream to the five hour time-of-travel (TOT) (Pennsylvania Department of Environmental Protection, 2006).
- Zone B – Represents a two-mile buffer on either side of the water body extending from the area 1/4 mile downstream of the intake upstream to the 25 hour TOT. (Pennsylvania Department of Environmental Protection, 2006).
- Zone C – The remainder of the watershed area (Pennsylvania Department of Environmental Protection, 2006).

Objective 2 - Water Quality

Maintained landscape areas and impervious surfaces (e.g. roadways, parking lots, common pedestrian areas, etc.) collect pollutants that are carried in solidified form, or are dissolved and transported via runoff to the surface waters of the Commonwealth. Pollutants such as nitrates, phosphorus, suspended solids, oils, and petroleum by-products can be transported to, and cause the pollution of nearby streams and lakes.

It has been shown in many studies that these pollutants display their heaviest concentrations at the start of a runoff event, often referred to as the “first flush.” Many particulates such as suspended solids, trash/litter, heavy metals, organic particles and clay particles can often be observed in a water body prior to the occurrence on the peak runoff.

Areas where accelerated pollutants are generated in are often referred to as pollutant “hot spots.” These hot spots often occur at the following locations:

- Fueling Stations
- Parking Lots
- Dumpsters and Trash Disposal Areas
- Industrial Sites
- Areas Prone to Heavy Travel and Traffic

While these areas appear obvious as potential sources of pollution, the notion that pervious areas do not generate pollution is a large misconception. Maintained lawns, landscaped areas, gardens, and other “natural” areas can cause pollution due to the use of chemicals and fertilizers. An undisturbed, pervious area can often possess the ability to treat and remove pollutants from direct runoff. However, the previously mentioned areas are often constructed upon heavily compacted soils that do not allow any natural infiltration or surface filtration of potentially polluted runoff. In essence, these heavily compacted areas can often take on the physical characteristics of impervious (e.g. paved, concrete, rooftops, etc.) areas.

The proper approach to managing stormwater quality is a two-phased method. The first phase is control of point source of pollutants, and the second phase is protecting, restoring, and creating the natural systems that are able to capture and remove these pollutants from direct stormwater runoff.

Stormwater quality and quantity are inherently linked. Their singular management can become a simultaneous endeavor, even in situations where this is not the designer's initial intent. This is related to the fact that many stormwater *quantity* BMPs, by the nature and physical process of how they function, actual serve as effective stormwater *quality* BMPs as well.

The two most common types of pollutants found in stormwater runoff are solutes (dissolved particles) or particulates (particles still in solidified form). An example of these two types of pollutants can be found by examining two common fertilizers, phosphorous (often referred to as total phosphorus or TP) and nitrate (NO_3). Stormwater BMPs that rely on filtration or delayed detention are highly effective at the removal of total phosphorous because the pollutant typically remains in particulate form and will bond to colloidal soil particles. This keeps the particulates larger in size, making them more easily captured.

Nitrates on the other hand, tend to be found in soluble form and are not impacted by structural BMPs that rely on filtration or capture of suspended solids. Therefore, it is imperative to consider exactly what types of pollutants are to be targeted.

As with many BMP applications, when compared with their intended use, the use of a cost-benefit analysis can often be a useful tool in determining the most effective means of implementing a BMP treatment design. While it may seem elementary in nature, one additional method of treating pollutants is to curtail the generation of them at the source. The selection of vegetative cover that requires little to no treatment or fertilization, emergency spill management plans, oil/grease separation devices, and any other means that either eliminates/decreases the potential for pollutants, or greatly aids in their immediate capture prior to being introduced to stormwater runoff is a very effective means of treating potential pollutants.

The PADEP BMP Manual offers many non-structural and structural solutions for treating pollutants in stormwater runoff that will help the designer meet the requirements of the technical objectives for water quality. Table V-3 lists some of the more common and recommended BMPs for water quality.

Table V-7[14]

Recommended BMPs for Water Quality Treatment

Non-Structural BMPs	Structural BMPs
Protect Sensitive and Special Value Areas	Landscape Restoration
Protect/Conserve/Enhance Riparian Areas	Constructed Wetlands
Cluster Uses at Each Site; Build on Smallest Area Possible	Vegetated Filter Strips
Concentrate Uses Area Wide Through Smart Growth Practices	Constructed Filters
Minimize Soil Compaction in Disturbed Areas	Infiltration Trenches/Infiltration Basins
Re-Vegetate and Re-Forest Disturbed Areas, Using Native Species	Subsurface Infiltration Beds

[14] BMP methods are taken directly from the Pennsylvania DEP's, *Pennsylvania Stormwater Best Management Practices Manual*, and are intended for use in the most commonly encountered site conditions. Specialized BMPs should be used as necessary.

A comprehensive list of non-structural and structural BMPs and their applicability towards a specific technical objective can be found in Figures V-7 and V-8 at the end of this chapter.

Another area of particular concern in regards to water quality is that of impaired waters and total maximum daily/pollutant loadings (TMDLs).

Using the watershed approach requires selection or definition of watershed size, and begins with a comprehensive assessment of water quality problems in the watershed. Pennsylvania has already begun this effort with its Un-assessed Waters Initiative, which will assess over 83,000 miles of surface waters. After water quality problems are identified, a planning process occurs to develop strategies that can successfully address and correct water pollution problems in the watershed. Pennsylvania is using this process, in conjunction with federal Clean Water Act requirements, for establishing TMDLs to clean up polluted streams so that they meet water quality standards. Water quality standards are the combination of water uses, such as water supply, recreation and aquatic life, to be protected and the water quality criteria necessary to protect them.

TMDLs must be developed for several categories[15]:

- Point sources (permitted sewage and industrial discharges)

  Point source TMDL development is very similar to developing water quality-based effluent limitations for water discharge permits. The TMDL is developed to meet water quality standards for the critical period during the summer, when streams are at low flow and the effluent makes up a greater percentage of the water. This method assures that under less severe conditions, water quality will also be protected. DEP has carried out this same type of analysis using several well-established modeling tools for many years under the National Pollutant Discharge Elimination System (NPDES) program. Under this program, DEP calculates limits on the amount of pollutants that sewage and industrial facilities may discharge and still protect water quality. New tools were not needed for these types of TMDLs and most have been completed. By regulation, the TMDLs are implemented through DEP's issuance and enforcement of permits.

- Nonpoint sources (agriculture and urban runoff)

  Nonpoint sources are not subject to the same regulatory requirements as point sources.

  Furthermore, the critical period for nonpoint or runoff sources is not during low flow conditions, but when rainfall washes pollutants across the land and into the streams. For these reasons, the tools that determine TMDLs for point sources do not work for nonpoint sources. DEP has developed a reference watershed approach to develop nonpoint source TMDLs. This method compares an unimpaired watershed of similar size, geology and land use distribution to the impaired watershed. Geographic Information Systems (GIS) technology is employed in the characterization of land use, background pollutant concentrations in soil and groundwater and other physical and chemical properties of each watershed. Computer simulation models are then used to estimate the loading rates in each watershed and to determine the load reductions of pollutants needed to correct the impairment. A load allocation is assigned to each contributing source, and those sources identified as the causes of impairment are given prescribed reductions. The TMDL sets the stage for citizens to define a plan to correct the impairments. DEP will support their efforts to develop the plan and, through Growing Greener grants, will provide funds to put practices in place to correct the problems. For nonpoint source TMDLs, the input of local citizens replaces the regulated implementation procedures for point source TMDLs.

[15] Per PA DEP Document 3800-FS-DEP2248

- Lakes

  Lakes have characteristics that differentiate TMDLs from other waters. Lakes are not free flowing like streams, but are contained waters that trap pollutants for long periods. Most lake impairments are from high nutrient or sediment loads. Wherever possible, lake TMDLs are developed with the information in the lake study reports that were sponsored by local watershed groups or other local interests. Target acceptable pollutant loads are set at the level of a watershed largely unaffected by human induced impacts. Load allocations are given to the pollutant sources using the same methods as nonpoint source TMDLs. Other indicators of water quality are also considered in the evaluation of a lake. One indicator is the Tropic Status Index (TSI), which refers to the degree of nutrient enrichment in the lake. Nutrient enrichment causes growths of algae that consume oxygen and interfere with the health of the aquatic organisms in the lake. The TSI is affected by factors such as lake volume, water residence time and nutrient loads to the lake. After target loads are set, the TSI is evaluated under reduced nutrient load conditions to assure that the pollutant reductions will bring the TSI into an acceptable range. Implementation of lake TMDLs is best accomplished though local participation.

- Abandoned mine drainage (also called acid mine drainage or AMD)

  AMD from abandoned surface and underground coalmines is a leading source of impairment to Pennsylvania waters. AMD can seriously degrade the aquatic habitat and the quality of water supplies because of toxicity, corrosion, incrustation and other effects from dissolved constituents. The TMDL analysis of AMD streams uses a statistical method of determining the in-stream allowable loading rate at the point of interest in the stream. Discharges that are permitted or have a responsible party are point sources, and make up the waste load allocation portion of the TMDL. Nonpoint sources are all other sources and constitute the load allocation. AMD impaired watersheds are evaluated for aluminum, iron, manganese and pH using statistics and Monte Carlo (probability) simulations to model existing conditions, to determine required reductions and to calculate allowable concentrations. When the reductions are met, the water quality standards will be met.

- Specific bio-accumulative chemicals (PCBs and chlordane that contaminate fish, resulting in fish advisories limiting or banning the number of fish that a person can safely consume)

  The overall goal of a PCB/chlordane TMDL is to achieve the fishable/swimmable goal of the Clean Water Act. Fish consumption advisories are issued when fish samples exceed certain triggers. For PCBs, the advisory is based on protection of human consumers from neurological effects. A Federal Drug Administration (FDA) action level determines when an advisory for chlordane is issued. Advisories cause the water to be listed as impaired and make TMDLs necessary. The method used for PCB/chlordane TMDLs is to translate the fish tissue concentration into a water column concentration by using a bio-concentration factor. Bio-concentration factors are mathematical expressions that account for fish accumulating the pollutants in their bodies. Accumulation is based on pollutants in the sediment being ingested by small organisms, which are then consumed by larger organisms, small fish and larger fish, each time magnifying the amount of pollutant that is introduced into tissue of the consumer. The TMDL defines how much the loading of pollutant must decrease in order to meet the water quality standard. Meeting the water quality standard in the water means the fish living in the water will be acceptable to consume.

- Complex situations (combinations of different types)

  Complex TMDLs draw on the procedures for all the TMDL types previously discussed.

A list of TMDLs currently identified in Lawrence County by major watershed, along with pertinent information is listed below[16]:

Table V-8

County TMDLs by Major Watershed

Watershed	Information	Status
Beaver River	County: Lawrence, Beaver Category: Fish Consumption Cause: Chlordane, PCB HUC: 5030101, 5030104	EPA Approved 4/9/2001
Duck Run	County: Lawrence Category: AMD Cause: Metals HUC: 5030105	EPA Approved 4/9/2009
Ohio River	County: Lawrence, Allegheny, Beaver, Washington Category: Fish Consumption Cause: Chlordane, PCB HUC: 5030101, 5030106, 5030201	EPA Approved 4/9/2001
Shenango River	County: Lawrence, Mercer Category: Fish Consumption Cause: Chlordane, PCB HUC: 5030102, 5030104	EPA Approved 4/9/2001

Refer to Table III-4 in Section III for a County summary of non-attaining segments of the Streams Integrated List representing stream assessments for the Clean Water Act Section 305(b) reporting and Section 303(d) listing.[17] PA DEP protects four (4) stream water uses: aquatic life, fish consumption, potable water supply, and recreation. If a stream segment is not attaining any one of its four uses, it is considered impaired.

Objective 3 – Reduce Channel Erosion

Several areas of stream bank erosion were found within Lawrence County and the associated watersheds during the stakeholder surveys and site visits. As storm flows increase, the corresponding flow velocities in streams also increase, thus exacerbating stream bank erosion problems. Typical stream bank capacities are equivalent to approximately the 1 ½-year storm, and stream banks begin to erode when flows approximate this depth. Therefore, stream flows kept to near the one-year storm flow would minimize stream bank erosion. Detaining the 2-year post-development storm to the one-year predevelopment storm and detaining the 1-year storm a minimum of 24 hours would therefore minimize the number of storms causing stream bank erosion. However, the County does not intend to implement this approach during this planning cycle. Instead, the County will assess the effect of implementing the

[16] PA DEP TMDL Website http://www.dep.state.pa.us/watermanagement_apps/tmdl/default.aspx, more detailed information pertaining to these TMDLs and their physical properties, including locations and quantities can be found on the website
[17] PA DEP Office of Water Management, Bureau of Water Supply & Wastewater Management, Water Quality Assessment and Standards Division, 2006

proposed model ordinance countywide and evaluate whether this approach should be reconsidered during the next planning cycle

The PADEP BMP Manual's approach to mitigating the 2-yr, 24-hour stormwater runoff volume also greatly assists in achieving this Objective. The on-site retention (through infiltration, re-use, etc.) of this runoff volume interrupts site-specific stormwater runoff events and delays the arrival of any site-specific hydrographs to the watershed's point of interest (POI). The continuous delay of water contribution to a watershed's conveyance stream will greatly decrease the volume of water that the stream must convey at any one time (and flow velocity as well). This delay allows less water to be conveyed over a longer period. This not only helps restore the benefits of the natural water cycle, but also aids in the reduction of stream channel erosion.

Table V-9[18]

Recommended BMPs for Preventing Stream bank Erosion
(Tennessee Department of Environment and Conservation)

Vegetative BMPs	Structural BMPs
Stream Buffers	Infiltrative Practices to Reduce Overall Volume
Erosion Control Blankets and Netting	Detention/Retention to Delay Time to Peak of Peak Flows
Select Vegetative Covering	Sediment Filtering Devices (silt fence, interceptor devices, sediment basins, constructed wetlands, slope drains, etc.)
Disturbed Area Stabilization (e.g. mulch, sod, etc.)	Check Dams (to reduce flow velocities)
Spray Polymers and Other Binding Agents (for use in areas with very fine soil particles)	Protective Channel Linings (e.g. geotextiles, gabion baskets, rip rap linings, etc.)

Objective 4 – Manage Overbank Flood Events

Overbank and localized flooding events are a common problem in Lawrence County. Overbank events have the potential to damage conveyance structures and property downstream from the overbank event location. Overbank events are often caused by new development and the subsequent discharge of additional stormwater runoff to adjacent streams that do not have the capacity to convey the flows without exceeding the defined bed and bank of the stream.

The typical stream usually has the capacity to convey storm events up to the 2-year storm. The 2-year event is therefore generally assumed to be the point where a stream reaches its "bank full" capacity. This is the point where the stream is flowing completely full and is about to spill over bank and encroach into the adjacent flood plain.

An overbank event is typically considered a flooding event that occurs due to a rainfall between the 2-year and 10-year storm events (Center for Watershed Protection, 2000). Anything beyond the 10-year event usually floods to a much greater extent, commonly referred to as an "extreme event," which will be discussed in the next section.

The typical method for preventing overbank events is to properly manage runoff from the 2-year through 10-year storm events. This is most effectively done by not increasing the peak discharge of these storm events from the pre-development to post-development scenarios. Peak rate and volume mitigation of these storm events is a crucial

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[18] BMP methods are suggested based upon research and real-world performance, and are intended for use in the most commonly encountered site conditions. Specialized BMPs should be used as necessary.

factor in managing and preventing overbank events. In areas where there is a history of excessive overbank event occurrences, additional mitigation might be necessary to address the problem at a watershed level basis.

The necessity to go beyond managing stormwater to a degree where it is quantitatively equal from the pre-development and post-development conditions may not be adequate. Additional control measures using the “release rate” concept may be required in certain watersheds. The release rate concept will be discussed in more detail later in this Section.

While overbank events can have a detrimental impact on downstream property and structures, they also provide a beneficial effect to the ecosystem within the floodplain. The deposition of suspended sediments can help replenish topsoil to agricultural lands as well as raising the elevation adjacent to streams, which can help prevent further erosion over time. Overbank events that occur in typically rural and non-inhabited areas are often a benefit to the local ecosystem and are generally not considered for extensive mitigation measures.

Objective 5 – Manage Extreme Flood Events

Extreme events are similar to overbank events in that they represent a flooding scenario due to the lack of capacity in the conveying stream. However, these extreme events go beyond those of the previously discussed overbank events in their ability to cause damage.

Storm events in excess of the 10-year event have the greatest potential for causing extreme events. The most common storms (based on common modeling practices) that can lead to extreme events are the 25, 50, and 100-year storm events.

It is virtually impossible to eliminate all occurrences of overbank and extreme flooding events. However, it is prudent to control the frequency at which these events occur. The goal is to achieve a balance or between the recurrence interval of overbank and extreme events. This balancing point or benchmark is created so that upstream development can occur and yet not create a situation where downstream events occur on a more frequent basis and have more damaging effects.

D. Release Rate Stormwater Management District Concept (For Overbank and Extreme Events)

Throughout the Commonwealth, many of the previously created Act 167 plans implemented a “release rate” approach to stormwater management. The release rate concept is simply a way of managing post-development runoff rates by pre-determining a release rate (as a percentage value of the pre-development peak runoff rates) that is applicable to a specific watershed or portion of a watershed.

This release rate value is created to limit the amount of water being discharged from a smaller, sub-watershed area into a larger watershed area downstream. This is typically done in areas where problems already exist and flooding events are more common. Release rates are a way of over-detaining stormwater runoff to help alleviate downstream capacity problems.

A release rates is calculated by analyzing the peak rate of runoff for an overall watershed area, as well as the time at which this flow peaks. This time is then applied to each individual sub-watershed area. The rate of runoff from each individual sub-watershed area (at the overall watershed’s peak time) is documented. The runoff rate from the overall watershed is then divided by the runoff rate from the sub-watershed’s runoff rate (at the peak time of the overall watershed). If the peak runoff rate for the overall watershed is greater than that of the individual sub-watershed, a value that is greater than or equal to 1.0 is achieved. This indicates that no additional rate release constraints need to be applied to the sub-watershed area. However, if the overall watershed’s peak rate of runoff is less than that of any sub-watershed’s peak runoff (at the time to peak of the overall watershed), then a decimal value is achieved (Paul A. DeBarry, 2004)

Release Rate Calculation Example:

In a fictitious watershed consisting of two sub watersheds comprising one overall watershed, the pre-development runoff rates are shown in Figure V-4:

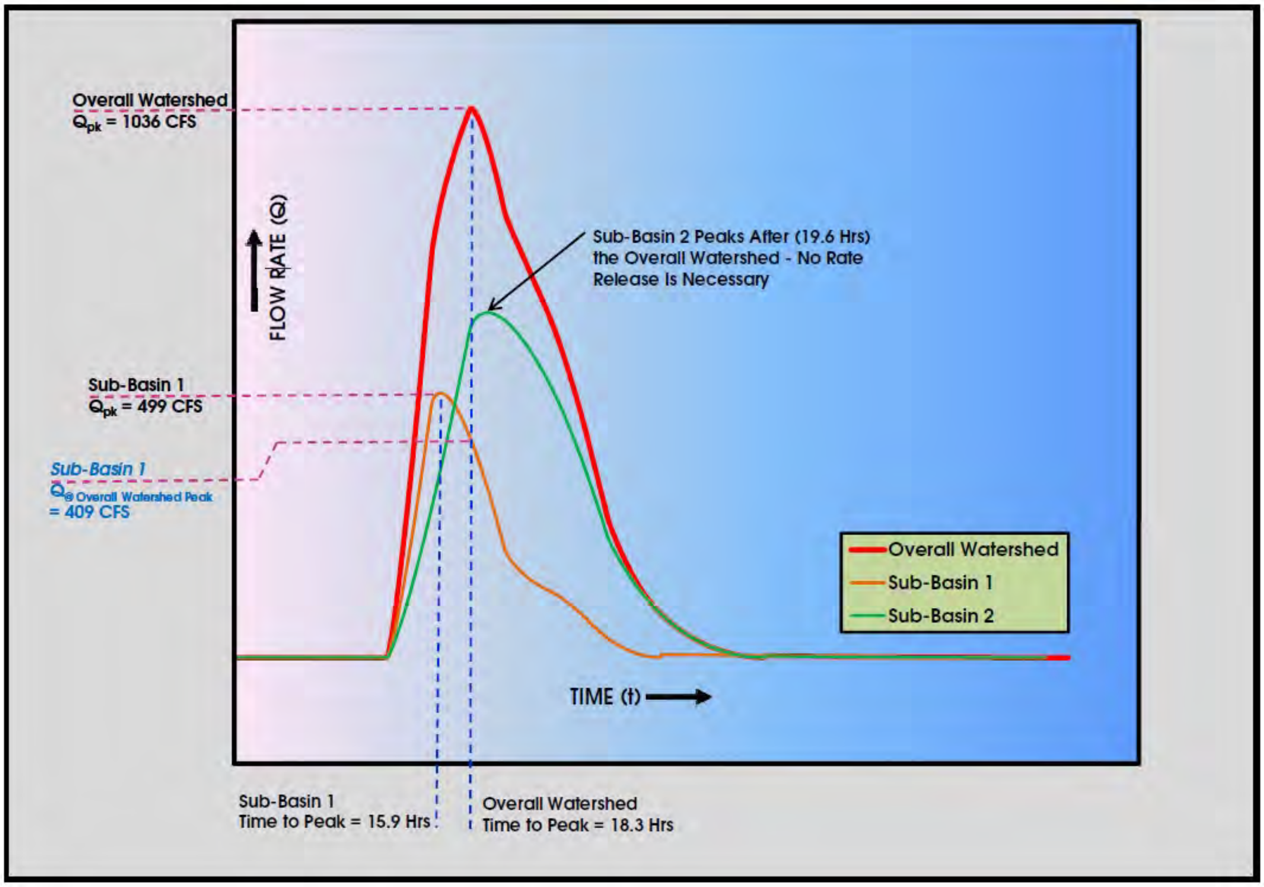

Figure V-4

The pre-development runoff rate of Sub-Basin 1 is 499 CFS and this watershed peaks at 15.9 hours. The pre-development runoff rate of Sub-Basin 2 is 650 CFS and this watershed peaks at 19.6 hours. The pre-development runoff rate of the overall watershed (Sub-Basin 1 and Sub-Basin 2 combined) is 1036 CFS and this watershed peaks at 18.3 hours.

Based upon the fact that Sub-Basin 1 peaks prior to the overall watershed, Sub-Basin 1 contributes a flow of 409 CFS at the time of peak of the overall watershed.

In the rate release method, only sub-watersheds that peak prior to the overall watershed are taken into account. Therefore, Sub-Basin 2 does not require any release controls.

Development within Sub-Basin 1 later occurs which results in an overall increase of runoff from Sub-Basin 1. The flow increases from 499 CFS to 713 CFS. Traditionally, the design of a detention structure would be implemented to control the peak rate of runoff from the developed watershed to ensure that the post-development rate is equal to or less than that of the pre-development conditions. The results of the impacts of the new detention basin that will control flow and limit post-development runoff to 499 CFS (the pre-development flow rate) are shown in Figure V-5:

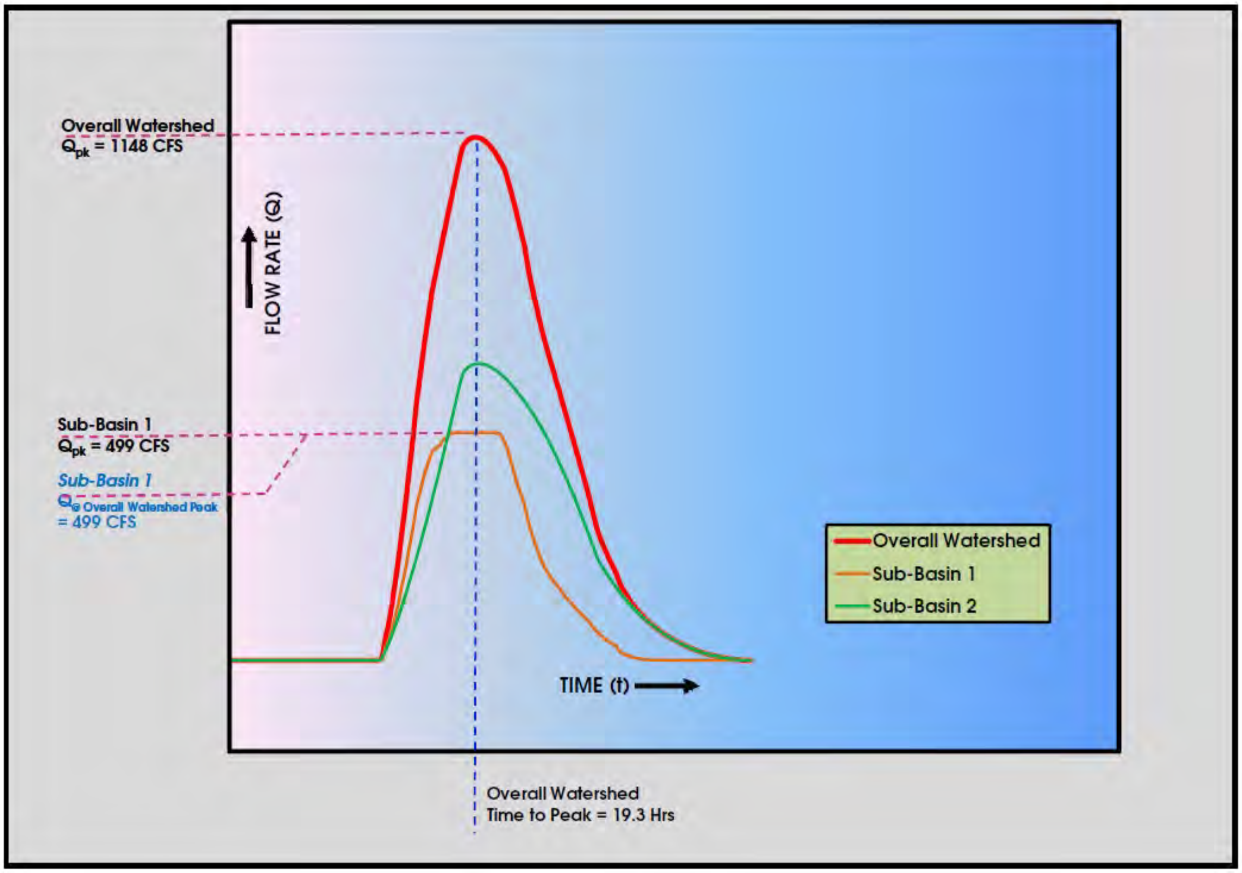

Figure V-5

As can be seen from the figure, the pre-developed flow rate of 499 CFS from Sub-Basin 1 has been maintained. However, the amount of flow that Sub-Basin 1 contributes to the overall watershed, at the overall watershed's time to peak, has increased by 90 CFS. This is a result of the new detention structure in Sub-Basin 1 releasing a higher volume of water, at a slower rate and over a longer period. While the flow discharging from Sub-Basin 1 is equal between the pre and post-developed conditions, the overall watershed's discharge rate has increased 112 CFS.

Therefore, instead of simply controlling the rate of release of Sub-Basin 1 as a singular entity, it must be analyzed in a more comprehensive manner, as part of the overall watershed.

Taking into account the pre-development runoff rate of Sub-Basin 1 at the time the Sub-Basin peaks (499 CFS) and the amount of runoff from Sub-Basin 1 at the time the overall watershed peaks (409 CFS), this creates the need for rate release control.

The calculation is done by dividing the amount of pre-development runoff from Sub-Basin 1 at the time the overall watershed peaks (in this case 409 CFS) and the peak rate of runoff from Sub-Basin 1. Keeping in mind only sub-basins that peak <u>prior</u> to the overall watershed peaks require rate controls.

Therefore: 409 CFS / 499 CFS = 81.9%

In order to simplify the release rate districts or zones, the calculated release rates can be rounded slightly. In this case, 81.9% will be rounded to 80%. This is now the allowable release rate for Sub-Basin 1. Any development that will result in a net increase of runoff from the pre-developed condition to the post-developed condition will require an additional 80% beyond the pre-development peak runoff rate.

A sample development in this example Sub-basin 1 may have a development condition peak flow of 100 CFS. Using the calculated release rate, then the final post-development site can only release a peak flow of 80% of 100 CFS, or 80 CFS.

Looking at the original example, when the 80% release rate is applied to Sub-Basin 1, the following results are achieved:

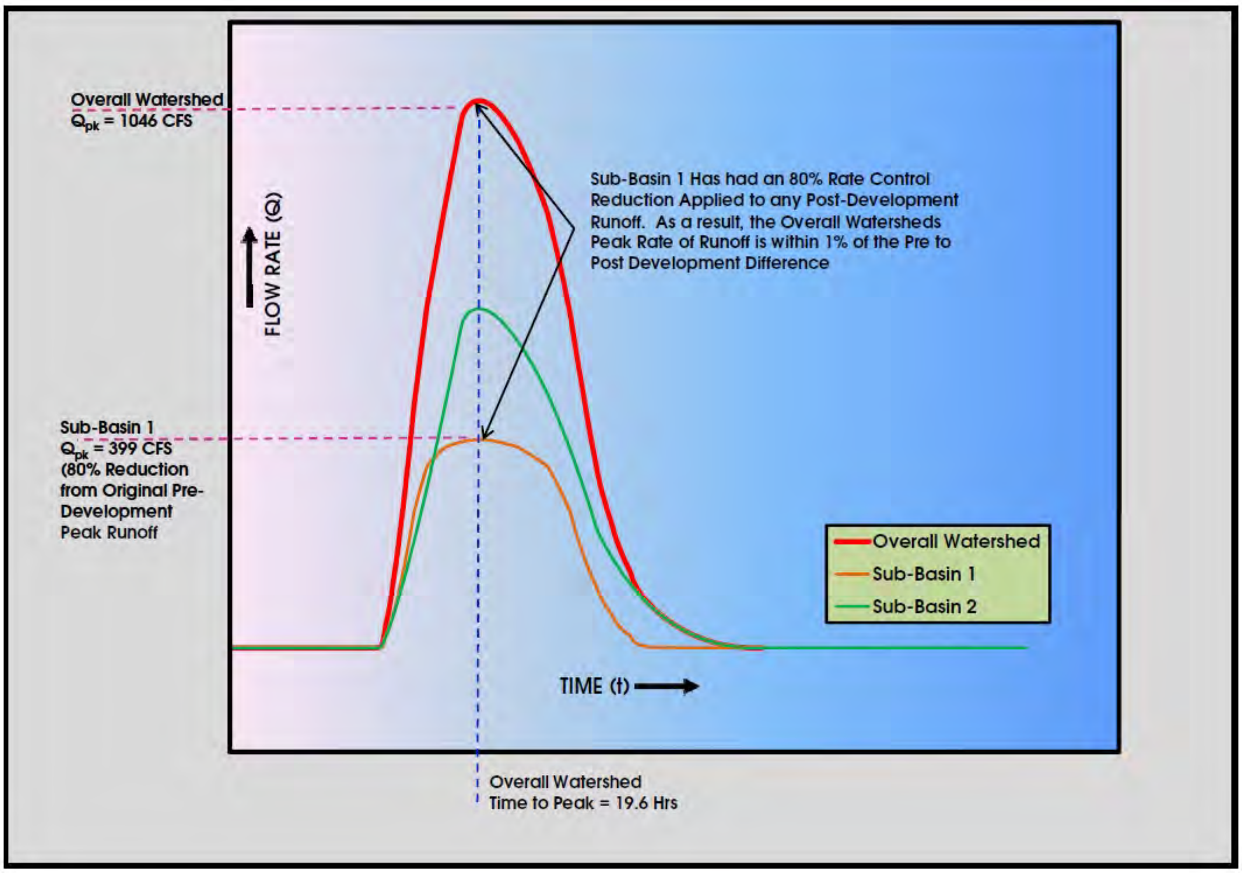

Figure V-6

The overall peak rate of runoff from Sub-Basin 1 is now 399 CFS. Sub-Basin 2 remains un-changed, as it was not necessary to apply rate release controls.

The peak rate of runoff from the overall watershed is now 1046 CFS, an increase of only 10 CFS from the entire watershed. This results in a net change of less that 1% between the pre and post-development runoff rates from the overall watershed. Therefore, the 80% release rate application to Sub-Basin 1 achieved its intended results. Due to the nature of the calculations and specific rounding of values, getting the values to match exactly is nearly impossible. However, a net change of less than 1% is well within the threshold of what the theory is trying to accomplish and it has now been accomplished in this watershed.

Release rate analyses performed on the Marshall and Coffee Run watersheds did not justify establishing post-development release rates below 100% of the pre-development. As noted earlier, hydrologic modeling and release rate analyses were not performed on any other watersheds within Lawrence County due to the reduction in Plan Scope and budget. Future planning cycles will model and evaluate additional watersheds within the County.

E. Structural and Non-Structural BMPs

The following two figures are a comprehensive listing of structural and non-structural BMPs available for the assistance in mitigation of the four major stormwater functions in Pennsylvania. The BMPs are ranked (in potential efficiency) from high to low for each of the four functions, peak rate mitigation, recharge, volume mitigation, and stormwater quality.

The BMPs come directly from the PADEP BMP Manual and are accompanied by the following acronyms (indicating potential effectiveness when properly applied and administered):

VH Very High

H High

HL High to Low (a special category in which specific parameter dictate a BMPs effectiveness)

MH Medium to High

LM Low to Medium

L Low

VL Very Low

LN Low to None

N None or Not Applicable

The figure(s) can be used by a design professional by determining which desired function is to be mitigated and then working down the chart and selecting BMP(s) that will work singularly or in combination with other BMPs to mitigate a specific function or multiple functions. The most effective means of selecting BMPs is to choose a BMP or multiple BMPs that have moderately high rates of success for all, or some combination, of all the desired functions requiring mitigation.

For example, the use of the BMP dictating the reduction of parking imperviousness is an effective BMP for all four of the mentioned stormwater functions. It rates VH (very high) for three of the functions and H (high) for the fourth. This makes the potential use of this BMP a practical selection.

However, BMP selection is based on a number of criteria including:

- Applicability to existing conditions
- Efficiency
- Cost Benefit
- Maintenance Concerns

Non-Structural Best Management Practices (BMPs)

Stormwater Desired Functions

Volume Reduction	Recharge	Peak Rate Control	Quality
Protect Sensitive and Special Value Areas (VH)	Protect Sensitive and Special Value Areas (VH)	Protect Sensitive and Special Value Areas (VH)	Protect Sensitive and Special Value Areas (VH)
Cluster Uses at Each Site; Build on Smallest Area Possible (VH)	Cluster Uses at Each Site; Build on Smallest Area Possible (VH)	Cluster Uses at Each Site; Build on Smallest Area Possible (VH)	Protect/Conserve/ Enhance Riprarian Areas (VH)
Concentrate Uses Area Wide Thru Smart Growth Practices (VH)	Concentrate Uses Area Wide Thru Smart Growth Practices (VH)	Concentrate Uses Area Wide Thru Smart Growth Practices (VH)	Cluster Uses at Each Site; Build on Smallest Area Possible (VH)
Minimize Soil Compaction in Disturbed Areas (VH)	Minimize Soil Compaction in Disturbed Areas (VH)	Reduce Street Imperviousness (VH)	Concentrate Uses Area Wide Thru Smart Growth Practices (VH)
Reduce Street Imperviousness (VH)	Reduce Street Imperviousness (VH)	Reduce Parking Imperviousness (VH)	Minimize Soil Compaction in Disturbed Areas (VH)
Reduce Parking Imperviousness (VH)	Reduce Parking Imperviousness (VH)	Minimize Total Disturbed Area - Grading (H)	Re-Vegetate and Re-Forest Disturbed Areas, Using Native Species (VH)
Minimize Total Disturbed Area - Grading (H)	Minimize Total Disturbed Area - Grading (H)	Minimize Soil Compaction in Disturbed Areas (H)	Minimize Total Disturbed Area - Grading (H)
Rooftop Disconnection (H)	Rooftop Disconnection (H)	Rooftop Disconnection (H)	Reduce Parking Imperviousness (H)
Disconnection From Storm Sewers (H)	Disconnection From Storm Sewers (H)	Disconnection From Storm Sewers (H)	Streetsweeping (H)
Protect/Conserve/ Enhance Riprarian Areas (M)	Protect/Conserve/ Enhance Riprarian Areas (M)	Protect/Utilize Natural Flow Pathways in Overall Stormwater Planning and Design (MH)	Protect/Utilize Natural Flow Pathways in Overall Stormwater Planning and Design (M)
Protect/Utilize Natural Flow Pathways in Overall Stormwater Planning and Design (LM)	Re-Vegetate and Re-Forest Disturbed Areas, Using Native Species (LM)	Protect/Conserve/ Enhance Riprarian Areas (LM)	Reduce Street Imperviousness (M)
Re-Vegetate and Re-Forest Disturbed Areas, Using Native Species (LM)	Protect/Utilize Natural Flow Pathways in Overall Stormwater Planning and Design (L)	Re-Vegetate and Re-Forest Disturbed Areas, Using Native Species (LM)	Rooftop Disconnection (L)
Streetsweeping (LN)	Streetsweeping (LN)	Streetsweeping (LN)	Disconnection From Storm Sewers (L)

Figure V-7[19]

[19] BMP methods are taken directly from the Pennsylvania DEP's, *Pennsylvania Stormwater Best Management Practices Manual*.

Structural Best Management Practices (BMPs)			
Stormwater Desired Fuctions			
Volume Reduction	Recharge	Peak Rate Control	Quality
Floodplain Restoration (HL)*	Floodplain Restoration (HL)*	Constructed Filter (HL)*	Landscape Restoration (VH)
Constructed Filter (HL)*	Constructed Filter (HL)*	Dry Extended Detention Basin (H)	Constructed Wetlands (H)
Subsurface Infiltration Bed (H)	Dry Well/Seepage Pit (H)	Wet Pond/Retention Basin (H)	Vegetated Filter Strip (H)
Infiltration Basin (H)	Infiltration Trench (H)	Constructed Wetlands (H)	Constructed Filter (H)
Vegetated Roof (MH)	Subsurface Infiltration Bed (H)	Vegetated Swale (MH)	Infiltration Trench (H)
Runoff Capture and Reuse (MH)	Infiltration Basin (H)	Subsurface Infiltration Bed (MH)	Subsurface Infiltration Bed (H)
Riparian Buffer Restoration (M)	Rain Garden/Bioretention (MH)	Infiltration Basin (MH)	Infiltration Basin (H)
Dry Well/Seepage Pit (M)	Riparian Buffer Restoration (M)	Floodplain Restoration (M)	Riprarian Buffer Restoration (MH)
Rain Garden/Bioretention (M)	Pervious Pavement with Infiltration Bed (M)	Soil Amendment and Restoration (M)	Infiltration Berm and Retentive Grading (MH)
Infiltration Trench (M)	Soil Amendment and Restoration (LM)	Infiltration Berm and Retentive Grading (M)	Vegetated Swale (MH)
Pervious Pavement with Infiltration Bed (M)	Landscape Restoration (LM)	Dry Well/Seepage Pit (M)	Rain Garden/Bioretention (MH)
Soil Amendment and Restoration (LM)	Vegetated Filter Strip (LM)	Infiltration Trench (M)	Floodplain Restoration (MH)
Landscape Restoration (LM)	Vegetated Swale (LM)	Pervious Pavement with Infiltration Bed (M)	Soil Amendment and Restoration (M)
Infiltration Berm and Retentive Grading (LM)	Level Spreader (L)	Landscape Restoration (LM)	Water Quality Filters and Hydrodynamic Devices (M)
Vegetated Filter Strip (LM)	Wet Pond/Retention Basin (L)	Riparian Buffer Restoration (LM)	Wet Pond/Retention Basin (M)
Vegetated Swale (LM)	Constructed Wetlands (L)	Rain Garden/Bioretention (LM)	Runoff Capture and Reuse (M)
Level Spreader (L)	Runoff Capture and Reuse (L)	Special Detention Areas - Parking Lot, Rooftop (LM)	Vegetated Roof (M)
Dry Extended Detention Basin (L)	Infiltration Berm and Retentive Grading (L)	Level Spreader (L)	Dry Well/Seepage Pit (M)
Wet Pond/Retention Basin (L)	Special Detention Areas - Parking Lots, Rooftop (VL)	Runoff Capture and Reuse (L)	Pervious Pavement with Infiltration Bed (M)
Constructed Wetlands (L)	Water Quality Filters and Hydrodynamic Devices (N)	Vegetated Roof (L)	Level Spreader (L)
Special Detention Areas - Parking Lots, Rooftop (VL)	Dry Extended Detention Basin (N)	Vegetated Filter Strip (L)	Dry Extended Detention Basin (L)
Water Quality Filters and Hydrodynamic Devices (N)	Vegetated Roof (N)	Water Quality Filters and Hydrodynamic Devices (N)	Special Detention Areas - Parking Lot, Rooftop (L)

Figure V-8[20]

[20] BMP methods are taken directly from the Pennsylvania DEP's, *Pennsylvania Stormwater Best Management Practices Manual*.

Additional Means for Objective Achievement

In addition to the criteria listed within this Plan, other methods of achieving the outlined methods may be required. Some of the more common and tangible methods for objective achievement include, but are not limited to:

- Changes, upgrades, and improvements to municipal maintenance policies
  - Including both frequency and method of practice, as well as dedicated funding
- Construction or improvement projects that will increase the efficiency and effectiveness of community stormwater and flood control facilities, collection and conveyance systems, and treatment appurtenances
- Improvements and changes to municipal construction codes and design standards which better implement methods and technologies that will address stormwater at the source and not at the eventual problem area
- Improvements and retrofit scenarios where existing stormwater and flood management facilities are made more efficient and effective in managing stormwater runoff and increasing their ability to support public welfare as well as private and public property

There is not a specific timeframe for completion of these upgrades. However, they should be implemented in a timely fashion and a fashion in which removed constraints allow. New technology, additional funding, increased public support, timely revisions to this Plan will all contribute to the expediting of improvement implementation.

Non-Achievable Objectives

Not all objectives can be immediately met through the implementation of this Plan. It is the intent of the Plan to meet each objective to the greatest extent possible. However, it is not feasible to correct every problem, known or otherwise, within the county.

Some of the potential reasons for not meeting objectives or correcting/mitigating known problems are:

- Reduction in scope in development of the Plan
- Limited technology or inefficient technology
- Financial constraints or limited resources for implementation of technology
- Political and social issues that complicate the corrective action necessary
- Lack of immediate public education and outreach programs (which through implementation of this Plan will better educate and inform the public of the impacts of stormwater)
- Limited historical data

The easiest and most efficient means of correcting and improving upon the limitations previously listed would involve periodic revisions (recommended every five years) of the Plan. This would include the implementation of new local, State, and Federal guidelines and regulations that could alleviate current impediments. Improved and more efficient technology that will augment the mitigation process. Implementation of, and additional analysis of watersheds based on newly acquired data or field gathered historical data that can be used to provide more efficient watershed analyses. Support from both the public and private sectors that will assist in the implementation, funding, and educational aspects of stormwater management methodologies.

The County and municipalities contained therein shall periodically review and revise the Plan at least every five years. It will be through these required revisions that the Plan will remain a feasible and tangible source of information and data that can be used to assist in the mitigation of known problems and to achieve objectives beyond what are outlined in this current revision of the Plan.

SECTION VI MUNICIPAL ORDINANCE INTRODUCTION

A. Supporting Information

Based upon the granted authority set forth in the Storm Water Management Act, October 4, 1978, P.L. 864 (Act 167), 32 P.S. Section 680.1, et. seq., as amended, all municipalities within the Commonwealth of Pennsylvania are empowered to regulate all land use activities within their boundaries.

Act 167 requires the implementation and management of stormwater at the local level, with municipalities taking on the leadership role. In accordance with Act 167, Sections 11 (a) and (b):

1. After adoption and approval of Plan in accordance with Act 167, the location, design and construction within the watershed of storm water management systems, obstructions, flood control projects, subdivisions and major land developments, highways and transportation facilities, facilities for the provision of public utility services and facilities owned or financed in whole or in part by funds from the Commonwealth shall be conducted in a manner consistent with the watershed storm water plan.

2. Within six months following adoption and approval of the Plan, each municipality shall adopt or amend, and shall implement such ordinances and regulations, including zoning, subdivision and development, building code, and erosion and sedimentation ordinances, as are necessary to regulate development within the municipality in a manner consistent with the applicable watershed storm water plan and the provisions of this act.

The adoption of the model ordinance as a stand-alone ordinance may not require the revision of existing subdivision, land development and/or zoning ordinances within individual municipalities; these revisions are already addressed by the repealer clause in Section 106 of the model ordinance.

A model stormwater ordinance has been prepared as a part of this plan and is available to be accepted, with minor revisions, by each subject municipality. Each municipality is free to accept the model ordinance, or have the freedom to revise the ordinance to enact more stringent requirements than what the model ordinance prescribes.

Each municipality will also be faced with the task of updating and revising any existing land development, zoning, and subdivision ordinances to provide the correlating language that references the adopted stormwater management ordinance. These revisions would need to address to all applicable land use activities within the municipality and direct the potential applicant to the stormwater management ordinance for more detailed guidance.

The most critical of the necessary elements to be included in the model ordinance shall be:

- The stormwater drainage standards and management criteria – (Stormwater Management Ordinance, Article III, Section 301 and Appendix A)
- Technical performance requirements for stormwater management facilities
  - Detention/Retention Facilities for Peak Rate Control – (Stormwater Management Ordinance, Article III, Section 305 and Appendix B)
  - Volume Control BMPs - (Stormwater Management Ordinance, Article III, Section 304 and Appendix B)
    - Infiltration BMPs
    - Bioretention BMPs
    - Land Use/Impervious Area Reduction BMPs
    - Stormwater Collection/Re-Use BMPs

- **Water Quality Facilities and BMPs** – (Stormwater Management Ordinance, Article III, Section 301 and Appendix B)

The model ordinance should be understandable and practical in all aspects of its intent. It is not intended to be too rigid and should encourage hybrid solutions and creativity in order to achieve the overall intent, which is to manage stormwater effectively, safely, and efficiently. The ordinance, while it should be stringent in nature, should also not be overly oppressive in a manner in which it could actually limit potential development by creating restrictions that could serve as a deterrent to potential developers. It is not the purpose of the ordinance/stormwater management plan to solve stormwater issues by eliminating development. It is the intent to provide an effective and safe means by which development can continue and expand in a regulated and safe environment where the natural hydrology of the county is not only protected and maintained, but also improved by the use of new technologies that will help mitigate existing problems, as well as preventing future ones.

B. Required Ordinance Contents

- Article I- General Provisions
  - This section is intended to provide information based upon the following items:
    - A short title identifying the ordinance document.
    - A statement of findings indicating general information that reinforces the need and requirements for the creation of a universal stormwater management ordinance.
    - A section identifying the purpose of the ordinance. This will include verbiage addressing topics related to both public welfare legal precedents and requirements for the creation of the document, as well as basic technical information that the document will address.
    - A brief section outlining the statutory authority that the empowerment of the ordinance is based upon.
    - A brief section identifying the applicability of the ordinance and the types of activities the ordinance as the authority to regulate.
    - A section indicating that any additional ordinances within the municipality in question that are not consistent with the provisions of this ordinance, are hereby repealed to the extent of the inconsistencies.
    - A section describing that if any standing court order declares any section of this ordinance invalid, this decision will not affect the validity of the remaining provisions of the ordinance.
    - A statement indicating that compliance with this ordinance does not release the applicant from adherence with any other local codes, laws, or regulations. Nor does it release them from their necessary duty to acquire required permits and approvals from other governing bodies.
- Article II- Definitions
  - This section is intended to provide the appropriate and intended interpretation of certain words, terms and entities included in the ordinance.
- Article III- Stormwater Management Standards
  - This section is intended to clearly present and define the technical regulations for stormwater management within the municipality. This should, at a minimum, include the following:
    - Definition of water quality (WQ) requirements and provisions

    - All necessary design criteria and applicable supporting data
    - Requirements for meeting erosion and sedimentation control guidelines and regulations
    - Acceptable methods and models for preparing calculations
    - Information concerning applicable stormwater management districts and the implementation of specific control criteria therein
    - Small project exemption criteria
    - Waiver criteria
    - Information pertaining to timber harvesting and silviculture activities
- Article IV- Stormwater Management Site Plan Requirements
  - This section is intended to provide an outlined description of the necessary components that will represent an acceptable stormwater management site plan. It shall also include information describing the appropriate procedures for plan submittal, review, approval guidelines and protocol, fees, sub-sequent follow up, and closeout procedures at project completion.
- Article V-Operation and Maintenance
  - This section defines the municipality's roles and authority in the determination of operation and maintenance of any and all stormwater management facilities. The determination of the ultimate party responsible for such operation and maintenance will be made prior to final plan approval. An appropriate O/M agreement should also be included that defines the owner's responsibility for proper operation and maintenance of the facility and the municipality's rights to enforce the agreement or charge fees associated with maintenance of any facility owned by an entity other than the municipality.
- Article VI-Fees and Expenses
  - This section should outline all costs incurred in the review fee, and that the municipality may charge such fees to an applicant. The review fee may include but not be limited to costs for the following:
    - Administrative/clerical processing.
    - Review of the SWM Site Plan.
    - Attendance at Meetings.
    - Inspections
- Article VII-Prohibitions
  - This section addresses all necessary prohibitions and definition of unacceptable activities, which are deemed to not adhere to the language of the ordinance. Items of the following type, but not limited to, should be included in this section:
    - Any illegal and illicit discharges prohibited under the provisions of the ordinance
    - Specific guidelines regulating the installation and function of residential and commercial roof drain systems
    - Specific guidelines regulating the alteration or retrofitting of any existing stormwater management facility or BMP device
- Article VIII-Enforcements and Penalties

- This section outlines the municipality's rights concerning enforcement of the ordinance guidelines and applicable and allowable penalties. A detailed description of the following items should be included:
    - The municipality's right of entry
    - The municipality's right of inspection
    - The municipality's rights of enforcement of the terms of the ordinance and any associated agreements
    - Information concerning suspensions and revocation
    - A detailed listing of penalties that are considered in direct violation of the terms of the ordinance and any associated agreements
    - A detailed outline of the appeals process available to any applicant

- Article IX- References
    - Supporting documentation used for the creation and formulation of any portion of the ordinance

- Appendix A:
    - Low Impact Development Practices
- Appendix B:
    - Site Conditions Suitable for Infiltration
    - BMPs for Infiltration
    - BMPs for Rate Control
    - BMPs for Evapotranspiration
- Appendix C:
    - Operation and Maintenance Agreement, Stormwater Best Management Practices
- Appendix D:
    - Rational Formula Runoff Coefficients
- Appendix E:
    - Small Project SWM Plan Application and Worksheets
- Attachment A:
    - Additional Ordinance and Technical Guidelines Toolbox

SECTION VII PRIORITIES FOR IMPLEMENTATION

The preparation of the Lawrence County Act 167 Stormwater Management Plan concludes with the county's final acceptance of the plan and the submittal of the plan to the Pennsylvania Department of Environmental Protection (PA DEP) for final review and approval. Municipalities have a period of no more than six (6) months from the date of PADEP's approval of the County's adopted plan to complete and finalize ordinance adoption.

A. DEP Approval of the Plan

Once the final plan is adopted by Lawrence County, it is then submitted to the PA DEP for approval. A preliminary/draft copy of the stormwater management plan and model ordinance was submitted to the PA DEP prior to the county's adoption. The PA DEP reviews the draft and determines that all necessary components are present and all necessary tasks have been completed. The PA DEP then reviews the plan for the following additional items:

- Consistency and adherence with floodplain management plans
- Commonwealth regulations concerning the management of dams, waterway encroachments, and all other possible waterway obstructions
- Commonwealth and Federal flood control guidelines

This specific Act 167 Plan was prepared exclusively for Lawrence County and the municipalities located therein. However, based upon the fact that watersheds boundaries overlap between counties (and in this case actual states), the plan must be consistent and compatible with other Act 167 and stormwater management plans and policies that are already in place, or currently being prepared in adjacent jurisdictions.

B. Publishing the Final Plan

In order to remain consistent with the Scope of Study for Lawrence County, the County will publish additional copies of the plan after receipt of final approval from the PA DEP. The County will provide one copy to each municipality within Lawrence County at this time. Copies of the Lawrence County Stormwater Management Model Ordinance will be published for use by all county municipalities.

C. Municipal Adoption of Ordinance to Implement the Plan

The most critical part of implementation of the Act 167 Plan is the adoption of the required ordinance provisions by each county municipality.

As discussed in previous sections, each municipality would have the ability to accept the model ordinance "as-is," and this would meet the requirements for implementation at the municipal level. The adoption of the model ordinance as a stand-alone ordinance may not require the revision of existing subdivision, land development and/or zoning ordinances within individual municipalities; these revisions are already addressed by the repealer clause in Section 106 of the model ordinance.

The correlating provisions would refer the applicant engaged in any applicable regulated activities (as defined in the ordinance) within the municipality from the previous ordinance(s) to the newly adopted ordinance.

As an additional recommendation to the adopting municipality, it is suggested that the previously determined and approved watershed delineation areas and the management criteria assigned to them (e.g., rate release controls, etc.) be included within the municipality's zoning or sub-division ordinance(s). This creates a scenario where the stormwater management requirements will apply to all proposed land use changes and will not be limited by activities that are subject to the provisions outlined in the existing land development and sub-division ordinance(s).

D. Level of Government Involvement in Stormwater Management

The current process for the management of stormwater from a regulatory basis within the Commonwealth of Pennsylvania is a blended mixture of objectives and directives from a number of governing bodies.

Stormwater within a single watershed currently has the potential to be managed and regulated at a federal, state, county and local (municipal) level. Each of these entities can possess their own guidelines and regulations based on their specific intent and place as a stakeholder in the regulatory process. It becomes the responsibility of the developer or applicant to address, adhere, and gain approval from each separate entity based upon their singular guidelines, which at times, can even be in direct conflict or contradiction with another regulatory entities guidelines and regulations. This lack of a sole, regulatory entity, responsible for the implementation of all rules, regulations, reviews, assistance, and approval during the stormwater process makes the process in and of itself extremely difficult to navigate.

Implementation of the plan guidelines and minimum requirements of Act 167 can be accomplished without significant disruption to the current permitting and approval process in any particular watershed. The most significant action will occur at the municipal and county level. The technical review of stormwater management plans must include the input of both a representative municipality as well as the county in a joint, cooperative effort. Along with the review and approval of plan applications, intermittent updates to the computer model (created as an end product of the plan preparation, and provided as a final deliverable) are required in order for data to remain current and to indentify new or potential problems. The collection and storage of physical data (new development, changes to the watershed(s), etc.) also will be required in order to have a current inventory of county stormwater infrastructure and impacts to hydrology.

Upon final adoption of the plan, the following types of projects will be subject to the provisions of the plan and remain consistent with the rules and regulations set forth in the plan:

- New Public Facilities
- New Facilities for the Provision of Public Utilities
- New Facilities Owned or Financed by Commonwealth Funds

These public or publically funded facilities are required to comply with the plan even if they are not subject to any municipal regulation.

The primary role of the municipality will be the implementation of the Plan through ordinance adoption. This process must be completed within six months of PADEP's approval of the County's Plan. The required model ordinance provisions will be made available to each municipality by the county. The Lawrence County Conservation District and the Lawrence County Planning Commission will be available to assist any municipality in the adoption process or to assist in the necessary steps to incorporate the new guidelines into any existing ordinances.

The necessary evidence that state and federal agencies have been contacted and notified of regulated activities will also be required. This applies in most instances to any impact or potential impact to areas, through acceptable delineation practices, which are considered wetlands. This process is intended to ensure that all plan guidelines and regulations are being followed and have been implemented.

E. Correction of Existing Drainage Problems

The completion of the stormwater management plan will provide an outline and source of reference for the elimination of existing stormwater management problems within the county. Each municipality will have at its disposal a resource for identifying and addressing these problems at the local level. The municipality will not only have a better framework for addressing and correcting existing problems, but for providing an environment in which future problems are prevented.

The information provided is not intended to be the only approach to correcting problems and in no way is anything listed considered to be mandatory. It is only a list of suggestions for providing an individual municipality a means to correcting existing problems. Since problems, as well as the means to correcting them, vary between municipalities, not every recommendation is applicable in all cases.

- A list of existing stormwater management issues within the municipality should be created and prioritized. This list should take into account the following parameters:
  - Threat to human life
  - Threat to property and existing infrastructure
  - Frequency of occurrence
  - Proximity to other existing problems
  - Financial ramifications
- A technical evaluation of each problem area, costing evaluation to determine repair requirements, and a proposed course of action for the municipality to follow
- Implementation of the corrective action plan should begin and be integrated with the municipal capital or maintenance improvement budget on an annual basis

F. Culvert Replacement

One of the most common drainage problems within the county is flooding caused by unmanaged or insufficiently managed stormwater runoff from development that is tributary to culverts. A large number of these culverts were never designed to pass the higher flows generated by excessive development. These culverts are not able to safely convey these higher flows, resulting in localized flooding, damage to infrastructure, roadway overtopping which results in driving hazards, as well as many other problems.

A culvert replacement plan should be enacted as part of the overall corrective action plan for each municipality. In general, the procedure for determining the proper culvert size is as follows:

- Identify the location of the problem culvert from the obstruction data provided in the Act 167 Plan and its assigned identification number
- Determine the appropriate design storm frequency based upon the PA DEP’s Chapter 105 guidelines:
  - In determining flood flows and frequencies for purposes of this subchapter, hydrologic analysis shall be by methods generally accepted in the engineering profession
    - Rural areas—25-year frequency flood flow
    - Suburban areas—50-year frequency flood flow
    - Urban areas—100-year frequency flood flow
- Using the information provided in the Act 167 Plan, locate the appropriate flow (CFS) for the obstruction in question and based upon the return period criteria listed above. Information pertaining to certain physical characteristics (including locations) of known culverts can be found within Volumes 3 of this Plan.
- Using sound and acceptable engineering practices, size the culvert based upon the determined parameters and within any ordinance or regulatory agency having jurisdictional control over the culvert replacement

- All necessary local, state, and federal permits and approvals must be obtained prior to construction

Not all obstructions within the county were identified and/or modeled. In the event of a known problem obstruction area that is not listed in the Act 167 Plan, sound and acceptable engineering practices should be used in the proper design and replacement of the culvert. Portions of the previously listed method for replacement are still applicable, and should be implemented to the greatest extent possible. The most notable exception is that of calculated flow for the obstruction. This must be calculated by the design engineer for the culvert replacement and should be done in accordance with sound engineering practice as well as all local, state, and federal regulations governing the design of culverts in the municipality in question.

G. PennVEST Funding

PENNVEST has been empowered by Pennsylvania state law, Pennsylvania Infrastructure Investment Authority Act 16 of 1988, to administer and finance the Clean Water State Revolving Fund (CWSRF) and the Drinking Water State Revolving Fund (DWSRF) pursuant to the federal Water Quality Act of 1987, as well as to administer the American Recovery and Reinvestment Act of 2009 (ARRA) funds. PENNVEST also finances, through the issuance of special obligation revenue bonds, water management, solid waste disposal, sewage treatment and pollution control projects undertaken by or on behalf of private entities.

The PENNVEST Clean Water State Revolving Fund (CWSRF) program provides funding to projects throughout PENNSYLVANIA for the construction and maintenance of wastewater treatment facilities, storm water management projects, nonpoint source pollution controls, and watershed and estuary management.

This program offers low interest loans with flexible terms to assist a variety of borrowers that include local governments, municipalities, and privately owned entities and to establish partnerships to leverage other funding sources.

The CWSRF program is managed under the Pennsylvania State Regulations for PENNVEST funding wastewater projects. In partnership with the Pennsylvania Department of Environmental Protection, management occurs during project planning, application submission, contracting and financing, and site inspection and reporting.

The Pennsylvania Code establishes project evaluation criteria for PennVEST funding. The criteria for stormwater projects seeking PennVEST assistance is currently defined as[21]:

- Public health and safety
  - Elimination of critical ongoing safety or health hazard
  - Elimination of a chronic safety or health hazard which frequently occurs
  - Elimination of a potential safety or health hazard associated with periodic flooding
- Environmental impact
  - The improvement or prevention of a problem to the environment or to natural resources
  - Whether the project is located in areas of karst topography and susceptible to sinkhole development or has no natural watercourse within the municipal boundaries encompassing the project
- Economic development
  - Development, activity and job creation retention resulting directly or indirectly from a project
  - Opportunity to use other State programs, such as the Business Infrastructure Development, Site Development and Community Facilities Programs, to fund the project

[21] The Pennsylvania Code, §963.9a adopted July 7, 1995, effective July 8, 1995, 25 Pa.B. 2720

    - Degree of local distress in the county where the project is located

- Compliance
    - Improvement of compliance with existing laws, rules and regulations if compliance will eliminate the necessity to issue an order
    - Compliance with law, an order, decree, agreement or a deadline specified in regulation

- Adequacy and efficiency
    - The extent that the project proposes facility regionalization or system consolidation to improve operation, maintenance or function of the stormwater facility
    - The extent that the project involves multiple-governmental participation
    - The extent that the project has a sponsoring municipal entity which has a population less than or equal to 12,000 residents as reported in the latest census

In order to qualify for funding consideration, the applicant must meet two important factors:

- The project seeking funding must be located within a watershed where a DEP approved and county adopted stormwater management plan is currently in place
- The project seeking funding must be located within a watershed where a stormwater management ordinance has been implemented as is consistent with the guidelines of the county-wide stormwater management plan

H. Landowner's/Developer’s Responsibilities

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

- To assure that the maximum rate of storm water runoff is no greater after development than prior to development activities; or
- To manage the quantity, velocity and direction of resulting storm water runoff in a manner which otherwise adequately protects health and property from possible injury.

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