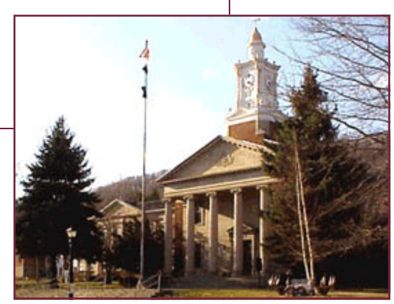
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services

McKean County Planning Commission

McKean County
Act 167 County-Wide
Stormwater Management Plan
Phase II

June 2010



[BUILDING RELATIONSHIPS.
DESIGNING SOLUTIONS.]

474 Windmere Drive Suite 100 • State College, Pennsylvania 16801 • 814.238.7117 [phone]

This page has been left blank intentionally.

ACKNOWLEDGEMENTS

The McKean County Planning Commission would like to thank the following individuals, municipalities, and agencies for their assistance and support of this project:

MCKEAN COUNTY COMMISSIONERS

JOSEPH DEMOTT | AL PINGIE | JUDY CHURCH

PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION

BARRY NEWMAN | TIM BRUNO | RUTH SITLER

MCKEAN COUNTY PLANNING COMMISSION

DEBORAH L. LUNDEN, DIRECTOR
JOAN M. BIEHLER, ASSISTANT PLANNER

MCKEAN COUNTY CONSERVATION DISTRICT

SANDY THOMPSON, DISTRIC MANAGER
CAROL RIEDMILLER, RESOURCE CONSERVATION TECHNICIAN

MCKEAN COUNTY PLAN ADVISORY COMMITTEE

Name	Representing
DAVID MCFALL	ANNIN TOWNSHIP
ROSS NEIDICH	BRADFORD CITY
DONALD CUMMINS	BRADFORD TOWNSHIP
JOSEPH NEAL	CERES TOWNSHIP
TIMOTHY YOHE	CORYDON TOWNSHIP
DENNIS MONG	ELDRED BOROUGH
JEFFREY RHINEHART	ELDRED TOWNSHIP
CHRIS WOLCOTT	FOSTER TOWNSHIP
BRIAN BASTOW	HAMILTON TOWNSHIP
THOMAS KREINER	HAMLIN TOWNSHIP
PATRICK NUZZO	KANE BOROUGH
CHESTER TANNER	KEATING TOWNSHIP
JOHN KNOX	LAFAYETTE TOWNSHIP

Name	Representing
VINCENT MONTECALVO	LEWIS RUN BOROUGH
GARY TURNER	LIBERTY TOWNSHIP
THOMAS GEER	MT. JEWETT BOROUGH
PAUL LATHROP	NORWICH TOWNSHIP
MARK PALMER	OTTO TOWNSHIP
RICHARD KALLENBORN	PORT ALLEGANY BORO.
JAMES MORGAN	SERGEANT TOWNSHIP
DAVID BALL	SMETHPORT BOROUGH
ROLAND CONKLIN	WETMORE TOWNSHIP
DEBORAH LUNDEN	MCKEAN COUNTY
SANDY THOMPSON	MCKEAN COUNTY CONS.
JAMES CLARK	PENN STATE COOPER. EXT.
JOSEPH DEMOTT	COUNTY COMMISSIONER

This page has been left blank intentionally.

TABLE OF CONTENTS

Part I

LIST OF PLATES

LIST OF APPENDICES

Section I – Introduction

This stormwater management plan is the product of a collaborative effort between the varied stakeholders within the Act 167 Designated Watersheds in McKean County, Pennsylvania. The Plan has been developed based upon the requirements contained within the *Pennsylvania Stormwater Management Act*, Act 167 of 1978, and guidelines established by the Pennsylvania Department of Environmental Protection (DEP). The intent of this document is to present the findings of a two-phased multi-year study of the watersheds within the county. Generally, the study was undertaken to develop recommendations for improved stormwater management practices, to mitigate potential negative impacts by future land uses, and to improve conditions within impaired waters. The specific goals of this plan are discussed in detail in the following section. This section introduces some basic concepts relating the physical elements of stormwater management, the hydrologic concepts, and the planning approach used throughout this study.

RAINFALL AND STORMWATER RUNOFF

Precipitation that falls on a natural landscape flows through a complex system of vegetation, soil, groundwater, surface waterways, and other elements as it moves through the hydrologic cycle. Natural events have shaped these components over time to create a system that can efficiently handle stormwater through evaporation, infiltration, and runoff. The natural system often sustains a dynamic equilibrium, where this hydrologic system evolves due to various ranges of flow, sediment movement, temperature, and other variables. Alterations to the natural landscape change the way the system responds to precipitation events. These changes often involve increasing impervious area, which results in decreased evaporation and infiltration and increased runoff. The increase in stormwater runoff is manifested in runoff quantity, or volume, and runoff rate. These two factors cause the natural system to change beyond its natural dynamic equilibrium, resulting in negative environmental responses such as accelerated erosion, greater or more frequent flooding, increased nonpoint source pollution, and degradation of surface waters. Decreased infiltration means less groundwater recharge which in turn leads to altered dry weather stream flow.

Some level of stormwater runoff occurs as the infiltrative capacity of the surface is exceeded. This occurs even in undisturbed watersheds. However, the volume and rate of runoff are substantially increased as land development occurs. Stormwater management is a general term for practices used to reduce the impacts of this accelerated stormwater runoff. Stormwater management practices such as detention ponds and infiltration areas are designed to mitigate the negative impacts of increased runoff. Volume of runoff and rate of runoff are often referred to by the term "water quantity". Water quantity controls have been a mainstream part of stormwater management for years. Another aspect of runoff is water quality. This refers to the physical characteristics of the runoff water. Common water quality traits include temperature, total suspended solids, salts, and dissolved nutrients. Water quality is an emerging topic in stormwater management and the general water resources field. Both water quantity and water quality can contribute to degradation of surface waters.

As development has increased, so has the problem of managing the increased quantity of stormwater runoff. Individual land development projects are frequently viewed as separate incidents, and not necessarily as an interconnected hydrologic and hydraulic system. This school of thought is exacerbated when the individual land development projects are scattered throughout a watershed (and in many different municipalities). However, it is has been observed, and verified, that the cumulative nature of individual land surface changes dramatically influences flooding conditions. This cumulative effect of development in some areas has resulted in flooding of both small and large streams, with substantial financial property damage and endangerment of the public health and welfare. Therefore, given the distributed and cumulative nature of the land alteration process, a comprehensive (i.e., watershed-level) approach must be taken if a reasonable and practical management and implementation approach or strategy is to be successful.

Watersheds are an interconnected network in which changes to any portion within the watershed carry throughout system. There are a variety of factors that influence how runoff from a particular site will affect the overall watershed. Many of the techniques for managing stormwater within a watershed are unique to each watershed. An effective stormwater management plan must be responsive to the existing characteristics of the watershed and recognize the changing conditions resulting from planned development. In Pennsylvania, stormwater management is generally regulated on the municipal level, with varying degrees of coordination on types and levels of stormwater management required between adjoining municipalities. A watershed-based stormwater management plan can minimize inconsistencies to more effectively address the issues which contribute to a watershed's degradation. While land use regulation remains at the municipal level, the framework established within a watershed plan enables municipalities to see the impact of their regulations on the overall system, and coordinate their efforts with other stakeholders within the watershed.

WATERSHED HYDROLOGY

Under natural conditions, watershed hydrology is in dynamic equilibrium. That is, the watershed, its ground and surface water supplies, and resulting stream morphology and water quality evolve and change with the existing rainfall and runoff patterns. This natural state is displayed by stable channels with minimal erosion, relatively infrequent flooding, adequate groundwater recharge, adequate base flows, and relatively high water quality. When all of these conditions are present the streams support comparatively healthy, diverse and stable in-stream biological communities. The following is a brief discussion of the impact of development on these steam characteristics:

1. Channel Stability – In an undisturbed watershed, the channels of the stream network have reached an equilibrium over time to convey the runoff from its contributing area within the channels banks. Typically, the channel will be large enough to accommodate the runoff from a storm, the magnitude of which will occur approximately every 18-24 months. Disturbances, such as development, in the watershed disrupt this equilibrium. As development occurs, additional runoff reaches the streams more frequently. This results in the channel becoming instable as it attempts to resize itself. The resizing occurs through bed and bank erosion, altered flow patterns, and shifting sediment deposits.
2. Flooding – When a watershed is disturbed and channel instability occurs, it results in increased localized flooding, and other associated problems. Overbank flows will occur more frequently until the channel reaches a new equilibrium. It is important to realize that this equilibrium may take many years to be attained once the new runoff patterns are in place. In watersheds with continuous development, a new equilibrium may not be reached. Additionally, floodplain encroachment and in-stream sediment deposits from channel erosion may exacerbate flooding.
3. Groundwater Recharge – In an undisturbed watershed, runoff is minimal. Natural ground cover, undisturbed soils, and uneven terrain provide the most advantageous conditions for maximum infiltration to occur. When development occurs, these favorable conditions are

diminished, or removed, causing more rainfall to become runoff that flows to receiving streams instead of infiltrating. Less water is retained in the watershed to replenish groundwater supplies.

4. Base Flows – Loss of groundwater recharge, as described above, leads to insufficient groundwater available to replenish stream flow during dry weather. As a result, streams that may have an adequate base flow during dry weather under natural conditions may experience reduced flow, or become completely dry, during periods of low precipitation in developed watersheds. Thermal degradation of the waterbody often accompanies the reduction of base flow originating from groundwater. This source of base flow is generally much cooler than surface water sources. The increase in water temperature can be detrimental to many ecological communities.
5. Water Quality – Stormwater from developed surfaces carries a wide variety of contaminants. Pesticides, herbicides, fertilizers, automotive fluids, hydrocarbons, sediment, detergents, bacteria, increased water temperatures, and other contaminants that are found on land surfaces are carried into streams by runoff. These contaminants affect the receiving streams in different way, but they all have an adverse impact on the quality of the water in the stream.
6. Stream Biology – Biological communities reflect the overall ecological integrity of a stream. The composition and density of organisms in aquatic communities responds proportionately to stressors placed on their habitat. Communities integrate the stresses over time and provide an ecological measure of fluctuating environmental conditions. The adverse impacts of improperly managed runoff and increased pollution are evident in the biological changes in impacted streams. When biological communities within a waterbody degrade the overall ecological integrity of the stream is also diminishing.

It is important to understand that watershed hydrology, rainfall, stormwater runoff, and all of the above characteristics are interconnected. The implications of this concept are far reaching. How we manage our watersheds has a direct impact on the water resources of the watershed. Any decision that affects land use has implications on stormwater management and, in turn, impacts the quality of the available water resources. The quality of water resources has an economic consequence as well as an effect on the quality of life in the surrounding areas. This understanding is at the core of current stormwater management approaches.

The stormwater management philosophy of this Plan is reflected in the technical standards: peak flow management, volume control, channel protection, and water quality management. The philosophy and the standards reflect an attempt to manage stormwater in such a way as to maintain the watershed hydrology as near to existing, or historical, conditions as possible.

STORMWATER MANAGEMENT PLANNING

Historically, the approach to stormwater management was to collect the runoff and deliver it, via a system of inlets and pipes, as quickly as possible to the nearest receiving waters. The increased volume of stormwater delivered quickly to receiving waters had a detrimental effect on channel morphology. Negative impacts, such as severe channel erosion and significant in-stream sediment deposits resulted. These impacts lead to unstable, deepened and widened channels, nuisance flooding, infrastructure damage, increased culvert and bridge maintenance requirements, and have a detrimental affect on the stream quality in terms of habitat for aquatic organisms. In addition, large amounts of rainfall are lost to the watershed and become unavailable for infiltration and groundwater recharge, and contaminants on the land surface enter the stream untreated. This approach cannot be considered stormwater management in any meaningful terms.

This approach was later replaced with the stormwater management standards that largely exist today in municipalities. This latter approach requires that peak flows from development sites be managed, usually through detention ponds, such that the peak discharge from the site is no greater than 100% of the peak discharge rate from the site prior to development. While this may have helped reduce some stormwater problems, there were two significant failings with this approach.

The first failing of this approach is that it does not consider the watershed as a single interrelated hydrologic unit. An integrated watershed management approach is needed to overcome this situation. Two points are emphasized regarding the need for an overall watershed management approach:

1. Stormwater regulatory responsibility, absent arrangements to the contrary, rests with the municipal governments in Pennsylvania. Therefore, stormwater management regulations, if applied at all, are implemented by a municipality only within the boundaries of its own jurisdiction. There is no guarantee that all municipalities within a given watershed have comparable standards. When standards are implemented by individual municipalities the problems caused by unmanaged stormwater in an area with poor, or no, regulations are conveyed to municipalities downstream. Upstream municipalities can, and do, cause stormwater problems for downstream neighbors. In these situations, downstream municipalities are forced to deal with problems associated with increased water volume, increased sediment loads, and increased pollutants which originate in areas they have no control over.
2. Each area within a watershed is unique in terms of it's contribution to the overall watershed hydrology. When the same standards are implemented throughout a municipality, and the overall watershed hydrology is not considered, these standards can result in over-management in some areas and under-management in other areas. In some cases, this type of management could actually exacerbate stormwater problems. Further, this "one-size-fits-all" approach does not take into account conditions such as soil infiltration rates, slopes, or channel conditions, which vary throughout a watershed and municipality.

The second key failing is that this approach does not consider the aspects of water quality, channel protection, or the importance of infiltration in the hydrologic cycle. Simply managing the rate at which stormwater leaves a development site does not maintain the overall watershed hydrology. When implementing a peak rate control strategy as the sole method of controlling stormwater runoff, pollutants are still delivered to surface waters, rainfall is still unavailable to the watershed for recharge, and channel erosion and sedimentation still occur.

LOW-IMPACT DEVELOPMENT AND STORMWATER MANAGEMENT

Low-Impact Development (LID) is an approach to land development that uses various land planning and design practices and technologies to simultaneously conserve and protect natural resource systems and reduce infrastructure costs (HUD, 2003). As the term applies to stormwater management, LID is an approach to managing stormwater in a manner similar to nature by managing rainfall at the source using uniformly distributed, decentralized, micro-scale controls (Low Impact Development Center, 2007). These concepts are the origin of many of the strategies identified to achieve the goals presented in this Plan.

As a comprehensive technology-based approach to managing stormwater, LID has developed significantly since its inception, in terms of policy implementation and technical knowledge. The goals and principles of LID, as describe in *Low-Impact Development Design Strategies* (Prince George's County, 1999) are defined as follows:

- Provide an improved technology for environmental protection of receiving waters.
- Provide economic incentives that encourage environmentally sensitive development.
- Develop the full potential of environmentally sensitive site planning and design.
- Encourage public education and participation in environmental protection.
- Help build communities based on environmental stewardship.
- Reduce construction and maintenance costs of the stormwater infrastructure.
- Introduce new concepts, technologies, and objectives for stormwater management such as micromanagement and multifunctional landscape features (bioretention areas, swales, and conservation areas); mimic or replicate hydrologic functions; and maintain the ecological/biological integrity of receiving streams.
- Encourage flexibility in regulations that allows innovative engineering and site planning to promote smart growth principles.
- Encourage debate on the economic, environmental, and technical viability and applicability of current stormwater practices and alternative approaches.

The overall design concepts and specific design measures for BMPs are derived from the following conceptual framework (Prince George's County, 1999):

1. The site design should be built around and integrate a site's pre-development hydrology;
2. The design focus should be on the smaller magnitude, higher frequency storm events and should employ a variety of relatively small, best management practices (BMPs);
3. These smaller BMPs should be distributed throughout a site so that stormwater is mitigated at its source;
4. An emphasis should be given to non-structural BMPs; and
5. Landscape features and infrastructure should be multifunctional so that any feature (e.g., roof) incorporates detention, retention, filtration, or runoff use.

The LID process is meant to provide an alternative approach to traditional stormwater management; *Table 1.1* highlights the difference between the two approaches. These concepts, as they apply to stormwater, are the basis for the stormwater management approach presented in this Plan.

LID Approach		Traditional Approach	
Approach	Examples	Approach	Examples
1. Integration of Pre-Development Hydrology	A development built around a drainage way outside of functional floodplain	Elimination of all water features from project site	Redirection and conveyance of drainage; alteration of floodplain to meet site design
2. Emphasis on smaller magnitude, higher frequency storm events	Several small BMPs	Large stormwater ponds and facilities that focuses on 10 and 100-year events	A single stormwater pond
3. Stormwater to be mitigated at source	BMPs located near buildings, within parking lot islands	Stormwater to be conveyed to low point in site	A single stormwater pond
4. Use simple, non-structural BMPs	Narrower drive ways, conservation easements, impervious disconnection	Use of pipe and stormwater ponds	A single stormwater pond
5. Use of multifunctional landscape and infrastructure	Green roofs, rain gardens in parking lot islands	Stormwater and site feature kept as separate as possible	No consideration given

Table 10.1. Comparison of LID Versus Traditional Stormwater Management Approach

When implemented at the site level, LID has been found to have a beneficial impact on water quality and in reducing peak flows for more frequent storm events (Bedan and Clausen, 2009; Hood et. al., 2007). There are numerous case studies and pilot projects that emphasize similar finding about the benefits of site level development and of specific LID BMPs (EPA, 2000; DEP, 2006; Low Impact Development Center, 2009).

When implemented at the watershed level, as proposed in this Plan, there are quantifiable benefits in terms of reduced peak discharges coming from future developments (as discussed in *Section VI*). The approach of considering water quality and existing condition hydrology will help address documented stream impairments (as discussed in *Section IX*). Additionally, adopting a LID approach will help alleviate the economic impact of the additional regulations proposed in the model ordinance (as discussed in *Section VIII*). Several other Act 167 Plans that have been recently prepared or are being prepared concurrently with this Plan further support these findings.

Section II – Goals and Objectives of the Act 167 Stormwater Management Plan

This plan was developed to present the findings of a two-phased multi-year study of the watersheds within the county. Watershed-based planning addresses the full range of hydrologic and hydraulic impacts from cumulative land developments within a watershed rather than simply considering and addressing site-specific peak flows. Although this plan represents many things to many people, the principal purposes of the Plan are to protect human health and safety by addressing the impacts of future land use on the current levels of stormwater runoff and to recommend measures to control accelerated runoff to prevent increased flood damages or additional water quality degradation.

GOALS OF THIS PLAN

The overall objective of this Plan is to provide a plan for comprehensive watershed stormwater management throughout McKean County in accordance with Section 3 of Act 167. The Plan is intended to enable every municipality in the county to meet the intent of Act 167 through the following goals:

1. Manage stormwater runoff created by new development activities by taking into account the cumulative basin-wide stormwater impacts from peak runoff rates and runoff volume.

2. Meet the legal water quality requirements under Federal and State laws.

3. Provide uniform stormwater management standards throughout McKean County.

4. Encourage the management of stormwater to maintain groundwater recharge, to prevent degradation of surface and groundwater quality, and to protect water resources.

5. Preserve the existing natural drainage ways and water courses.

6. Ensure that existing stormwater problem areas are not exacerbated by future development and provide recommendations for improving existing problem areas.

These goals provided the focus for the entire planning process. A scope of work was developed in Phase 1 that focused efforts on gathering the necessary data and developing strategies that address the goals. With the general focus of the Plan determined, Phase II further researched county specific information, provided in-depth technical analysis, and developed a model ordinance to achieve these goals. On the following page, *Table 2.1* shows the preferred stategies to address the goals, and where these strategies are addressed in the Plan:

1. Manage stormwater runoff created by new development activities by taking into account the cumulative basin-wide stormwater impacts from peak runoff rates and runoff volume	
Develop models of selected watersheds to determine their response to rainfall	*Section VI, Appendix A*
Determine appropriate stormwater management controls for these basins	*Section VI, Appendix A*
2. Meet the legal water quality requirements under Federal and State laws	
Provide recommendations for improving impaired waters within the county	*Section IX*
Encourage the use of particularly effective stormwater management BMPs	*Section VII*
3. Provide uniform standards throughout McKean County	
Develop a Model Stormwater Management Ordinance with regulations specific to the watersheds within the county	*Model Ordinance*
Adopt and implement the Model Ordinance in every municipality in McKean County	*Model Ordinance*
3. Encourage the management of stormwater to maintain groundwater recharge, to prevent degradation of surface and groundwater quality, and to protect water resources	
Provide education on the correlation between stormwater and other water resources	*Section I, Section X*
Require use of the Design Storm Method or the Simplified Method	*Model Ordinance*
4. Preserve the existing natural drainage ways and water courses	
Provide education on the function and importance of natural drainage ways	*Section I, Section X*
Protect these features through provisions in the Model Ordinance	*Model Ordinance*
5. Ensure that existing stormwater problem areas are not exacerbated by future development and provide recommendations for improving existing problem areas	
Develop an inventory of existing stormwater problem areas	*Section V*
Analyze problem areas and provide conceptual solutions to the problems	*Section V*

Table 2.1. Preferred Strategies to Address Plan Goals

STORMWATER PLANNING AND THE ACT 167 PROCESS

Recognizing the increasing need for improved stormwater management, the Pennsylvania legislature enacted the *Stormwater Management Act* (Act 167 of 1978). Act 167, as it is commonly referred to, enables the regulation of development and activities causing accelerated runoff. It encourages watershed based planning and management of stormwater runoff that is consistent with sound water and land use practices, and authorizes a comprehensive program of stormwater management intended to preserve and restore the Commonwealth's water resources.

The Act designates the Department of Environmental Resources as the public agency empowered to oversee implementation of the regulations and defines specific duties required of the Department. The Department of Environmental Resources was abolished by Act 18 of 1995. Its functions were transferred to the Pennsylvania Department of Conservation and Natural Resources (DCNR) and the Department of Environmental Protection (DEP). Duties related to stormwater management became the responsibility of DEP (Act 18 of 1995).

As described in Act 167, each county must prepare and adopt a watershed stormwater management plan for each watershed located in the county, as designated by the department, in consultation with the municipalities located within each watershed, and shall periodically review and revise such plan at least every five years. Within six months following adoption, and approval, of the watershed stormwater plan, each municipality must adopt or amend, and must 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 stormwater plan and the provisions of the Act.

Section 5 of Act 167 sets forth the Plan contents required for each Stormwater Management Plan. Section 5.b lists thirteen (13) elements to include in the Plan, and Section 5.c lists an additional two (2) elements for inclusion. The following table addresses these elements in Section 5 of Act 167, and present the necessary information to inventory and address issues with stormwater management in the County.

SECTION 5b
(1) A survey of existing runoff characteristics in small as well as large storms, including the impact of soils, slopes, vegetation and existing development;
Section 3 identifies and analyzes factors that impact the hydrologic response of the identified watershed for including existing and future land use conditions. Section 6 discusses the technical analysis performed on the on focused watersheds. The other watersheds within the County should be considered in future Plans. Appendix A details the modeling completed to perform the technical analysis. In addition, relevant details of the factors and elements impacting the hydrologic response of the watersheds are shown graphically in the Plates.
(2) A survey of existing significant obstructions and their capacities;
The municipalities, through the PAC, responded to a survey which compiled an inventory of obstructions. Section 5 provides the inventory as well as a discussion. Capacities of the obstructions were not fully developed as Budgetary impacts reduced the scope of the Plan. Plate 7 shows the identified obstructions.
(3) An assessment of projected and alternative land development patterns in the watershed, and the potential impact of runoff;
A hydrologic model was developed and used to assess the impacts future land development alternatives in order to address the potential impacts of increased runoff, as discussed in the following portions of the Plan: Section 3 (Land Use and Surface Water Quality), Section 5 (Significant Problem Areas and Obstructions) Sections 6 (Technical Analysis) and Section 7 (Technical Standards and criteria for control of stormwater runoff), Section 9 (Water Quality Impairments and Recommendations), and Section 10 (Additional Recommendations Low-Impact Development Site Design) as well as Appendix A.
(4) An analysis of present and projected development in the flood hazard areas, and its sensitivity to damages from future flooding or increased runoff;
Federal flood insurance studies have been used as reference for the location of flood plain areas as identified in Plate 8. Section 3 provides a discussion and an analysis showing damages to existing development due to flood hazard areas caused by increased runoff in the watershed. Recommendations where made with measures to mitigate future damages in Section 7.
(5) Survey of existing drainage problems and proposed solutions;
The municipalities, through the PAC, responded to a survey which compiled an inventory of existing problem areas. Section 5 provides the inventory as well as a discussion. Plate 7 shows the identified problem areas as well as Appendix C.
(6) A review of existing and proposed stormwater collection systems;
The more urbanized areas of the County contain storm sewer systems, as do the many roadways that traverse the County. Storm sewer collection systems have a significant effect on the hydrologic response of a watershed as pipe networks rapidly increase runoff rate. If stormwater control facilities do not intercept runoff from storm sewer systems, flooding often increases, as well as other stormwater problems such as streambank erosion and sedimentation. Plate 7 shows the collection systems as identified by the municipalities through the PAC.
(7) An assessment of alternative runoff control techniques and their efficiency in the particular watershed;
Section 6 of the Plan describes the detailed analysis of the Chartiers Creek watershed and recommended alternative control criteria. Section 7 of the Plan identifies a variety of runoff control techniques are available for use in all watersheds in the County. It references and expands upon the

Pennsylvania Stormwater Best Practices Manual to identify innovative methods of controlling runoff. In addition, traditional engineering solutions such as drainage structure replacement, streambank restoration, etc. were also identified in situations where alternative runoff controls are not applicable.
(8) An identification of existing and proposed state, federal and local flood control projects located in the watershed and their design capacities;
Section 3 lists the local, state, and federal flood control projects in the County which was shown on Plate 8. Where the effectiveness in mitigating flooding or design capacity data was readily available, this information was also documented.
(9) A designation of those areas to be served by stormwater collection and control facilities within a 10-year period, an estimate of the design capacity and costs of such facilities, a schedule and an identification of the existing or proposed institutional arrangements to implement and operate the facilities;
Stormwater control facilities were identified and documented by municipalities and through the completion of the Questionaire. Although data was compiled and tabulated for those municipalities which provided data, the future facilities were not fully developed as Budgetary impacts reduced the scope and intent of the Plan. Sections 7 and 9 identify recommended strategies to address runoff impacts from future development.
(10) An identification of flood plains within the watershed;
Flood insurance studies prepared under the National Flood Insurance Program were identified in Section 3 and shown on Plate 8.
(11) Criteria and standards for the control of stormwater runoff from existing and new development which are necessary to minimize dangers to property and life and carry out the purposes of this act;
Standards and criteria were developed in Section 7 which is to be implemented through the Model Ordinance. Additional recommendations are contained in Section 10.
(12) Priorities for implementation of action within each plan; and
Section 7 contains recommended BMP's and implementation of stormwater management controls. Section 11 details the preparation process completed and the County adoption of the draft Plan with submission to PADEP for approval. This will initiate the mandatory schedule of adoption of ordinances needed to implement stormwater management criteria.
(13) Provisions for periodically reviewing, revising and updating the plan.
Section 11 discusses the requirement of Section 5(a) of the Act that each plan must be reviewed and any necessary revisions made at least every five years after its initial adoption.
SECTION 5c
(1) Contain such provisions as are reasonably necessary to manage stormwater such that development or activities in each municipality within the watershed do not adversely affect health, safety and property in other municipalities within the watershed and in basins to which the watershed is tributary; and
With the adoption of the Model Stormwater Management Ordinance provided with this Plan, each municipality must enforce development, redevelopment, and other regulated activities consistent with the standards and criteria contained in the Model Ordinance. These standards and criteria have been developed to ensure regulated activities will not adversely affect health, safety, and property in the County.
(2) Consider and be consistent with other existing municipal, county, regional and State environmental and land-use plans.
Section 3 identifies several planning efforts which the County conducted in the past. These include watershed Act 167 Plans, comprehensive planning including open space planning and land use plans, and hazard mitigation planning. In addition, Section 4 contains identified existing stormwater regulations.

Table 2.2. Elements of Act 167

PLAN ADVISORY COMMITTEES

Public participation by local stakeholders is an integral part of comprehensive stormwater management planning. Coordination amongst these various groups facilitates a more inclusive

Plan, that is able to better address the variety of issues experienced throughout the county. Several Plan Adisory Committee meetings were facilitated throughout the development of this Plan.

A Plan Advisory Committee (PAC) was formed at the beginning of the planning process, as required by the Stormwater Management Act. The purpose of the PAC is to serve as an access for municipal input, assistance, voicing of concerns and questions, and to serve as a mechanism to ensure that inter-municipal coordination and cooperation is secured. The PAC consists of at least one representative from each of the municipalities within the county, the County Conservation District, and other representatives (such as watershed groups, State Departments, etc.) as appropriate. A full list of the PAC members can be found in the Acknowledgements section at the beginning of this Plan.

As per Act 167, the Committee is responsible for advising the county throughout the planning process, evaluating policy and project alternatives, coordinating the watershed stormwater plans with other municipal plans and programs, and reviewing the Plan prior to adoption. *Table 2.3* is a summary of the PAC meetings that were held throughout the planning process.

PAC Meeting	Purpose of Meeting	Meeting Dates
3	Phase 2 Start-up Meeting – Re-Introduce the Act 167 Phase 2 planning process. Emphasize the importance of full municipal involvement. Present summary of the Phase 1 Report and review Phase 2 Scope.	2.21.2009
4	Review the project status, solicit input from municipalities, provide summary of stormwater problems, discuss stream impairments. Identify areas that require detailed hydrologic modeling. Discuss stormwater management standards and begin Model Ordinance discussions.	7.21.2009
5	Discuss state budget impacts to the project, review modeling (selection and setup, initial modeling runs, calibration), presented proposed SWM standards and solicit input on criteria, preliminary technical content for ordinances, & Small Project approaches.	12.15.2009
6	Municipal Engineers invited to meeting; Reviewed detailed modeling results, present standards and criteria; presented overview of Model Ordinance and implementation examples of small projects; solicited input on Ordinance provisions. (Draft MODEL ORDINANCE sent to municipalities prior to meeting).	2.16.2010
Public Hearing	Conduct the hearing as required by Act 167 to present the PLAN to the public.	TBD
8	Municipal Implementation Workshop: Provide assistance to municipalities on implementation of the PLAN including adaptation, enactment, and implementation of the ordinances and other action items.	TBD
Public Workshop	Public Implementation Workshop: Provide introduction and overview of the PLAN to public.	TBD

Table 2.3. Summary of PAC Meetings

This page has been left blank intentionally.

Section III – McKean County Description

McKean County is located in the north-central part of Pennsylvania. It is bounded to the north by the New York counties of Cattaraugus and Allegany, and in Pennsylvania to the east by Potter County, to the south by Cameron County and Elk County, and to the west by Warren County. The county was settled after the American Revolution (1775-1783) by way of the upper reaches of the Allegheny River. The county was officially formed in 1804, from a portion of Lycoming County. It is named in honor of former Pennsylvania Governor, and signer of the Declaration of Independence, Thomas McKean. It is approximately 38 miles wide (east and west) by 27 miles long (north and south) and encompasses 981.7 square miles. The elevation of the county ranges from a low of 1,260 feet on Kinzua Creek at the McKean-Warren county line, to a high of 2,460 feet on Prospect Hill (Socolow, 1973).

The first settlements were along the fertile valleys, a pattern which continues today. Lumbering, the first major industry, is still important today. The first successful oil well in the county was drilled in 1871 and the county was the leading oil producer in Pennsylvania until 1981. The oil and gas industry is still an important industry in the county. Smethport Borough is the county seat and serves as the administrative headquarters of the county. A commission form of government, comprised of three elected commissioners, rests both executive and legislative powers in the county with the commissioners.

POLITICAL JURISDICTIONS

McKean County is classified as a sixth class county and is comprised of 22 municipalities. The political jurisdictions include 1 city, 6 boroughs, and 15 second class townships. The county has a total population of 45,936 according to the 2000 census. Bradford City has the largest population with 9,175. Bradford Township, Foster Township, and Kane Borough are the only other municipalities to exceed 4,000 people (with 4,816, 4,566, and 4,126 respectively). Sergeant Township has the smallest population with 176 people. Keating Township is the largest municipality geographically with a total land area of 98.1 square miles which is closely followed by Norwich Township with 95.6 square miles, while Eldred Borough is the smallest covering just 0.9 square miles. All of the municipalities in the county are listed with their land area in *Table 3.1*.

Townships	Area (mi^2)	Townships	Area (mi^2)	Boroughs/Cities	Area (mi^2)
Annin Township	33.6	Keating Township	98.1	Eldred Borough	0.9
Bradford Township	55.6	Lafayette Township	71.2	Kane Borough	1.6
Ceres Township	40.7	Liberty Township	83.5	Lewis Run Borough	1.9
Corydon Township	73.2	Norwich Township	95.6	Mt Jewett Borough	2.4
Eldred Township	39.4	Otto Township	34.8	Port Allegany Borough	1.8
Foster Township	46.4	Sergeant Township	80.3	Smethport Borough	1.7
Hamilton Township	72.0	Wetmore Township	79.0	Bradford City	3.4
Hamlin Township	64.6				

Table 3.1. McKean County Municipalities

LAND USE

Land use is a crucial component of stormwater management planning. An analysis of existing land use provides background information for estimating existing stormwater runoff. Existing land use and general development patterns are used to forecast future land use. General growth patterns and future land use is essential information used to develop stormwater management controls that are appropriate for a particular region.

EXISTING LAND USE

In 1980, the county's population was 50,635; by 2000, the population had decreased to 45,936. This represents a population reduction of around ten percent (10%) over the 20 year time period. The US Census Bureau Population Estimates Program (PEP) estimates a -5.2% population change from April 1, 2000 to July 1, 2008. However, population trends are not directly correlated with land used patterns. Though the population has declined, new development has continued to take place as residents relocate within the county, as new seasonal residents construct second homes, and as businesses and institutions expand and improve their facilities. The location, intensity, and character of this new development has drifted away from the traditional "small town" and rural community development patterns that were previously typical of the area. The *McKean County Comprehensive Plan* (2007) classified all the land uses within the county in 2006:

	Area		**Change from**
Land Use	**mi^2**	**%**	**1977 (mi^2)**
Forest	758.61	77.09%	-75.30
Agriculture	146.62	14.90%	28.34
Non-Intensive Uses Subtotal	*905.23*	*91.99%*	
Residential	32.18	3.27%	21.40
Industrial	4.62	0.47%	0.71
Public Utility	0.73	0.07%	-11.55
Commercial	9.81	1.00%	8.88
Institutional	31.45	3.20%	26.92
Intensive Uses Subtotal	*78.79*	*8.01%*	

Table 3.2. McKean County Existing Land Use

There has been a 48,000 acre reduction in forested land since 1977. The most significant changes in land use have been increases in agricultural (+18,139 acres), residential (+18,139 acres), and commercial (+18,139 acres) uses.

<u>Forests and Publicly Owned Lands</u>

Just over 77% of McKean County's total land area is forested land, much of which is publicly owned land. Forested land is the predominant, and single largest, land use category in the county. This category includes the Allegheny National Forest and other publicly-owned forest lands such as state forests, state parks, state game lands, and privately-owned forest lands, including seasonal camps. The Allegheny National Forest dominates the western portion of the county and accounts for over 135,000 acres (21.5%) of the county. Other publicly-owned forests include portions of the Elk and Susquehannock State Forests which account for almost 28,000 acres. Another significant category of publicly owned land is the nearly 22,850 acres of State Game Lands managed by the Pennsylvania Game Commission.

State Game Lands	**Area (ac)**
SGL 30	11,572
SGL 301	842
SGL 61	9,099
SGL 62	1,334
TOTAL	22,847

Other important forested lands include 12,000 acres in the Marilla Brook and West Branch Tunungwant Creek watersheds owned and controlled by the Bradford City Water Authority, Kinzua Bridge State Park which is a 329 acre tract owned by the State, and many privately owned forest tracts.

Farmlands
Agricultural use is the second largest land use category in McKean County. This land use accounts for just under 15% of total county land use. Agricultural land use is scattered throughout the county, however, it is the dominant land use in the northeast portion of the county.

Prime farmland, as defined by the U.S. Department of Agriculture (USDA) in the National Soil Survey Handbook, is the land that is best suited to producing food, feed, forage, and fiber and oilseed crops. It has the soil quality, growing season, and water supply needed to economically produce a sustained high yield of crops when it is treated and managed using acceptable farming methods (NRCS, 2007). In 1972, the USDA tasked the Soil Conservation Service to inventory the prime and unique farmlands, and farmlands of state and local importance, to assist planners and other officials in their decision making to avoid unnecessary, irrevocable conversion of good farmland to other uses. Of McKean County's total land area 21.6% (136,309 acres) are classified as prime farmland (NRCS, 2009). According to the USDA, prime farmland soils are usually classified as capability Class I or II. The soils classified as prime farmland are scattered throughout the county according to the *Soil Survey of McKean County, Pennsylvania* (SCS, 1987).

Farmland soils of statewide importance are soils that are predominantly used for agricultural purposes within a given state, but have some limitations that reduce their productivity or increase the amount of energy and economic resources necessary to obtain productivity levels similar to prime farmland soils. Of McKean County's total land area 14.1% (89,016 acres) is classified as farmland of statewide importance (NRCS, 2009). These soils are usually classified as capability Class II or III.

The importance of identifying these areas, and planning accordingly, is significant. The loss of good farmland is often accompanied by such environmental problems as surface water runoff and interference with the natural recharging of groundwater. Furthermore, when prime agricultural areas are no longer available, farmers will be forced to move to marginal lands, usually on steeper slopes with less fertile soils, which are more apt to erode and less likely to produce. Clearly, decision makers must be able to make informed judgments about the development of farmland as part of a comprehensive stormwater policy.

Industry
Although it is a relatively small portion of the County, industrial activities can be a potential source of water pollution. The main industries in McKean County are manufacturing, education and health services, and trade, transportation services. Together, these industry sectors employ almost 70% of the County's workforce. The leading County employers include Zippo Manufacturing, Bradford Regional Medical Center, Bradford Area School District, W.R. Case & Sons Cutlery, Wal-Mart, and American Refining Group, Inc..

TRANSPORTATION

Mckean County has a fairly extensive system of highways. Due to its rural location, the county's transportation system predominantly consists of state and local highways. Two important major roads serve the county. US Route 6, the east-west link across the northern tier of Pennsylvania, passes through the southern-middle portion of the county. US Route 219 provides a link to

Interstate 80 to the south and US Route 17 to the north in New York. Other state highways connect population centers to the major roads and interconnect each other. These include US Route 59 which provides access to the Allegheny National Forest areas in the western portion of the county, US Route 46 which provides a north-south route in the eastern part of the county, and others. An extensive network of local roads provides further interconnection among the various municipalities and destinations throughout the county.

A commercial airport at Mount Alton (i.e. Bradford Regional Airport) and two railroads are present and provide support for large industry but are not as convenient, efficient, or cost-competitive as trucking for small business transportation needs. Likewise public transit services are available but are challenged to meet the needs of a highly dispersed population (McKean County Planning Commission, 2007).

FUTURE GROWTH PATTERNS

As noted in the *County Comprehensive Plan*, land use trends in McKean County can be summarized as follows:

- Changes have been gradual for the past 30 years.
- The biggest changes in land use have been increases in agricultural, residential, and commercial land, which account for the majority of the reduction in forested land.
- The Bradford area desires to focus development and preserve forested lands for timber harvest and overall environmental quality.
- Keating, Wetmore, and Otto Townships have seen the most subdivision activity.

The *County Comprehensive Plan* offers a Land Use Strategy that "is based on the principle that land use patterns are planned by location and compatibility, growth areas are designated based on water and sewer service areas, and natural resources are managed for resource-based industries and environmental integrity." Future growth patterns have been planned based on this strategy.

Future "growth" areas where also designated in the *Comprehensive Plan*, focusing on the urban areas around Bradford, some industrial growth in certain sectors including information technologies, specialized manufacturing (e.g. wood, metal coatings), tourism, and natural resource extraction. Planned residential growth areas are focused around the existing villages and towns throughout the county including Bradford, Eldred, Kane, Port Allegheny, Smethport, and other similar areas. Industrial areas identified were south of Bradford along Routes 219 & 46, along Route 59 in Lafayette Township, and north of Kane along Route 6. Tourism growth is to be centered on the Allegheny National Forest and the Route 6 corridor.

The vast majority (almost 98%) of the County is designated Rural Resource Area. The *Comprehensive Plan* developed strategies to encourage "smart" growth initiatives and provides tools for future use by the municipalities to use in managing changes in the use of land.

CLIMATE

McKean County is situated in the Northwest Plateau Climatic Divisions and the climate is classified as humid continental. The area is mostly affected by weather systems that develop in the Central Plains or mid-west and are carried by prevailing westerly winds. Canada is the primary source of cold air and the Great Lakes is the main source of moisture. In general, the winters in McKean County are cold and the summers are warm and somewhat humid. Average highs for the summer linger below 80°F. The county's prevailing January temperature averages about 29°F while the minimum temperatures experienced often dips anywhere between 10 to 0

F. There are about 120 frost-free days during the year in McKean County. Annual precipitation varies throughout the county but is about 42" of which about 21" drains out of the county. Several weather records are held by McKean County including the World Record for a 4.5-hour rainfall of 30.8" on July 18, 1942, Smethport (NOAA) and National Record of 34.5" July 17-18, in Smethport. The average annual snowfall amounts up to 90" a year.

RAINFALL

Figures 3.1 and *3.2* show the rainfall statistics for McKean County. The average rainfall, shown in Figure 3.1 portrays the amount of precipitation throughout each year since November 1934. Although there can be significant variation in the annual rainfall total (between 32 and 61 inches). While this variation can have a significant impact on water supply and vegetative growth, it is the quantity of rain in a relatively short time period (1-hour, 6-hour, 24-hour, 48-hour) that receives the focus of most stormwater regulations.

Figure 3.2 show the annual maximum rainfall events recorded over the same time period graphed and the NOAA Atlas 14 values for the 2-year and 100-year storm events, derived using partial series data. The annual maximum rainfall for a station is constructed by extracting the highest precipitation amount for a particular duration in each successive year of record. A partial duration series is a listing of period of record greatest observed precipitation depths for a given duration at a station, regardless of how many occurred in the same year. Thus, a partial data series accounts for various storms that may occur in a single year.

Historical focus on the annual maximum rainfall and the larger magnitude, low frequency storm events as done in previous stormwater planning efforts throughout Pennsylvania has lead to neglect of 1) the majority of storm events that are smaller than the annual maximum and their subsequent value to the landscape in terms of volume and water quality and 2) the fact that inclusion of every storm may increase the 24-hour rainfall total typically used in design.

The majority of rainfall volume in McKean County comes from storms low magnitudes. Only 10% of the daily rainfall values between 1934 and 2009 exceeded 0.70 inches, which is below any design standards currently being used in the county. Thus, any stormwater policy should incorporate provisions such as water quality, infiltration, or retention BMPs that account for these small events. It is important to acknowledge that many of these smaller **rainfall** events lead to larger **runoff** events as they may be saturating the soils prior to a larger storm or occurring within a short time period that still overwhelm existing conveyance facilities.

For the gage shown in Figure 3.1 and 3.2, the NOAA Atlas 24-hour, 2-year storm event total of 2.48 inches was exceeded 93 times in 75 years of data. When analyzing only the annual maximum series, the NOAA Atlas 24-hour, 2-year storm was exceeded only 27 times. Thus, viewing only the annual maximum series neglects a substantial number of significant historical rainfall events. The implication for stormwater policy in McKean County is that best management practices should incorporate the NOAA Atlas 14, partial duration data series to ensure the best available data is being used for design purposes.

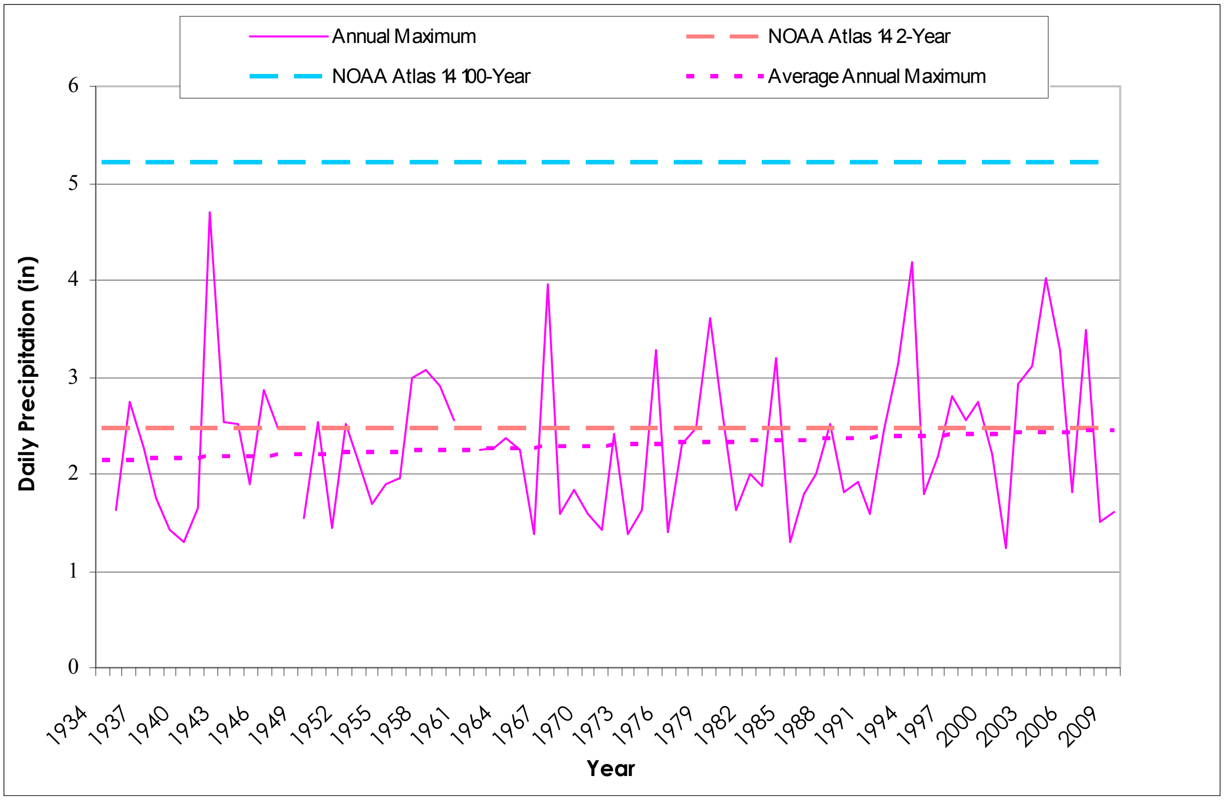


Figure 3.1. Annual Precipitation at Bradford 4 SW, Pennsylvania (Coop ID #360868)

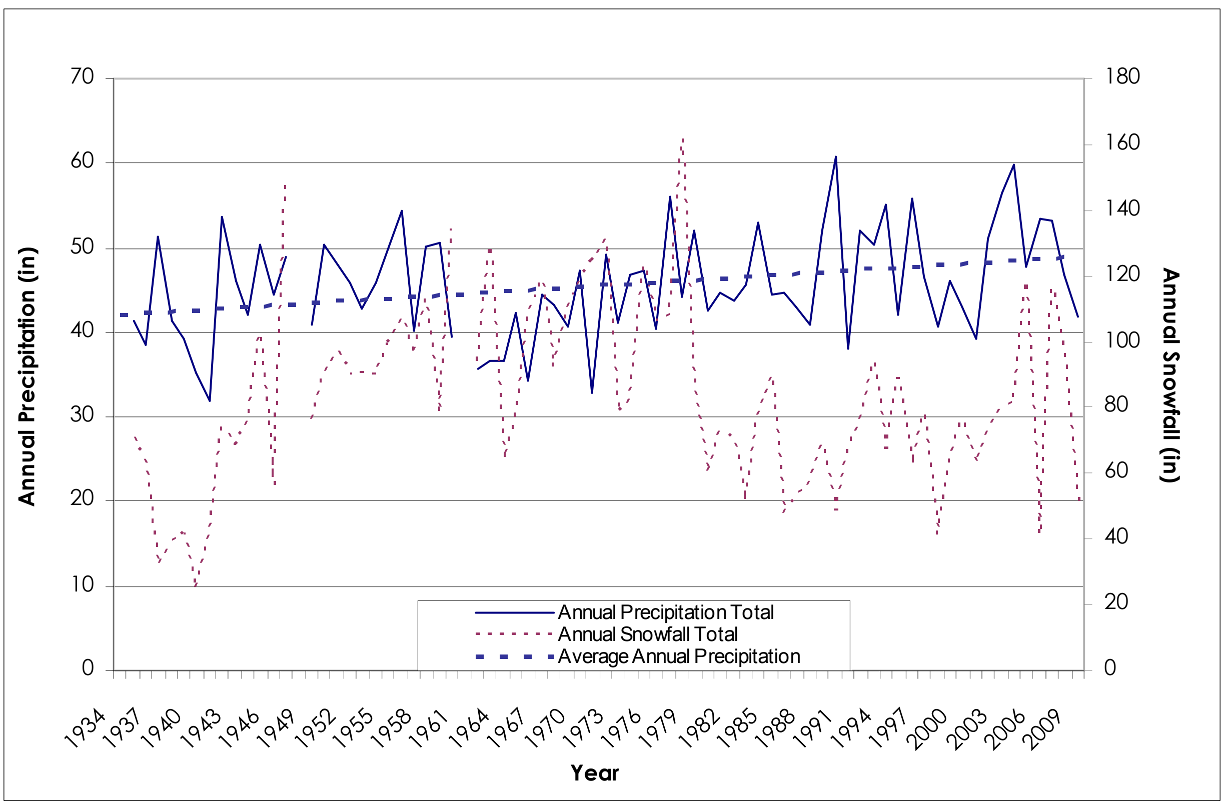


Figure 3.2. Daily Precipitation at Bradford 4 SW, Pennsylvania (Coop ID #360868)

GEOLOGY

McKean County is located primarily within the Deep Valleys Section of the Appalachian Plateaus Physiographic Province. The southwest part of the county is within the High Plateau Section and the very northeast corner lies within the Glaciated High Plateau Section, both of the Appalachian Plateaus Physiographic Province. The remainder of the present day surface forms were created through millions of year of uplifting and subsiding, geologic erosion, and stream cutting. These processes changed what had previously been a nearly level surface formed by freshwater inland seas to a highly dissected, rolling and hilly relief. Most of the county is hilly, but some parts are only slightly dissected. A very small area (about a square mile) of the extreme northeast corner is the only portion of the county to have been covered by glacial ice.

The Appalachian Plateau Province is by far the largest province in the state. It contains mostly rock that is not faulted and folded but sits relatively flat. Many of the folds that do exist in this province are high amplitude and stretch for miles. The dominant topographic form of the Deep Valleys Section is very deep, angular valleys with some broad to narrow uplands. It has moderate (301 to 600 feet) to very high (> 1,000 feet) local relief and angulate and rectangular drainage patterns. The High Plateau Section is characterized by broad, rounded to flat uplands having deep, angular valleys. It has moderate (301 to 600 feet) to high (601 to 1,000 feet) local relief and dendritic drainage patterns. The dominant topographic form of the Glaciated High Plateau Section is broad to narrow and rounded to flat, elongated uplands and shallow valleys. The local relief is low (101 to 300 feet) to high (601 to 1,000 feet) and the drainage patterns are agulate and dendritic. (Sevon, 2000). Refer to *Plate 6 – Geology* for more information.

BEDROCK FORMATIONS

The bedrock formations in McKean County are nearly level, and very gently sloping synclines and anticlines southwest and northeast. Bedrock in the county is primarily sedimentary in origin and includes eight different geologic formations that range from Devonian-age (354 – 417 million years ago) to Pennsylvanian-age (290 – 323 million years ago) (Barnes and Sevon, 2002). The formations consist of sandstone, siltstone, mudstone, shale, and conglomerate as well as some clay, claystone, limestone and coal. The formation names and their respective areas are as follows (Berg et al., 1980):

Formation	Dominant Lithology	% of County
Allegheny Formation	Sandstone	4.3%
Catskill Formation	Sandstone	18.3%
Chadakoin Formation	Siltstone	7.8%
Huntley Mountain Formation	Sandstone	1.0%
Lock Haven Formation	Mudstone	0.1%
Pottsville Formation	Sandstone	32.9%
Shenango Formation through Oswayo Formation, undivided	Sandstone	31.9%
Venango Formation	Siltstone	3.6%

Table 3.3. Geologic Formations

The youngest rocks present are of the Pennsylvanian age and they underlie the highest elevation in the south and west of the county. These include the Allegheny and Pottsville Formations. They are primarily a cyclic sequence of shale, siltstone, sandstone, and, in the Allegheny group, some coal. Next in age are the Mississippian age rocks. Bedrock formed during this age includes the Shenango through Oswayo Formations and the Huntley Mountain Formation. These formations are cyclic sequences of shale, siltstone, and sandstone and are mainly located on the sides of valleys. The oldest bedrock in the county was formed during the Devonian age. This group includes the Catskill, Chadakoin, Lock Haven and Venango Formations. The Catskill Formation consists red siltstone, shale, and sandstone. The Venango and Chadakoin Formations consist of gray siltstone, shale, and sandstone with some interfingering of red shale from the Catskill Formation found in the Venango Formation.

OUTSANDING AND UNIQUE FEATURES

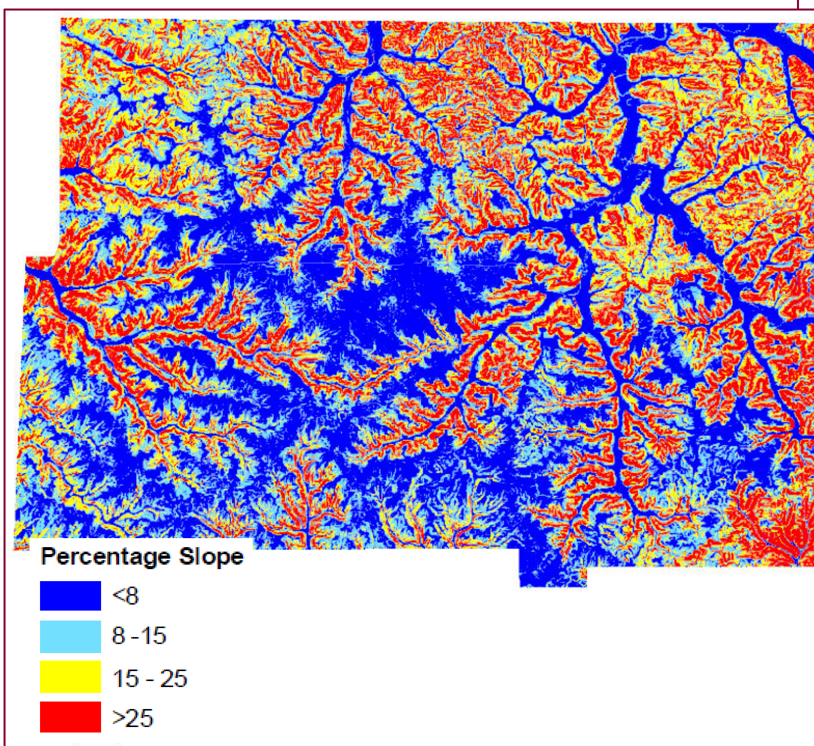
Pennsylvania's outstanding and unique scenic geological features have been identified by the *Outstanding Scenic Geological Features of Pennsylvania* (Geyer and Bolles, 1979). McKean County contains three of these resources as identified below.

Devil's Den – Located in Keating Township, Devil's Den is a series of rock outcrops of sandstone that form several "rock caves" and passageways.

The Nipple – About 2.3 miles to the north-east of Devil's Den, is a formation capped by a weather-resistant sandstone in the upper part of the Catskill Formation. This small, round, slender erosional feature rises above the surrounding countryside in spectacular fashion.

Kinzua Gorge - The Kinzua Gorge is location in Kinzua Bridge State Park approximately 8.2 miles southwest of Smethport Borough. This spectacular gorge offers a scenic view of the High Plateau. This is the site of the famous Kinzua Viaduct, the second highest bridge of this type on the North American continent (301 feet high and 2110 feet long), which spans Kinzua Creek. The steel structure was built in 1900 as a replacement for the original iron viaduct of the same dimensions built in 1882. The iron viaduct was the highest railroad bridge in the world at the time (1882). The Kinzua Viaduct was listed in the *National Register of Historic Places* in 1977 and as a *National Historic Civil Engineering Landmark* in 1982. A large portion of the bridge collapsed during a tornado in 2003.

SLOPES



The slope of the land not only delineates drainage patterns, but it is an indication of suitable land uses and the ability to develop land. Erie County's land area is comprised of varying degrees of slope, ranging from nearly level plateaus to severe slopes. The general characteristics and development potentials and limitations of each category of slope are described as follows:

Slopes with grades of 15% or greater are considered steep. If disturbed, these areas can yield heavy sediment loads on streams. Very steep slopes, with over 25% grade, produce heavy soil erosion and sediment loading. Approximately 44% of the county's total land area is sloped greater than 15%. However, over one-third of the county has a slope of less than 8%. This slope range has vey few associated land use restrictions. Slope values are broken into four categories and shown in *Table 3.4* below. Also shown is the total area in McKean County within each category, the total area as a percentage of all land in the county, and the general slope restrictions associated with each category.

Slope Classification	Slope Range	Land Area (mi^2)	Portion of Total Area	Slope Restrictions
Flat to Moderate	0-8%	331.2	33.7%	Capable of all normal development for residential, commercial, and industrial uses; involves minimum amount of earth moving; suited to row crop agriculture, provided that terracing, contour planting, and other conservation practices are followed
Rolling Terrain and Moderate Slopes	8 - 15%	211.3	21.5%	Generally suited only for residential development; site planning requires considerable skill; care is required in street layout to avoid long sustained gradients; drainage structures must be properly designed and installed to avoid erosion damage; generally suited to growing of perennial forage crops and pastures with occasional small grain plantings
Steep slopes	15 - 25%	213.6	21.7%	Generally unsuited for most urban development; individual residences may be possible on large lot areas, uneconomical to provide improved streets and utilities; overly expensive to provide public services; foundation problems and erosion usually present; agricultural uses should be limited to pastures and tree farms
Severe and Precipitous Slopes	> 25%	226.3	23.0%	No development of an intensive nature should be attempted; land not to be cultivated; permanent tree cover should be established & maintained; adaptable to open space uses (recreation, game farms, & watershed protection)

Table 3.4. Summary of Slopes in McKean County

SOILS

The behavior of a soil's response to rainfall and infiltration is a critical input to the hydrologic cycle and in the formation of a coherent stormwater policy. The soils within McKean County have variable drainage characteristics and have various restrictions on their ability to drain, promote vegetative growth, and allow infiltration. The following describes the predominant soil series found in McKean County (SCS, 1987).

Series Name	Map Symbols	Hydrologic Soil Group	% of County	Restrictions
Albrights	AbB, AbC, AdC	C	5.4	Fragipan (18-32in.)
Atkins	At	B/D	1.5	Lithic bedrock (60-99in.)
Barbour	Ba	B	0.2	
Basher	Bb	B	0.8	
Braceville	BeB	C/D	0.2	Fragipan (20-32in.)
Brinkerton	BrA, BrB, BsB	D	2.2	Fragipan (15-34in.)
Buchanan	BuB, BuC, BuD, BxB, BxD	C	15.4	Fragipan (20-36in.)
Cavode	CaA, CaB, CaD	C/D	0.6	Paralithic bedrock (40-72in.)
Castile	CbB	B	<0.1	
Ceres	CeC, CeD, CeE, CeF	B	0.5	Lithic bedrock (40-60in.)
Chenango	ChB	A	0.2	

Series Name	Map Symbols	Hydrologic Soil Group	% of County	Restrictions
Clymer	ClB	B	0.5	Lithic bedrock (40-60in.)
Cookport	CoA, CoB, CoC	C/D	11.3	Lithic bedrock (40-78in.)
Nolo	CpB	D	5.4	Fragipan (18-35in.)
Cookport	CpD	C	2.6	Fragipan (20-32in.)
Eldred	EdB	C	<0.1	
Elko	ElB, ElC	C	0.2	Fragipan (18-30in.)
Gilpin	GnB, GnC, GpF, GsC	C	0.2	Lithic bedrock (20-40in.)
Hartleton	HaB, HaC, HaD	B	4	Paralithic bedrock (40-60in.)
Hazleton	HbB, HbC, HdB, HdD, HdF	A	13.9	Lithic bedrock (40-60in.)
Hartleton	HeD, HeF	B	21.6	Paralithic bedrock (40-60in.)
Kinzua	KnB, KnC, KnD, KnE, KnF	B	0.7	
Leck Kill	LeB, LeC, LeD, LeF	B	8.7	Paralithic bedrock (40-60in.)
Mandy	MaB, MaC, MaE, MbC, MbD	C	0.1	Lithic bedrock (20-40in.)
Mecksesville	MeD	C	0.2	
Onoville	OnC, OxD	C	<0.1	Fragipan (16-36in.)
Palms	Pa	D	<0.1	
Philo	Ph	B	1.7	Lithic bedrock (61-120in.)
Pope	Po	B	0.4	
Portville	PoB	C	<0.1	Fragipan (12-36in.)
Rexford	ReA	C	0.1	
Shongo	ShB	C	<0.1	Fragipan (16-30in.)
Udorthents	Sm	C	0.2	
Wharton	WaB, WaC, WaD, WxB	C/D	0.7	Lithic bedrock (40-60in.)
Other	W,	--	0.5	Water

Table 3.5. Soil Characteristics of McKean County (NRCS, 2008)

One of the impediments to drainage throughout McKean County is the presence of fragipan soils, typically a loamy, brittle soil layer that has minimal porosity and organic content and low or moderate in clay but high in silt or very fine sand. With fragipans, upwards of 60% of input water moves laterally above the fragipan layer which is typically 12-36 inches below the surface in McKean County (Ciolkosz and Waltman, 2000; NRCS, 2008). Thus, higher runoff rates and reduced infiltration capacity typically exist in these soils. Additional impediment to subsurface drainage include lithic and paralithic bedrock (i.e., solid and weather or broken layers of bedrock) although the depths (varying between < 2' - 10') may offer excellent drainage. *Table 3.6* displays the proportion of fragipan and restrictive bedrock in McKean County.

Restrictions	% of County
Fragipan	41.0%
Lithic bedrock	20.4%
Paralithic bedrock	35.1%
None identified	3.5%

Table 3.6. Soil Restrictions in McKean County

An additional indicator of the response to rainfall of the soils in McKean County is the hydrologic soil group assigned to each soil. This classification varies between "A" which has very low runoff potential and high permeability and "D" which typically has very high runoff potential and low permeability. *Table 3.6* show a summary of the hydrologic soil groups for McKean County. Some soils have variable runoff potential depending on whether or not they are drained or undrained. For example, agricultural field with tile drainage may decrease the runoff potential from hydrologic soil group D to hydrologic soil group A. Over 85% of the soils in McKean County are hydrologic soil group A, B, or C indicating a moderate runoff potential (Refer to *Plate 4 – Hydrologic Soils*).

Hydrologic Soil Group	Runoff Potential	% of County
A	Low	5.4%
B	Moderate to Low	47.9%
B/D		1.5%
C	Moderate to High	33.5%
C/D		4.2%
D	High	7.0%
Not identified		0.5%

Table 3.7. Hydrologic Soil Groups in McKean County

Groundwater recharge rates are variable over time and space. In Pennsylvania, 80% of groundwater recharge occurs from November to May, with March typically having the greatest amount of recharge. Areas that receive the most recharge are typically those that get the most rainfall, have favorable surface conditions, and are less susceptible to the influences of high temperatures and thus evapotranspiration. Across Pennsylvania, mean-annual recharge values range from about 7-22 inches. Reese and Risser (2010) identified ranges for mean-annual recharge value based on Hydrologic Unit Code watershed boundaries. In McKean County, these values fall into one of four ranges: 14.01-16 in in, 16.01-18 in, 18.01-20 in, or 20.01-22 inches, with the majority of the county being in the 16.01-20 inch range.

HYDRIC SOILS

The analysis of hydric soils has recently become an important consideration when performing almost any kind of development review. These soils are important to identify and locate because they provide an approximate location where wet areas may be found. Wetland areas are lands where water resources are the primary controlling environmental factor as reflected in hydrology, vegetation, and soils. Thus, the location of hydric soils is one indication of the potential existence of a wetland area. Wetland areas are now protected by DEP and should be examined before deciding on any type of development activity. The following table lists the hydric soils found in McKean County (NRCS, 2010):

Albright silt loam	Brinkerton silt loam	Philo silt loam
Atkins silt loam	Buchanan silt loam	Pope loam
Barbour loam	Cavode silt loam	Rexford silt loam
Basher silt loam	Cookport loam	Udorthents
Braceville silt loam	Palms muck	Wharton silt loam

Table 3.8. Hydric Soils

WATERSHEDS

Surface waters include rivers, streams and ponds, which provide aquatic habitat, carry or hold runoff from storms, and provide recreation and scenic opportunities. Surface water resources are a dynamic and important component of the natural environment. However, ever-present threats such as pollution, construction, clear-cutting, mining, and overuse have required the protection of these valuable resources.

Watersheds are delineated and subdivided for the sake of management and analysis. The physical boundaries of a watershed depend on the purpose of the delineation. Often times a watershed is called a "basin" but is also a "subbasin" to an even larger watershed. This indistinct nature often leads to confusion when trying to categorize watersheds. As show in *Figure 3.4*, DEP has divided Pennsylvania into seven different major river basins, based upon the major waterbody to which they are tributary. These include: Lake Erie Basin, Ohio River Basin, Genesee River Basin, Susquehanna River Basin, Potomac River Basin, Elk & Northeast / Gunpowder Rivers Basin, and Delaware River Basin.

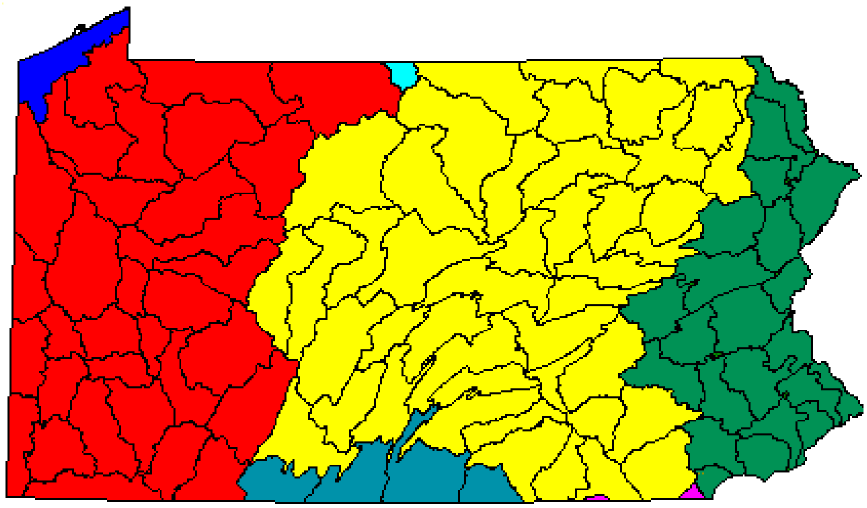


Figure 3.3. Pennsylvania's Major River Basins as Delineated by DEP (DEP, 2009)

For the purpose of this Plan, these are the largest basins within the Commonwealth. The major river basins are further divided into "subbasins" and "Act167 Designated Watersheds" for stormwater management purposes. Act 167 divided the Commonwealth into 29 subbasins and 357 designated watersheds. McKean County lies almost entirely within the Ohio River Basin (97.4%), with a small portion of the county that is tributary to the Susquehanna River Basin. Within the Ohio River Basin, the entire county drains to the Allegheny River subbasin, with the exception of 76 square miles that is tributary to the Clarion River. The 2.6% of the county's land that flows to the Susquehanna River Basin is tributary to the West Branch Susquehanna River subbasin. McKean County contains at least a portion of nine different Act 167 Designated Watersheds. This classification of the county's watersheds is summarized in the following table:

Major River Basin	Subbasin	ACT 167 Designated Watershed
Ohio River Basin	Direct Discharges	Allegheny River
		Clarion River
	Allegheny River	Allegheny River Potter County
		Oswayo Creek
		Potato Creek
		Tionesta Creek
		Tunungwant Creek
Susquehanna River Basin	West Branch Susquehanna River	Sinnemahoning Creek
		Sinnemahoning Portage Creeks

Table 3.9. Classification of McKean County Watersheds

ACT 167 DESIGNATED WATERSHEDS

All runoff in McKean County is tributary to one of nine Act 167 Designated Watersheds. Each of these basins drains surface water into the major streams and rivers running through the county. The Act 167 Designated Watersheds within McKean County are shown in *Figure 3.4*.

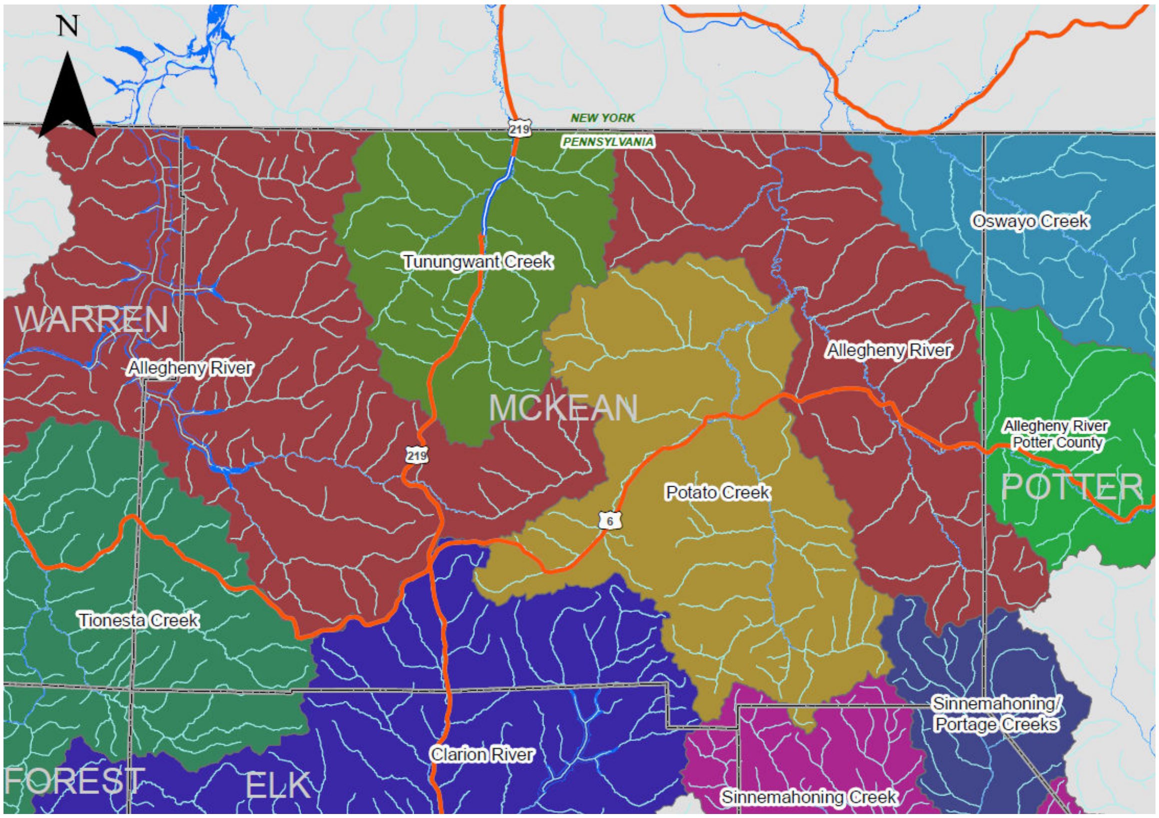


Figure 3.4. Act 167 Watersheds in McKean County

A large portion of the county (80.9%) lies within three of these watersheds: Allegheny River, Potato Creek, and Tunungwant Creek. All of the Act 167 Designated Watersheds in the county are listed in *Table 3.10* along with the total area of each watershed (as delineated within Pennsylvania) and the area of the watershed that is within the county.

Watershed	Total Area (mi^2)	Area within County (mi^2)
Allegheny River	1556.5	439.5
Allegheny River Potter County	169.1	1.6
Clarion River	823.9	76.0
Oswayo Creek	158.2	29.2
Potato Creek	223.2	221.9
Sinnemahoning Creek	631.1	6.1
Sinnemahoning Portage Creeks	73.2	18.4
Tionesta Creek	478.6	57.2
Tunungwant Creek	135.4	135.4

Table 3.10. Act 167 Watershed Areas in McKean County

Allegheny River Watershed

The Allegheny River Watershed includes direct discharges to the Allegheny River that are not included in other designated watershed. This watershed is split into two separate pieces within the county because the Allegheny River flows north into New York. The "Act 167 Designated" Allegheny River watershed is very expansive. It originates in Potter County and stretches across 10 Pennsylvania counties before joining the Monongahela River in Pittsburgh to form the Ohio River. The total drainage area is also very expansive at 1556.5 square miles total, of which 439.5 miles are within McKean County. *Table 3.11* details the county's municipalities within the watershed, and their contributing area:

Watershed	Municipality	Area (mi^2)
Allegheny River	Annin Township	33.4
	Bradford Township	3.6
	Ceres Township	11.5
	Corydon Township	73.8
	Eldred Borough	0.9
	Eldred Township	33.3
	Foster Township	2.9
	Hamilton Township	52.0
	Hamlin Township	31.0
	Kane Borough	0.7
	Keating Township	13.5
	Lafayette Township	37.8
	Liberty Township	77.5
	Mount Jewett Borough	1.1
	Norwich Township	5.3
	Otto Township	29.4
	Port Allegany Borough	1.8
	Wetmore Township	29.7

Table 3.11. Allegheny River Watershed

The upper sections of the watershed are the only portion of this watershed that was included in the detailed analysis for this Plan. This area is also referred to as the "Potter County to New York state line" reach. The headwaters of the Allegheny River are located in Allegany and Sweden Township, east of Coudersport, Potter County. This area is part of the "Allegheny River Potter County" Act 167 Designated Watershed. Another headwater section of the Allegheny River watershed is the Allegheny Portage Creek, mostly in Liberty Township, McKean County with a small portion in Keating Township, Potter County. These two headwater reaches join at Port Allegany Borough. From this point the Allegheny River flows north towards Cattaraugus County, New York before exiting the county just northeast of Eldred Borough.

Potato Creek Watershed

Potato Creek is directly tributary to the Allegheny River. This watershed is in the central part of McKean County. The total drainage area is 223.2 square miles, all of which is within the county except for 1.3 square miles that flows from Cameron County. There are 605.3 miles of streams in the watershed and the mean basin elevation is 1950 feet. The watershed has many Special Protection Waters (i.e. Exceptional Value or High Quality) that reflect good overall water quality within the watershed. There are 56.1 miles of Exceptional Value waters and another 203.6 miles of High Quality Cold Water Fisheries. The following table details the municipalities within the watershed and their land area:

Watershed	Municipality	Area (mi^2)
Potato Creek	Annin Township	0.3
	Bradford Township	0.3
	Eldred Township	5.7
	Foster Township	1.9
	Hamlin Township	24.6
	Keating Township	82.6
	Liberty Township	3.3
	Mount Jewett Borough	0.7
	Norwich Township	68.3
	Otto Township	4.8
	Sergeant Township	27.6
	Smethport Borough	1.7

Table 3.12. Potato Creek Watershed

The Potato Creek watershed begins in its headwaters in and around State Game Lands No. 80 in Norwich Township. From this point it flows north towards Smethport Borough. Like most of McKean county, this watershed is primarily (90%) forested land. Marvin Creek, the only major tributary (55.5 square mile drainage area) in this watershed, begins south of Mount Jewett and flows east towards its confluence with Potato Creek in Smethport. From this point, Potato Creek flows northeast towards its confluence with the Allegheny River just southwest of Larabee, located at the intersection Route 446 and Route 155.

<u>Tunungwant Creek Watershed</u>

The Tunungwant Creek watershed is located in the north-central part of the county. The total drainage area of this watershed, within Pennsylvania, is 135.4 square miles. The watershed is mostly forested (92%) and has a mean basin elevation 0f 1960 feet. There are 317.5 miles of streams within the watershed. More than half (54.7%) of the stream miles in the watershed are Special Protection waters (i.e. Exceptional Value or High Quality). *Table 3.13* details the county's municipalities within the watershed, and their contributing area:

Watershed	Municipality	Area (mi^2)
Tunungwant Creek	Bradford Township	52.1
	City Of Bradford	3.4
	Corydon Township	0.1
	Foster Township	41.4
	Keating Township	2.4
	Lafayette Township	33.5
	Lewis Run Borough	1.8
	Otto Township	0.7

Table 3.13. Tunungwant Creek Watershed

Tunungwant Creek flows from its headwater reaches, located mostly in Lafayette Township, north towards the City of Bradford and then on to Cattaraugus County, New York. From this point it continues to flow north until it joins the Allegheny River just southwest of the intersection of Route 219 and Interstate 86.

IMPOUNDMENTS

There are numerous small lakes, ponds and impoundments located throughout McKean County. Most of these are small run-of-the-river dams that have some localized impacts but do not have a significant impact on the overall watershed hydrology. The largest impoundments in the county are two branches of the 12,000 acre Allegheny Reservoir which extend into the county along Sugar Run and Kinzua Creek. Hamlin Lake contains 17 acres on the south side of Smethport Borough. Other impoundments that were determined to have negligible impact on the overall watershed hydrology are shown in *Figure 3.5*, along with the three impoundments that were included in the watershed models completed for this Plan.

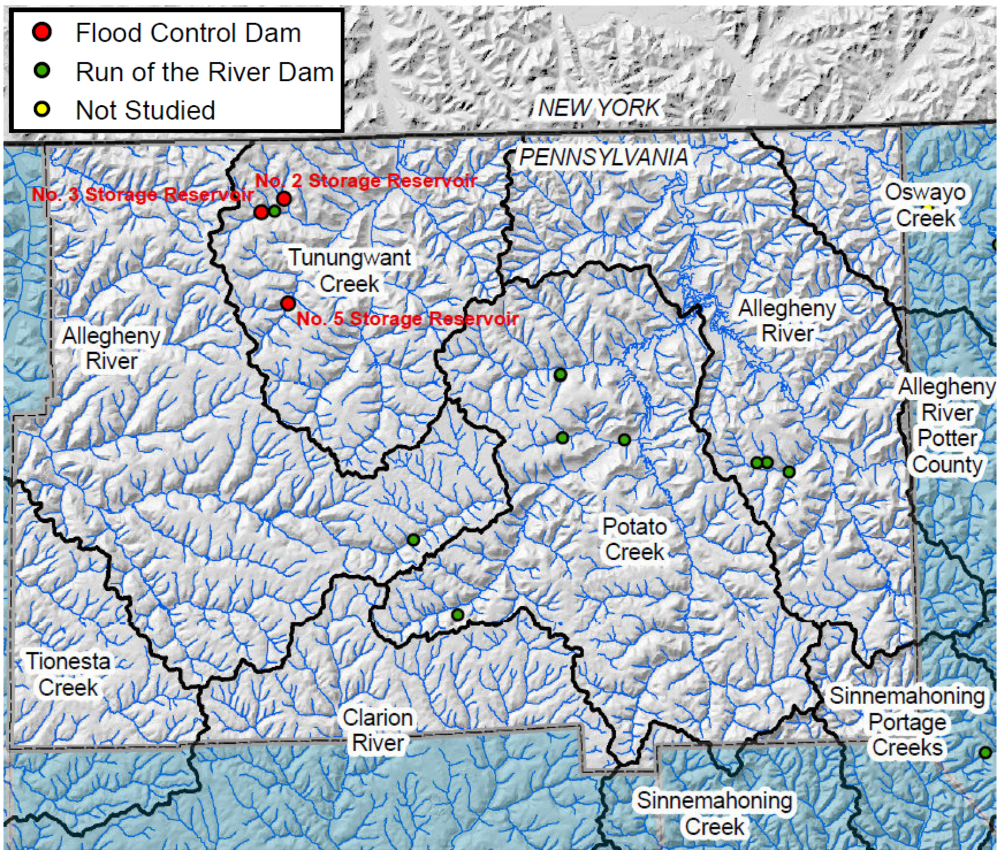


Figure 3.5. McKean County Impoundments

Three impoundments were considered to significantly impact the hydrology of the Tunungwant Creek watershed. Bradford City Water Authority owns several water supply reservoirs located in Bradford Township. Three of these facilities: Bradford Reservoir No. 2 (632 acre-ft), Bradford Reservoir No. 3 (368 acre-ft), and Bradford Reservoir No. 5 (3,390 acre-ft), were included in the watershed models developed for this Plan. The tributary drainage area to these dams is relatively small compared to the total drainage area of the watershed, however, operation of these facilities was found to impact the overall hydrology of the watershed.

SURFACE WATER QUALITY

Water Quality Standards for the Commonwealth are addressed in *The Pennsylvania Code, Title 25, Chapter 93*. Within Chapter 93, all surface waters are classified according to their water quality criteria and protected water uses. According to the antidegradation requirements of §93.4a, "Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected." Certain waterbodies which exhibit exceptional water quality and other environmental features, as established in §93.4b, are referred to as "Special Protection Waters." These waters are classified as High Quality or Exceptional Value waters and are among the most valuable surface waters within the Commonwealth. Activities that could adversely affect surface water are more stringently regulated in those watersheds than waters of lower protected use classifications. The existing water quality regulations are discussed in more detail in *Section IV – Existing Stormwater Regulations and Related Plans*.

McKean County streams are shown with their Chapter 93 protected use classification in *Figure 3.6* below. (This figure is provided for reference only, the official classification may change and should be checked at: http://www.pacode.com/index.html) An explanation of the protected use classifications can be found in *Section IV*.

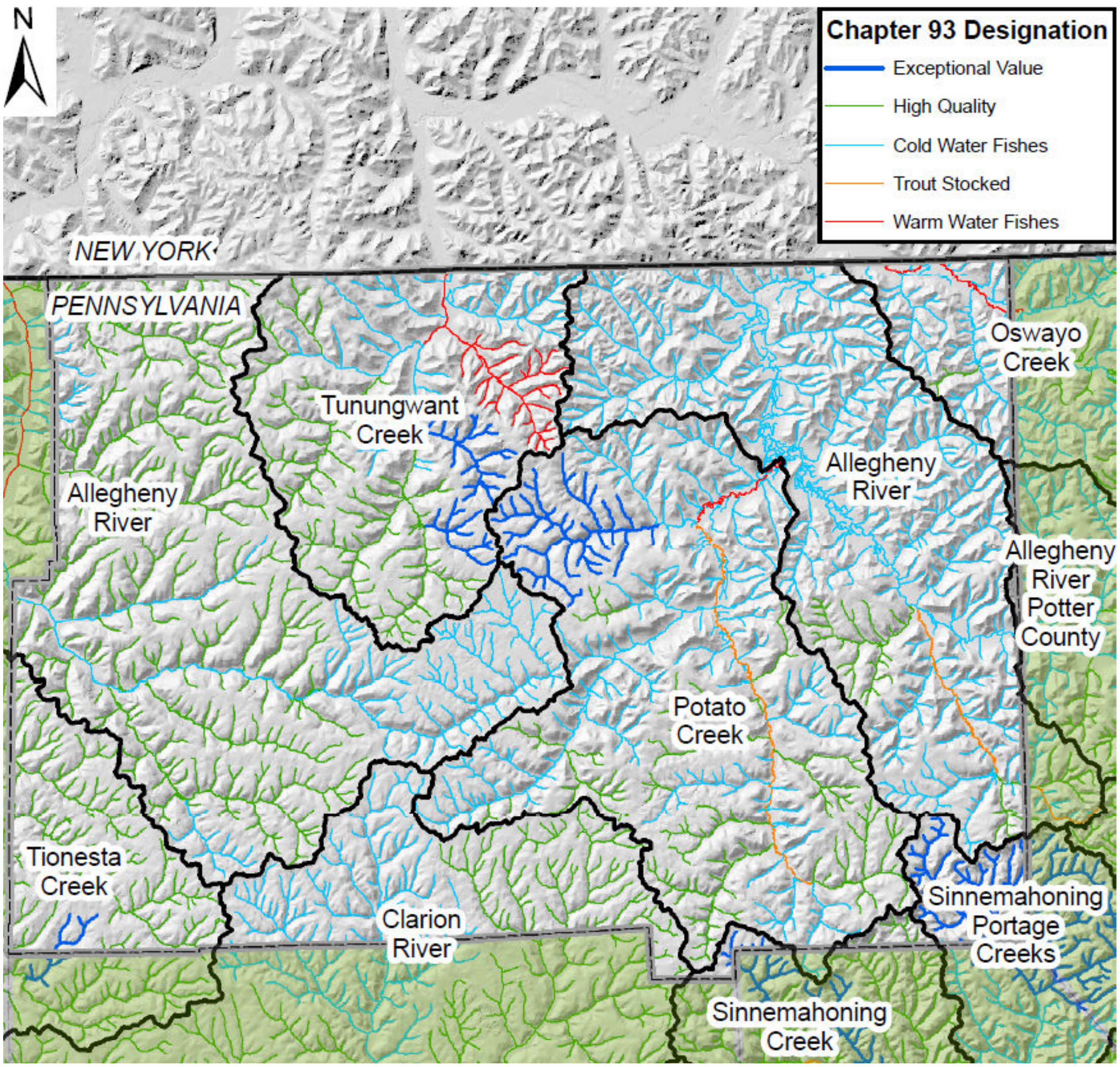


Figure 3.6. Chapter 93 Classification of McKean County Streams

In Pennsylvania, bodies of water that are not attaining designated and existing uses are classified as "impaired". Water quality impairments are addressed in *Section IX* of this Plan. A summary of the impaired waters within McKean County is also included in that section.

FLOODPLAIN DATA

A flood occurs when the capacity of a stream channel to convey flow within its banks is exceeded and water flows out of the main channel onto and over adjacent land. This adjacent land is known as the floodplain. For convenience in communication and regulation, floods are characterized in terms of return periods, e.g., the 50-year flood event. In regulating floodplains, the standard is the 100-year floodplain, the flood that is defined as having a 1 percent chance of being equaled or exceeded during any given year. These floodplain maps, or Flood Insurance Rate Maps (FIRMs), are provided to the public (http://msc.fema.gov/) for floodplain management and insurance purposes.

With the exception of Kane Borough, all of the municipalities within the county participate in the National Flood Insurance Program (NFIP). The NFIP is a Federal program enabling property owners to purchase insurance protection against losses from flooding. For a community to participate in the program the must adopt and enforce a floodplain management ordinance to reduce future flood risk. The following table lists the date of the effective Flood Insurance Rate Map for each municipality.

FEMA ID	Municipality	FIRM Date
421850	Annin Township	8/1/1987
420665	Bradford City	9/16/1981
422245	Bradford Township	9/16/1981
421853	Ceres Township	9/18/1987
422473	Corydon Township	3/1/1987
420666	Eldred Borough	9/3/1980
421854	Eldred Township	9/3/1980
421855	Foster Township	11/18/1981
421856	Hamilton Township	3/1/1987
421857	Hamlin Township	3/1/1987
422714	Kane Borough	N/A

FEMA ID	Municipality	FIRM Date
420667	Keating Township	6/1/1978
421858	Lafayette Township	6/30/1976
420669	Lewis Run Borough	3/1/1987
420668	Liberty Township	9/1/1977
420670	Mount Jewett Borough	6/30/1976
421859	Norwich Township	7/1/1987
421860	Otto Township	6/1/1987
420671	Port Allegany Township	6/15/1979
422474	Sergeant Township	7/3/1985
420672	Smethport Borough	4/17/1978
421861	Wetmore Township	4/1/1987

Table 3.14. Communities Participating in the National Flood Insurance Program

In 2007, the Pennsylvania Emergency Management Agency (PEMA) completed a statewide study to determine damage estimates for all major flood events. The study computed damages in dollars for total economic loss, building and content damage, and also estimated the number of damaged structures (PEMA, 2009). *Table 3.15* summarizes the findings from this study.

Storm Event	Number of Buildings at Least Moderately Damage	Total Economic Loss
10	114	$81 million
100	247	$122 million
500	358	$165 million

Table 3.15. Potential Impact Due to Flooding (PEMA, 2009)

Detailed Studies

There are various levels of detail in floodplain mapping. Detailed studies (Zones AE and A1-A30 on the floodmaps) are conducted at locations where FEMA and communities have invested in engineering studies that define the base flood elevation and often distinguish sections of the floodplain between the floodway and flood fringe. See *Figure 3.7* below for a graphical representation of these terms. For a proposed development, most ordinances state that there shall be no increase in flood elevation anywhere within the floodway; the flood fringe is defined so that any development will not cumulatively raise that water surface elevation by more than a designated height (set at a maximum of 1'). Development within the flood fringe is usually allowed, but most new construction is required to be designed for flooding (e.g. floodproofing, adequate ventilation, etc).

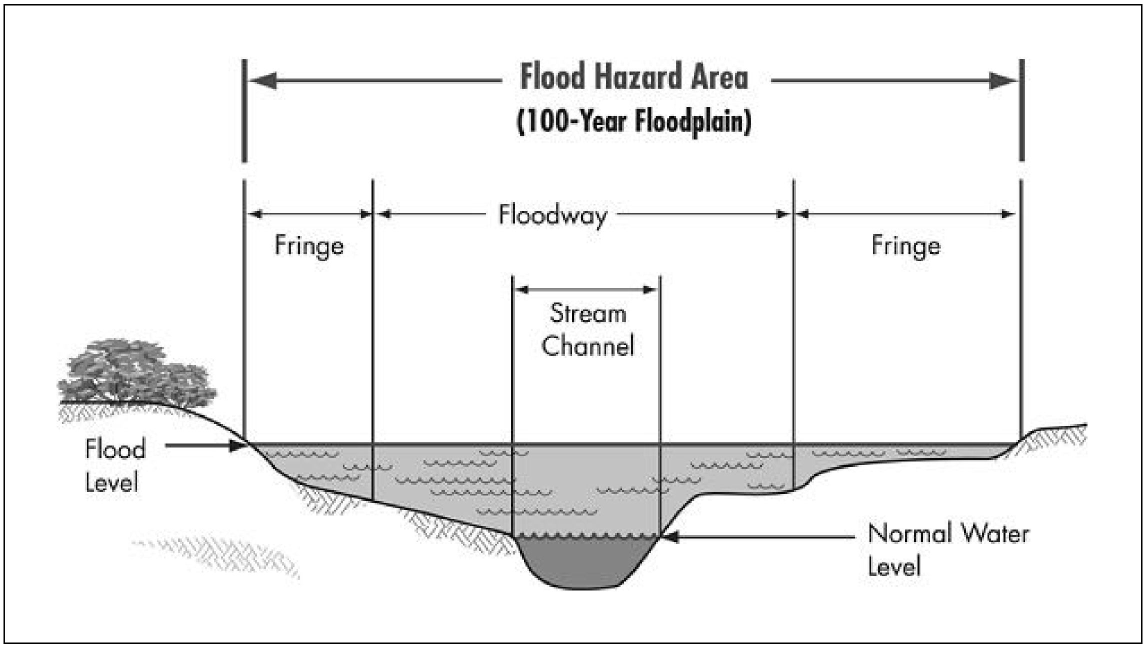


Figure 3.7. Floodplain Cross Section and Flood Fringe (NH Floodplain, 2007)

Approximate Studies and Non-delineated Floodplains

Approximate studies (Zone A on the DFIRM) delineate the flood hazard area, but are prepared using approximate methods that result in the delineation of a floodplain without providing base flood elevations or a distinction between floodway and flood fringe. If no detailed study information is available, some ordinances allow the base flood elevation to be determined based on the location of the proposed development relative to the approximated floodplain; at times, a municipality find it necessary to have the developer pay for a detailed study at the location in question.

One limitation of FIRMs and older Flood Insurance Rate Maps is the false sense of security provided to home owners or developers who are technically not in the floodplain, but are still within an area that has a potential for flooding. Headwater streams, or smaller tributaries located in undeveloped areas, do not normally have FEMA delineated floodplains. This leaves these areas unregulated at the municipal level, and somewhat susceptible to uncontrolled development. Flood conditions, due to natural phenomenon as well as increased stormwater runoff generated by land development, are not restricted only to main channels and large tributaries. In fact, small streams and tributaries may be more susceptible to flooding from increased stormwater runoff due to their limited channel capacities.

Pennsylvania's Chapter 105 regulations partially address the problem of non-delineated floodplains. Chapter 105 regulations prohibit encroachments and obstructions, including structures, in the regulated floodway without first obtaining a state Water Obstruction and Encroachment permit. The floodway is the portion of the floodplain adjoining the stream required to carry the 100-year flood event with no more than a one (1) foot increase in the 100-year flood level due to encroachment in the floodplain outside of the floodway. Chapter 105 defines the floodway as the area identified as such by a detailed FEMA study or, where no FEMA study exists, as the area from the stream to 50-feet from the top of bank, absent evidence to the contrary. These regulations provide a measure of protection for areas not identified as floodplain by FEMA studies.

Levees and Other Flood Control Structures

As administrator of the National Flood Insurance Program (NFIP), FEMA has a series of policies and guidelines concerning the protection of life and property behind levees. Periodically, FEMA updates the effective FIRMs as new data become available and to reflect changes within the community. In the ongoing map update process, FEMA (2007) issued Procedure Memorandum 43 (PM 43) – Guidelines for Identifying Provisionally Accredited Levees (PALs). For communities with levees, PM 43 has potential to substantially impact the communities protected by levees. A PAL is a levee that has previously been accredited with providing 1-percent-annual-chance flood protection on an effective FIRM. After being designated as a PAL, levee owners will have up to 24 months to obtain and submit documentation that the levee will provide adequate protection against a 1-percent-annual-chance flood. If the levee cannot be certified as providing protection from this flood, the areas currently being protected by the levees will be mapped and managed as if they were within the floodplain (i.e., in most cases, the residents and businesses currently being protected by the levees would be forced to purchase flood insurance in accordance with the NFIP).

Project	Owner	Waterbody
Eldred Project	Eldred Borough	Allegheny River & Barden Brook
Lillibridge Creek - Allegheny River Project	State of Pennsylvania	Lillibridge Creek & Allegheny River
Oswayo Creek Project	Ceres Township	Oswayo Creek

Table 3.16. Levee Systems in McKean County

There are three levee projects in McKean County: the Eldred Project, the Lillibridge Creek/Allegheny River Project, and the Oswayo Creek Project. The PAL status of each of the levee systems was not available at the time of publication of this Plan.

Community Rating System (CRS)

To reduce flood risk beyond what is accomplished through the minimum federal standards, the NFIP employs the Community Rating System to give a credit to communities that reduce their community's risk through prudent floodplain management measures. Several of these measures coincide with the goals and objectives of this plan: regulation of stormwater management, preservation of open space, and community outreach for the reduction of flood-related damages.

Flood insurance premiums can be reduced by as much as 45% for communities that obtain the highest rating. Only 28 of the Commonwealth's 2500+ municipalities participate in the CRS. Currently, there are no municipalities within McKean County participating in the CRS.

FIRM Updates

As new information becomes available, FEMA periodically updates the FIRMs to reflect the best available data and to address any new problem areas. McKeann County is scheduled to have a FIRM update available by early 2012. This will correspond to an effort by DCED to have all municipalities adopt and implement a new floodplain model ordinance that conforms to federal and state requirements.

This page has been left blank intentionally.

Section IV – Existing Stormwater Regulations and Related Plans

It is often helpful to assess the current regulations when undertaking a comprehensive planning effort. An understanding of current and past regulations, what has worked in the past, and what has failed, is a key component of developing a sound plan for the future. Regulations affecting stormwater management exist at the federal, state, and local level. At the federal level the regulations are generally broad in scope, and aimed at protecting health and human welfare, protecting existing water resources and improving impaired waters. Regulations generally become more specific as their jurisdiction becomes smaller. This system enables specific regulations to be developed which are consist with national policy, yet meet the needs of the local community.

EXISTING FEDERAL REGULATIONS

Existing federal regulations affecting stormwater management are very broad in scope and provide a national framework within which all other stormwater management regulations are developed. An overview of these regulations is provided below in *Table 4.1*.

Clean Water Act	Section 303	Requires states to establish Total Maximum Daily Loads for point sources of pollution that are allowable to maintain water quality and protect stream flora and fauna. Other water quality standards (e.g., thermal) are also regulated.
Clean Water Act	Section 404	Regulates permitting of discharge of dredged or fill material into the waters of the United States. Includes regulation of discharge of material into lakes, navigable streams and rivers, and wetlands.
Clean Water Act	Section 401/402	Authorizes the Commonwealth to grant, deny, or condition Water Quality Certification for any licensed activity that may result in a discharge into navigable waters. Established the National Pollutant Discharge Elimination System (NPDES) that regulates any earth disturbance activity of 5 acres (or more) or 1 acre (or more) with a point source discharge.
Rivers and Harbors Act of 1899	Section 10	Regulates activities that obstruct or alter any navigable waters of the United States.
Federal Emergency Management Act		Requires that any proposed structure within the floodplain boundaries of a stream cannot cause a significant increase in the 100-year flood height of the stream.

Table 4.1. Existing Federal Regulations

EXISTING STATE REGULATIONS

Pennsylvania has developed stormwater regulations that meet the federal standards and provide a statewide system for stormwater regulation. State regulations are much more specific than federal regulations. Statewide standards include design criteria and state issued permits. State regulations, found in *The Pennsylvania Code, Title 25*, cover a variety of stormwater related topics. A brief review of the existing state regulations is provided below in *Table 4.2*.

Chapter 92	Discharge Elimination	Regulates permitting of point source discharges of pollution under the National Pollutant Discharge Elimination System (NPDES). Storm runoff discharges at a point source draining five (5) or more acres of land or one (1) or more acres with a point source discharge are regulated under this provision.
Chapter 93	Water Quality Standards	Establishes the Water Use Protection classification (i.e., water quality standards) for all streams in the state. Stipulates anti-degradation criteria for all streams.
Chapter 96	Water Quality Implementation Standards	Establishes the process for achieving and maintaining water quality standards applicable to point source discharges of pollutants. Authorizes DEP to establish Total Mass Daily Loads (TMDLs) and Water Quality Based Effluent Limitations (WQBELs) for all point source discharges to waters of the Commonwealth.
Chapter 102	Erosion and Sediment Control	Requires persons proposing or conducting earth disturbance activities to develop, implement and maintain Best Management Practices to minimize the potential for accelerated erosion and sedimentation. Current DEP policy requires preparation and implementation of a post-construction stormwater management (PCSM) plan for development areas of 5 acres or more or for areas of 1 acre or more with a point source discharge.
Chapter 105	Dam Safety and Waterway Management	Regulates the construction, operation, and maintenance of dams on streams in the Commonwealth. Also regulates water obstructions and encroachments (e.g., road crossings, walls, etc.) that are located in, along, across or projecting into a watercourse, floodway, wetland, or body of water.
Chapter 106	Floodplain Management	Manages the construction, operation, and maintenance of structures located within the floodplain of a stream if owned by the State, a political subdivision, or a public utility.

Table 4.2. Existing State Regulations

STATE WATER QUALITY STANDARDS

Water Quality Standards for the Commonwealth are addressed in *The Pennsylvania Code, Title 25, Chapter 93*. Within Chapter 93, all surface waters are classified according to their water quality criteria and protected water uses. The following is an abbreviated explanation of these standards and their respective implications to this Act 167 plan.

General Provisions (§93.1 - §93.4)

The general provisions of Chapter 93 provide definitions, citation of legislative authority (scope), and the definition of protected and statewide water uses. DEP's implementation of Chapter 93 is authorized by the Clean Streams Law, originally passed in 1937 to "preserve and improve the purity of the waters of the Commonwealth for the protection of public health, animal and aquatic life, and for industrial consumption, and recreation," and subsequently amended. *Table 4.3* is a summary of the protected water uses under Chapter 93 that are applicable to McKean County.

Protected Use	Relative Level of Protection	Description
Aquatic Life		
Warm Water Fishes (WWF)	Lowest	Maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.
Trout Stocking (TSF)	↓	Maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.
Cold Water Fishes (CWF)	↓	Maintenance or propagation, or both, of fish species including the family Salmonidae and additional flora and fauna which are indigenous to a cold water habitat.
Special Protection		
High Quality Waters (HQ)	↓	A surface water that meets at least one of chemical or biological criteria defined in §93.4b
Exceptional Value Waters (EV)	Highest	A surface water that meets at least one of chemical or biological criteria defined in §93.4b <u>and</u> additional criteria defined in §93.4b.(b)

Table 4.3. Chapter 93 Designations in McKean County

Antidegradation Requirements (§93.4a - §93.4d)

According to the antidegradation requirements of §93.4a, "Existing in-stream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected." Certain waterbodies which exhibit exceptional water quality and other environmental features, as established in §93.4b and summarized in *Table 4.3*, are referred to as "Special Protection Waters." Activities that could adversely affect surface water are more stringently regulated in those watersheds than waters of lower protected use classifications. For WWF, TSF, or CWF waterbodies, many of the antidegradation requirements can be addressed using guidance provided in this plan and the DEP BMP Manual; for HQ or EV watersheds, the current regulations follow DEP's antidegradation policy.

For a new, or additional, point discharge with a peak flow increase to an HQ or EV water, the developer is required to use a non-discharge alternative that is cost-effective and environmentally sound compared with the costs of the proposed discharge. If a non-discharge alternative is not cost-effective and environmentally sound, the developer must use the best available combination of treatment, pollution prevention, and wastewater reuse technologies and assure that any discharge is non-degrading. In the case where allowing lower water quality discharge is necessary to accommodate important economic or social development in an area, DEP may approve a degrading discharge after satisfying a multitude of intergovernmental coordination and public participation requirements (DEP, 2003).

Water Quality Criteria (§93.6 - §93.8c)

In general, the water discharged form either a point source or a nonpoint source discharge may contain substances in a concentration that would be inimical or harmful to a protected water use. The specific limits for toxic substances, metals, and other chemicals are listed in this section.

Designated Water Uses and Water Quality Criteria (§93.9)

The designated use and water quality criteria for each stream reach or watershed is specified in §93.9. The majority of watersheds within McKean County have a cold water fisheries designated use. This is also the leading designated use within the county, in terms of total miles, with almost 191 miles of stream designated as cold water fisheries and another 169 miles designated as High Quality – Cold Water Fisheries. *Table 4.4* below summarizes the designate uses of all stream uses in McKean County.

Designated Use	Total Length (mi)	Percentage
Warm Water Fishes (WWF)	10.5	2.6%
Cold Water Fishes (CWF)	190.9	47.4%
High Quality Waters (HQ-CWF)	169.3	42.0%
Trout Stocking (TSF)	8.4	2.1%
Exceptional Value (EV)	23.6	5.9%

Table 4.4. Summary of Designated Uses for McKean County Waters

On the following page, *Table 4.5* shows the Chapter 93 designated uses for McKean County as defined by §93.9. This table was developed from the information contained in the Pennsylvania General Code. This information can be difficult to navigate in list form. A good resource for viewing stream designations graphically is DEP's internet based analytical mapping tool, *eMapPA* which can be accessed at the following website: <http://www.emappa.dep.state.pa.us/emappa/viewer.htm>

Stream (Zone)	Designated Use
Allegheny Portage Creek (main stem, Scaffold Lick Run to mouth)	TSF
Allegheny Portage Creek, (main stem, Brown Hollow to Scaffold Lick Run)	HQ-CWF
Allegheny River (main stem, source to PA-NY state border)	CWF
Annin Creek	CWF
Barden Brook	CWF
Bayer Brook	HQ-CWF
Bell Run (main stem)	CWF
Blacksmith Run (from Smethport Water intake to mouth)	CWF
Blacksmith Run (source to Smethport Water intake)	HQ-CWF
Bloomster Hollow	CWF
Bolivar Run (all sections in PA)	CWF
Brewer Run	HQ-CWF
Briggs Run	HQ-CWF
Browns Mill Hollow	CWF
Buck Lick Run	HQ-CWF
Buck Run	CWF
Bump Run	HQ-CWF
Cady Hollow	CWF
Camp Run	HQ-CWF
Canfield Creek	CWF
Carpenter Creek	CWF
Chapman Brook	CWF
Chappel Fork (main stem)	CWF
Cole Creek (source to South Branch Cole Creek)	CWF
Cole Creek (South Branch Cole Creek to mouth)	CWF
Colegrove Brook	HQ-CWF
Combs Creek	CWF
Combs Hollow	CWF
Coon Run	HQ-CWF
Coon Run (all sections in PA)	HQ-CWF
Crary Run	HQ-CWF
Daly Brook	HQ-CWF
Dutchman Run	HQ-CWF
East Branch Potato Creek (source to confluence with Havens Run)	HQ-CWF
East Branch Tunungwant Creek (Railroad Run to T-331 bridge)	HQ-CWF
East Branch Tunungwant Creek (source to Railroad Run)	HQ-CWF
East Branch Tunungwant Creek (SR 4002 to confluence with West Branch)	CWF
East Branch Tunungwant Creek (T-331 Bridge to SR 4002 bridge)	HQ-CWF
Evans Hollow	CWF
Fair Run	HQ-CWF
Foster Brook (all sections in PA)	CWF
Frog Camp Hollow	CWF

Stream (Zone)	Designated Use
Gilbert Brook	HQ-CWF
Glad Run	HQ-CWF
Hamilton Run	CWF
Havens Run (source to confluence with East Branch)	CWF
Heath Hollow	CWF
Hemlock Run	HQ-CWF
Horse Run (all sections in PA)	CWF
Hubert Run	CWF
Indian Creek (main stem, PA-NY state border to mouth)	CWF
Indian Run	CWF
Indian Run	CWF
Janders Run	HQ-CWF
Kansas Branch	CWF
Kendall Creek	WWF
Kimball Hollow	CWF
Kings Run	CWF
Kinzua Creek	CWF
Knapp Creek (main stem)	CWF
Libby Run	HQ-CWF
Lillibridge Creek	CWF
Little Meade Run	HQ-CWF
Marilla Brook (above Bradford Water Dam)	HQ-CWF
Marilla Brook (Bradford Water Dam to mouth)	CWF
Markham Run	HQ-CWF
Marvin Creek (main stem)	CWF
McCrea Run	CWF
Meade Run	HQ-CWF
Minard Run	EV
Mix Creek (all sections in PA)	CWF
Morrison Run	HQ-CWF
Mud Lick Run	HQ-CWF
Newell Creek	CWF
North Branch Indian Creek (all sections in PA)	CWF
North Fork	HQ-CWF
Open Brook	CWF
Oswayo Creek (main stem, Honeoye Creek to PA-NY state border)	WWF
Pierce Brook	CWF
Potato Creek (Cole Creek to mouth)	WWF
Potato Creek (main stem, confluence of East Branch and Havens Run to Cole Creek)	TSF
Railroad Run	EV
Red Mill Brook (main stem)	CWF

Stream (Zone)	Designated Use
Robbins Brook	HQ-CWF
Rock Run	CWF
Rock Run	CWF
Root Run	HQ-CWF
Sackett Hollow	CWF
Santeen Run	HQ-CWF
Sartwell Creek	CWF
Scaffold Lick Run	CWF
Sheppard Run	CWF
Sherman Run	HQ-CWF
Sicily Run	CWF
Skinner Creek	HQ-CWF
South Branch Cole Creek	EV
South Branch Kinzua Creek (main stem)	HQ-CWF
South Branch Knapp Creek	CWF
Stanton Brook	HQ-CWF
Taylor Brook	HQ-CWF
Thundershower Run	HQ-CWF
Tram Hollow Run	CWF
Tramroad Hollow	CWF
Tunungwant Creek (main stem, confluence of East and West Branches to PA-NY state border)	WWF
Tunungwant Creek (main stem, confluence of East and West Branches to PA-NY state border)	WWF
Turnup Run	HQ-CWF
Twomile Creek	CWF
UNT To Allegheny Portage Creek	CWF
UNT to Allegheny River (all sections in PA; PA-NY state border to Tunungwant Creek)	CWF
UNT to Allegheny River (all sections in PA; Tunungwant Creek to PA-NY state border)	CWF
UNT to Allegheny River (all sections in PA;sSource to PA-NY state border)	CWF
UNT to Bell Run	CWF
UNT to Chappel Fork	HQ-CWF
UNT to East Branch Tunungwant Creek (T-331 bridge to SR 4002)	CWF
UNT to Indian Creek (all sections in PA; source to PA-NY state border)	CWF
UNT to Indian Creek (main stem, PA-NY state border to mouth)	CWF
UNT to Kinzua Creek (Wintergreen Run to Mouth)	HQ-CWF
UNT to Knapp Creek	CWF
UNT to Marilla Brook (Bradford Water Dam to mouth)	CWF
UNT to Marvin Creek	CWF
UNT to Oswayo Creek (all sections in PA; Honeoye Creek to PA-NY state border)	CWF
UNT to Oswayo Creek (all sections in PA; PA-NY state border to mouth)	CWF
UNT to Potato Creek (confluence of East Branch and Havens Run to Cole Creek)	CWF

Stream (Zone)	Designated Use
UNT to Potato Creek (Cole Creek to mouth)	CWF
UNT to Quaker Run (all sections in PA)	HQ-CWF
UNT to Red Mill Brook	CWF
UNT to South Branch Kinzua Creek	HQ-CWF
UNT to Tunungwant Creek (all sections in PA; confluence of East and West Branches to PA-NY state border)	CWF
UNT to Tunungwant Creek (all sections in PA; PA-NY state border to mouth)	CWF
UNT to West Branch Clarion River (source to confluence with East Branch)	CWF
Walcott Brook	CWF
Warner Brook	HQ-CWF
Watermill Run	HQ-CWF
Wernwag Hollow	HQ-CWF
West Branch Potato Creek	HQ-CWF
West Branch Tunungwant Creek (Marilla Brook to confluence with East Branch)	CWF
West Branch Tunungwant Creek (source to Marilla Brook)	HQ-CWF
White Gravel Creek	HQ-CWF
Whiting Run	HQ-CWF
Wildcat Hollow	CWF
Willis Creek (all sections in PA)	HQ-CWF
Windfall Run	HQ-CWF
Windfall Run	CWF
Wintergreen Run	CWF
Wolf Run (all sections in PA)	HQ-CWF
Yeager Brook (all sections in PA)	HQ-CWF

Table 4.5. McKean County Designated Water Uses

Water Quality Impairments and Recommendations

Additional to the Chapter 93 regulations, DEP has an ongoing program to assess the qualities of water in Pennsylvania and identify streams and other bodies of water that are not attaining the required water quality standards. These "impaired" streams, their respective designations, and the subsequent recommendations are discussed in *Section IX*.

EXISTING MUNICIPAL REGULATIONS

In Pennsylvania, stormwater management regulations usually exist at the municipal level. A review of the existing municipal regulations helps us unravel the complex system of local regulation and develop watershed wide policy that both fits local needs and provides regional benefits. *Table 4.6* provides a summary of existing regulations for the 22 municipalities within McKean County.

MUNICIPALITY	STORMWATER MANAGEMENT		SUBDIVISION & LAND DEVELOPMENT (SALDO)		ZONING		FLOODPLAIN MANAGEMENT	
Annin Township			NO		NO			
Bradford City	YES [1]	1995	YES	1981	YES	2000		
Bradford Township	YES [1]	1995	YES	1983	YES	1998		
Ceres Township			NO		NO			
Corydon Township			NO		NO			
Eldred Borough			YES		YES	1974		
Eldred Township			NO		NO			
Foster Township	YES [1]	1995	YES	1985	YES	2000		
Hamilton Township			NO		NO			
Hamlin Township			NO		NO			
Kane Borough			YES		YES	1987		
Keating Township	YES [1]	1995	NO		NO			
Lafayette Township	YES [1]	1995	YES	1977	YES	1995		
Lewis Run Borough	YES [1]	1995	YES		YES	1974		
Liberty Township			NO		NO			
Mt Jewett Borough			NO		YES	1979		
Norwich Township			NO		NO			
Otto Township			NO		NO			
Port Allegany Borough			YES		YES	1997		
Sergeant Township			NO		NO			
Smethport Borough			NO		YES	1981		
Wetmore Township			NO		NO			

[1] Tunungwant Creek Act 167 Plan

Table 4.6. McKean County Municipal Ordinance Matrix

EXISTING RELATED PLANS

Review of previous planning efforts is another important component of regional planning. An analysis of previous plans, and the results achieved through implementation of recommendations within those plans, provides invaluable information for current and future planning efforts. The following table is a summary of related plans:

Plan Title	Date	Author
Act 167 Stormwater Management Plan – Tunungwant Creek Watershed	May 1994	McKean County Planning Commission
Clarion River Basin Conservation Plan	February 1998	Clarion River Basin Commission
McKean County Comprehensive Plan	2008	McKean County Planning Commission
Policies for the Future, McKean County Pennsylvania	June 1977	McKean County Planning Commission

Table 4.7. Related Plans Review

TUNUNGWANT CREEK WATERSHED ACT 167 PLAN

The Plan was sponsored by McKean County and was completed in 1994. The Plan covered 136 square miles and at least a portion if not all of 6 of the County's 31 municipalities:

City of Bradford	Foster Twp.	Lafayette Twp.
Bradford Twp	Keating Twp.	Lewis Run Boro

After analyzing the detail model with the existing and future conditions, the Plan identifies release rate method as the primary performance standard of control. The watershed was divided into 6 release rate areas each with specific release rate percentages which apply to the 2-, 5-, and 10-year design storms. Release rate percentages ranged from 75% to 100% of the pre-development peak flow. Some of the sub-areas were assigned Provisional No Detention. An optional standard also includes the basic post-development not to exceed pre-development peak discharge control standard is to be applied to the 25-, 50-, and 100-year storm for all areas, if the municipality decides. The Plan also identifies techniques to address water quality and groundwater recharge through in the implementation of Best Management Practices, but the Model Ordinance does not require such techniques to be used.

Section V – Significant Problem Areas and Obstructions

One of the stated goals of this Plan is to "ensure that existing stormwater problem areas are not exacerbated by future development and provide recommendations for improving existing problem areas." The strategy for achieving this goal required identification of the existing significant stormwater problem areas and obstructions, and than evaluation of the identified problem areas and obstructions.

The first task was to identify the location and nature of existing drainage problems within the study area, and where appropriate, gather field data to be used for further analysis of the problem. The geographical location data was used to plot all of the problem areas and obstructions on a single map (Reference Plate 9 – Problem Areas & Obstructions). Mapping the location of the sites in this manner enables you to identify isolated problems and determine which problems are part of more systemic problems. Systemic problems are often an idication that larger stormwater management problems exist, which may warrant more restrictive stormwater regulations. This information was used when modeling the watersheds and determining appropriate stormwater management controls.

The second part of this task was to analyze individual problem areas and obstructions, determine potential solutions for the most significant problems, and provide recommendations that can be implemented through the McKean County Stormwater Management Plan. All of the problem areas and obstructions were evaluated and potential solutions were developed. Where possible, the individual problem areas and obstructions were modeled to determine approximate capacities to be used for planning purposes. Then a preliminary prioritization assessment was conducted to give a county-wide overview of the severity of the existing problems. The priority assessment also provides general guidance on the relative order in which the problems should be addressed when considered at a county-wide level.

IDENTIFICATION OF PROBLEM AREAS AND OBSTRUCTIONS

Identification and review of existing information concerning the county's stormwater systems, streams, and tributary drainage basins within the project limits was conducted during Phase I and Phase II of this Plan. During Phase I, questionnaires were distributed to all of the municipalities in McKean County. The questionaire enabled the municipalities to report all of the known problem areas and obstructions within their municipality. All 22 municipalities in McKean County participated in the assessment process by returning completed questionaires. The responses were summarzied and reported in the Phase I report of this Plan. The responses were reviewed during Phase II of the Act 167 planning process. Field reconnaissance was subsequently conducted to confirm problem area locations, assess existing conditions, identify the general drainage patterns and gather data to complete a planning level analysis.

All of the reported obstructions and problem areas are listed in *Table 5.1* and *5.2*, respectively, on the following pages. A more detailed explanation of each site can be found in *Appendix C – Significant Problem Area Modeling and Recommendations*, which contains a summary of all of the data collected for each of the problem areas and obstructions reported throughout the county.

ID	Municipality	Location	Description
O01	Keating Township	Kent Hollow Road	Inadequate bridge
O02	Keating Township	East Valley Road	Inadequate bridge
O03	Bradford City	Seward Street Bridge	Replace bridge
O04	Bradford City	South Ave, Chataqua Place	Timber harvesting causes overload of existing pipes
O05	Bradford City	Bennett/Interstate Parkway	Increased runoff overloading ex. pipes
O06	Hamlin Township	Orchard Street	Inadequate pipes
O07	Hamlin Township	Marvindale-Kaison Road	Beaver dams
O08	Otto Township	Grant Street	30" pipe to 18" at SR 346
O09	Norwich Township	West Valley Road - Redmill Creek	Put in new bridge
O10	Norwich Township	West Valley Road - Brewer Run	Put in new bridge
O11	Norwich Township	SR 46 - White Hollow SEG 220	Put in new bridge
O12	Norwich Township	Twp RT 470 - Portage Creek	Put in new bridge

Table 5.1. Reported Obstructions

ID	Municipality	Location	Description
P01	Hamilton Township	South Hillside Ave	
P02	Hamilton Township	Wetmore Rd - Johnson to Niver Rds	Major road washouts
P03	Hamilton Township	Curtis Rd (behind Ludlow Fire Dept)	Flooding in heavy rain
P04	Hamilton Township	FR 133 RR crossing	Pipe silts shut
P05	Mt Jewett Borough	Route 6	Runoff diverted to one pipe under RR's, severe erosion.
P06	Wetmore Township	Jo Jo Road bridge	Runoff from heavy rain
P07	Wetmore Township	Jo Jo Road - both sides	Highwater flow - road washouts
P08	Wetmore Township	Old Mill Road	Road flooding in low areas
P09	Wetmore Township	Sleepy Hollow Road	Road flooding and washouts
P10	Wetmore Township	Dwights Road	Road flooding
P11	Wetmore Township	Mosier Hill Road	Road flooding in low areas
P12	Wetmore Township	Reigle Road	Road flooding
P13	Wetmore Township	Spring Street	Road flooding; property flooding
P14	Foster Township	Foster Brook thru Derrick City	
P15	Foster Township	Bolivar Run	
P16	Foster Township	Lafferty trib to Kendall Creek	
P17	Foster Township	Tunaguant Creek	

ID	Municipality	Location	Description
P18	Eldred Township	Derrick Road	Road flooding
P19	Eldred Township	Windfall Road	Road flooding
P20	Eldred Township	N. Branch Road	Road flooding
P21	Eldred Township	Driscoll Rd	Road flooding
P22	Eldred Township	Bells Hollow	Road flooding
P23	Eldred Township	Moody Loop Road	Road flooding
P24	Eldred Township	W. Eldred Road	Stream through road
P25	Eldred Township	Route 346	Stream erosion and road flooding
P26	Eldred Township	Canfield Creek	Stream full of silt
P27	Eldred Township	Carpenter Creek	Stream full of silt
P28	Eldred Township	Newell Creek	Stream full of silt
P29	Port Allegheny Borough	Route 6 Bridge over Allegheny River	Problem fixed in 2008
P30	Corydon Township	Willow Creek	Bank erosion and log jams
P31	Ceres Township	Chapman Brook Rd	Pipe under road too small
P32	Ceres Township	Coon Hollow Rd	Runoff from hill floods road
P33	Ceres Township	Taylor Brook Rd	Runoff from hill floods road
P34	Ceres Township	Church Hollow Rd	Stream floods road
P35	Ceres Township	Kings Run Rd	Stream floods road
P36	Ceres Township	Hanson Hollow Rd	Road flooding
P37	Ceres Township	Barden Brook Rd	Water from driveway in road
P38	Ceres Township	Whitetail Rd	Heavy rain washes out dirt road
P39	Ceres Township	Austin Rd	Water runs down road from connecting road
P40	Bradford Township	Browntown Rd	Road flooding
P41	Bradford Township	Pear Street	Inadequate culvert
P42	Bradford Township	Marilla Creek	Trees could block flow
P43	Bradford Township	Gates Hollow	Increased flow
P44	Smethport Borough	Black Smith Brook	Erosion
P45	Smethport Borough	Marvin Creek	Ice jams, erosion
P46	Smethport Borough	Potato Creek	
P47	Smethport Borough	West Willow	
P48	Smethport Borough	West High School	
P49	Smethport Borough	East High School	
P50	Smethport Borough	East Rosehil	
P51	Smethport Borough	East High School outfall	
P52	Smethport Borough	Fulton Franklin	Runoff from steep hillside discharges down Fulton and Franklin Streets
P53	Smethport Borough	State St	Runoff from steep upslope hillside is directed down State Street
P54	Smethport Borough	Upper Hamlin	Runoff from hillside is diverted to Hamlin Road
P55	Annin Township	Two Mile Rd	Small pipes, brush and debris
P56	Annin Township	Two Mile Creek	Runoff to road, inadequate pipe

ID	Municipality	Location	Description
P57	Annin Township	Sun Valley Road	Road flooding and washout
P58	Annin Township	Champlain Hill Rd	Road flooding
P59	Annin Township	Peich Run Rd	Erosion on side of road
P60	Annin Township	Turtlepoint Park	Stream bank erosion
P61	Annin Township	Open Brook	Inadequate pipes
P62	Keating Township	Galico Cross Rd	Shoulder washout
P63	Keating Township	Valley Cross Rd	Shoulder washout
P64	Keating Township	Dugout Rd	Shoulder washout
P65	Bradford City	Bolivar Run	Flooding, streambank erosion
P66	Bradford City	Bennet Brook	Erosion, minor flooding and property damage
P67	Bradford City	Kendall Creek at Melvin Ave	Overbank flow - property damage
P68	Bradford City	Neva Drive	Property damage due to runoff
P69	Bradford City	Bedford St	Increased flow causing ponding
P70	Hamlin Township	Dewey Ave	Marvin Creek flooding in park and property
P71	Hamlin Township	Marvin Creek	Increased runoff from hills causes flooding
P72	Hamlin Township	S. of Hazel Hurst	Runoff too much for ditches
P73	Hamlin Township	Kiln Rd	Runoff
P74	Hamlin Township	Guffey Rd	Erosion from runoff washing out roads
P75	Hamlin Township	Old Bradford Rd	Ponding of water
P76	Otto Township	Brooklyn St	Bank erosion re-routes flow
P77	Otto Township	Baker Trussel Bridge	Bank erosion re-routes flow
P78	Otto Township	Clark St bridge	Bank erosion re-routes flow
P79	Otto Township	Depot St bridge	Bank erosion re-routes flow
P80	Otto Township	Burger Hollow bridge	Bank erosion re-routes flow
P81	Otto Township	w of Old Valley Rd	Bank erosion and property damage
P82	Otto Township	Kansas Branch	Bank erosion and property damage
P83	Otto Township	Burger Hollow	Bank erosion and property damage
P84	Lewis Run Borough	Bridge over EB Tunungwant Creek	Sediment in creek both sides of bridge
P85	Eldred Borough	Main St (Rt 446)	Inadequate storm drains
P86	Eldred Borough	Elm St	Inadequate storm drains
P87	Eldred Borough	Clif-Nel Dr	Drainage problem
P88	Eldred Borough	Railroad Ave	Lack of drainage
P89	Eldred Borough	Main St (Rte 446)	Storm drain obstruction
P90	Eldred Borough	Main St (Rte 446)	Storm drain obstruction
P91	Norwich Township	Crosby Cross Road - Twp Rte 375	
P92	Norwich Township	Keystone Cross Rd - Twp Rte T 373	Area is in the backwater for the main channel
P93	Liberty Township	Buchenauer Rd area	Beaver dam
P94	Liberty Township	Fogel Crossing Rd	House in floodplain

Table 5.2. Reported Problem Areas

RECOMMENDATIONS

The reported stormwater problems within the study area can be attributed to one, or more, of several principal causes:

1. The existing storm drain system has insufficient capacity.
2. There is an incomplete collection and conveyance system or a lack of a formal/comprehensive system.
3. Maintenance is required on an existing system (e.g. catch basin inlets become plugged and local flooding occurs).
4. Problem areas are located in the floodplain area.

In addition, the problem areas mentioned in this section are more pronounced in the more populated/developed areas. This is most likely due to encroachments into floodplain areas and undersized culverts or bridges. Also, a large number of these stormwater related problems have been traced back to uncontrolled runoff from local and upstream areas, inadequate culverts or bridges, and obstructions in the system that are blocking the natural flow of stormwater.

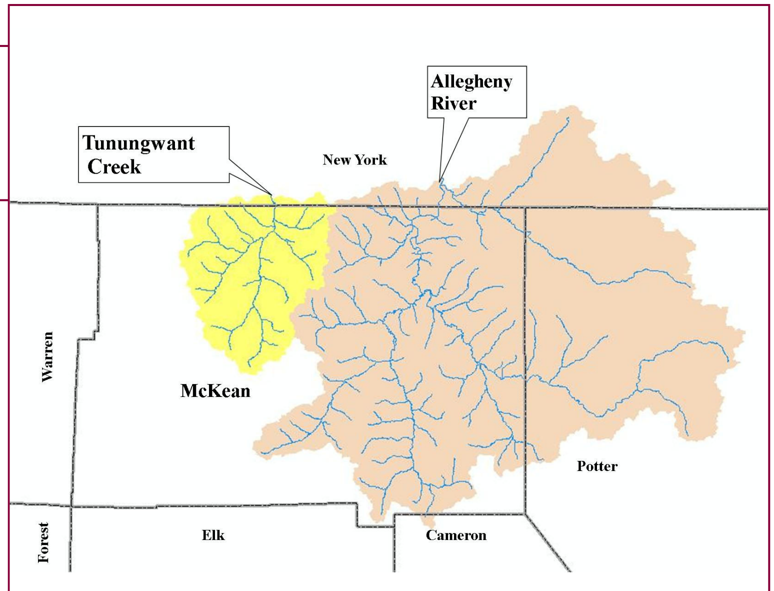
This study has identified some drainage problems that occur on a yearly basis. While a certain amount of flooding is natural in streams during heavy rain, periodic maintenance can prevent some of the identified problems with flooding and erosion. A stormwater facility maintenance program should be developed and implemented as part of the strategy to correct existing problems and alleviate future problem areas.

Continued improper development within the county will amplify these problems. Remedial actions will be necessary to correct existing drainage problems. In the long term, a comprehensive approach is needed to tackle these problems. This approach will have to incorporate regulations and development standards into local zoning, consider both on-site and off-site drainage, provide a consistent approach between communities, use natural elements for the transport and storage of stormwater, consider both quantity and quality of water, and treat the watershed as a whole.

Stormwater master planning is one way to address all of the needs and potential threats to a watershed. However, implementation of these practices can be difficult and may not be economically feasible for many communities. HRG, in cooperation with McKean County is taking the lead to develop economical solutions that address stormwater runoff issues that lead the industry and provide the regulatory community with solutions that meet EPA and DEP standards. Looking ahead, it is expected that the status of the current stormwater infrastructure will keep deteriorating with time. In addition to imposing stronger regulations to control new development, increased expenditures for maintenance and other improvements is necessary, or the systems will continue to deteriorate faster than the ability to fix and maintain them.

This page has been left blank intentionally.

Section VI – Technical Analysis - Modeling



TECHNICAL APPROACH

To provide technical guidance in the Act 167 planning process, hydrologic models were prepared for specific watersheds identified by the municipalities, the county and Pennsylvania Department of Environmental Protection. The results from these models increase the overall understanding of watershed response to rainfall and help guide policy. Through the development and analysis of a hydrologic model, effective and fair regulations can be applied on a county-wide basis, while addressing specific issues identified by the individual communities in McKean County. The hydrologic methodology used in the technical approach is the Natural Resource Conservation Service (NRCS) Rainfall-Runoff Method described in various NRCS publications (NRCS, 2008a). This method was chosen since it is the most common method used by designers in Pennsylvania and has widely available data (NRCS, 2008b). Additionally, this method is the basis for which many of the guidelines were developed in the *PA Stormwater BMP Manual* (DEP, 2006). The calculations for this methodology were performed with HEC-HMS, the US Army Corps of Engineers' Hydrologic Modeling System.

The modeling approach in this study was to:

1. Establish a reasonable estimate of rainfall-runoff response under existing conditions in year 2010,

2. Establish a reasonable estimate or rainfall-runoff response under an assumed future condition land development in year 2020,

3. Provide an examination of the impact with the implementation of guidelines from the *PA Stormwater BMP Manual* (i.e., Design Storm Method and Simplified Method), and finally,

4. Develop stormwater management districts where it is determined necessary to do so.

This approach was used on Tunungwant Creek and the upper portion of the Allegheny River for this Plan. As discussed in *Section III*, the Allegheny River watershed is very large. The modeling efforts for this Plan included all contributing areas upstream of where the Allegheny River leaves McKean County and flows into New York. "Allegheny River", as used in this section, refers to the area just described. This area contains all, or portions, of four different Act 167 Designated Watersheds: 1. Allegheny River Potter County, 2. Allegheny River (Potter County to New York state line reach), 3. Oswayo Creek, and 4. Potato Creek.

This section discusses the portion of the modeling effort that affects the Model Ordinance and the overall county stormwater policy. Generally, it was observed that the watersheds of McKean County have a relatively intense response to runoff (i.e., small rainfall events can result in large amounts of flow in the rivers). This response is a function of poorly drained soils and relatively shallow bedrock throughout the county. It was also observed that there is only slight to moderate projected "growth" throughout the county. The modeling effort provided evidence that implementing the *PA Stormwater BMP Manual* guidelines will help reduce the impacts of future development. With the minor projected changes in land use and the implementation of the *BMP Manual* guidelines, no stormwater management districts are proposed for McKean County.

A detailed explanation of this modeling effort is provided in *Appendix A*. Information from PAC meetings has been incorporated to direct the focus of this modeling effort and to ensure the most current DEP regulations are successfully incorporated throughout the entire county.

LAND USE

The variable that most affects the outcome of the modeling effort is the projected change in land use between 2010 and 2020. *Tables 6.1* and *6.2* summarize the existing and proposed land use for the two modeled watersheds: Tunungwant Creek and the Allegheny River in McKean County. In both watersheds, there are slight projected increases in commercial and residential land uses with a decrease in forested land uses.

Land Use	Existing Land Use (Year 2010)		Proposed Land Use (Year 2020)		Change Future - Existing
	Acres	%	Acres	%	%
Brush	141.8	0.2	142.2	0.2	0.0
Commercial and Business	2573.4	2.8	2699.8	2.9	0.1
Contoured Row Crops	18.7	0.0	18.7	0.0	0.0
Industrial	635.6	0.7	2914.9	3.2	2.5
Meadow	28.9	0.0	28.9	0.0	0.0
Newly graded areas	0.1	0.0	0.2	0.0	0.0
Open space	265.7	0.3	275.5	0.3	0.0
Pasture	11149.6	12.1	13180.9	14.4	2.2
Residential - 1 acre	5761.4	6.3	3317.4	3.6	-2.7
Residential - 1/2 acre	101.0	0.1	2198.2	2.4	2.3
Residential - 1/8 acre	0.0	0.0	1442.5	1.6	1.6
Water	231.9	0.3	231.9	0.3	0.0
Woods	70912.4	77.2	65369.4	71.2	-6.0
Total	91820.5	100.0	91820.5	100.0	n/a

Table 6.1. Existing and Future Land Use in the Tunungwant Creek Watershed

Land Use	Existing Land Use		Proposed Land Use		Change Future - Existing
	Acres	%	Acres	%	%
Brush	6767.0	1.2	6767.0	1.2	0.0
Commercial and Business	1547.2	0.3	1811.9	0.3	0.0
Contoured Row Crops	3694.1	0.7	3694.5	0.7	0.0
Industrial	786.4	0.1	811.2	0.1	0.0
Meadow	1237.7	0.2	1238.2	0.2	0.0
Newly graded areas	179.4	0.0	179.4	0.0	0.0
Open space	4796.8	0.9	4817.4	0.9	0.0
Pasture	102568.7	18.6	107557.8	19.5	0.9
Residential - 1 acre	9713.8	1.8	7446.4	1.3	-0.4
Residential - 1/2 acre	285.1	0.1	2270.0	0.4	0.4
Residential - 1/8 acre	0.0	0.0	3887.7	0.7	0.7
Water	7459.2	1.4	7468.9	1.4	0.0
Woods	412840.9	74.8	403925.8	73.2	-1.6
Total	551876.3	100	551876.3	100	n/a

Table 6.2. Existing and Future Land Use in the Allegheny River Watershed (within McKean County only)

EFFECTS OF FUTURE LAND USE

Using the HEC-HMS models for the Tunungwant Creek and Allegheny River, the effects of the land use change between the years 2010 and 2020 were examined. *Figures 6.1* and *6.2* shows the increase in peak flows for the 2-year storm event throughout the Tunungwant Creek and Allegheny River watersheds, respectively. This increase in peak flows uses the assumption that no stormwater controls would be implemented in the next 10 years. Although this scenario is highly unlikely, given the existing regulations in each municipality, or the regulations that would adopted with the recommendation of this Plan, it does provide a worst case scenario. More importantly, this scenario highlights the critical areas within the county where more stringent regulation might be beneficial.

As shown in *Figure 6.1*, the projected future increases for the Tunungwant Creek watershed are located mostly around the City of Bradford and the southern portion of the watershed. This development pattern indicates a potential need for peak rate controls more stringent than the traditional 100% release rates.

For the Allegheny River watershed, the projected future increases are located in numerous areas throughout the county, as depicted in *Figure 6.2*.

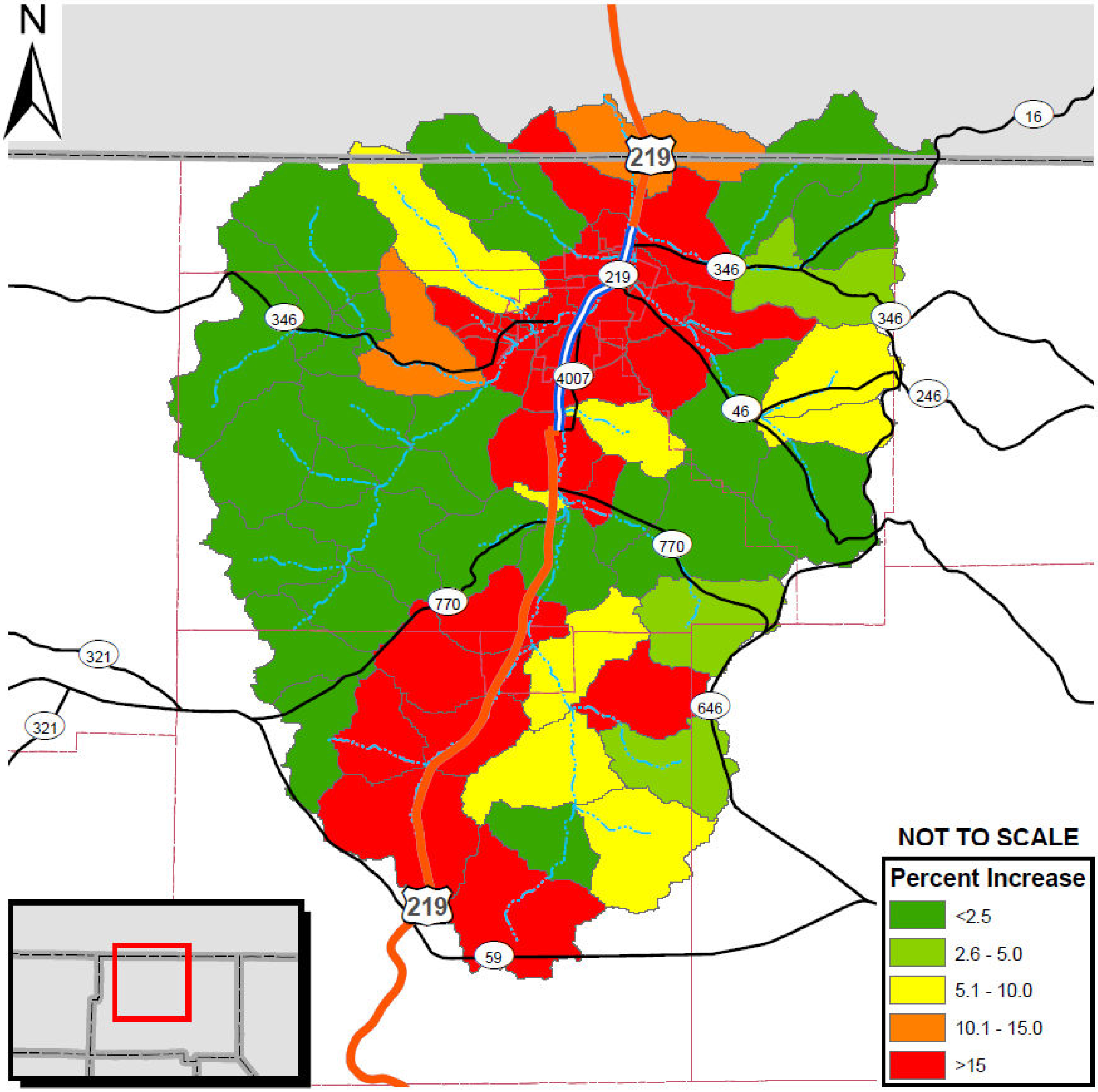


Figure 6.1. Percentage Increase in Peak Flows for the 2-Year Storm Event in the Tunungwant Creek Watershed

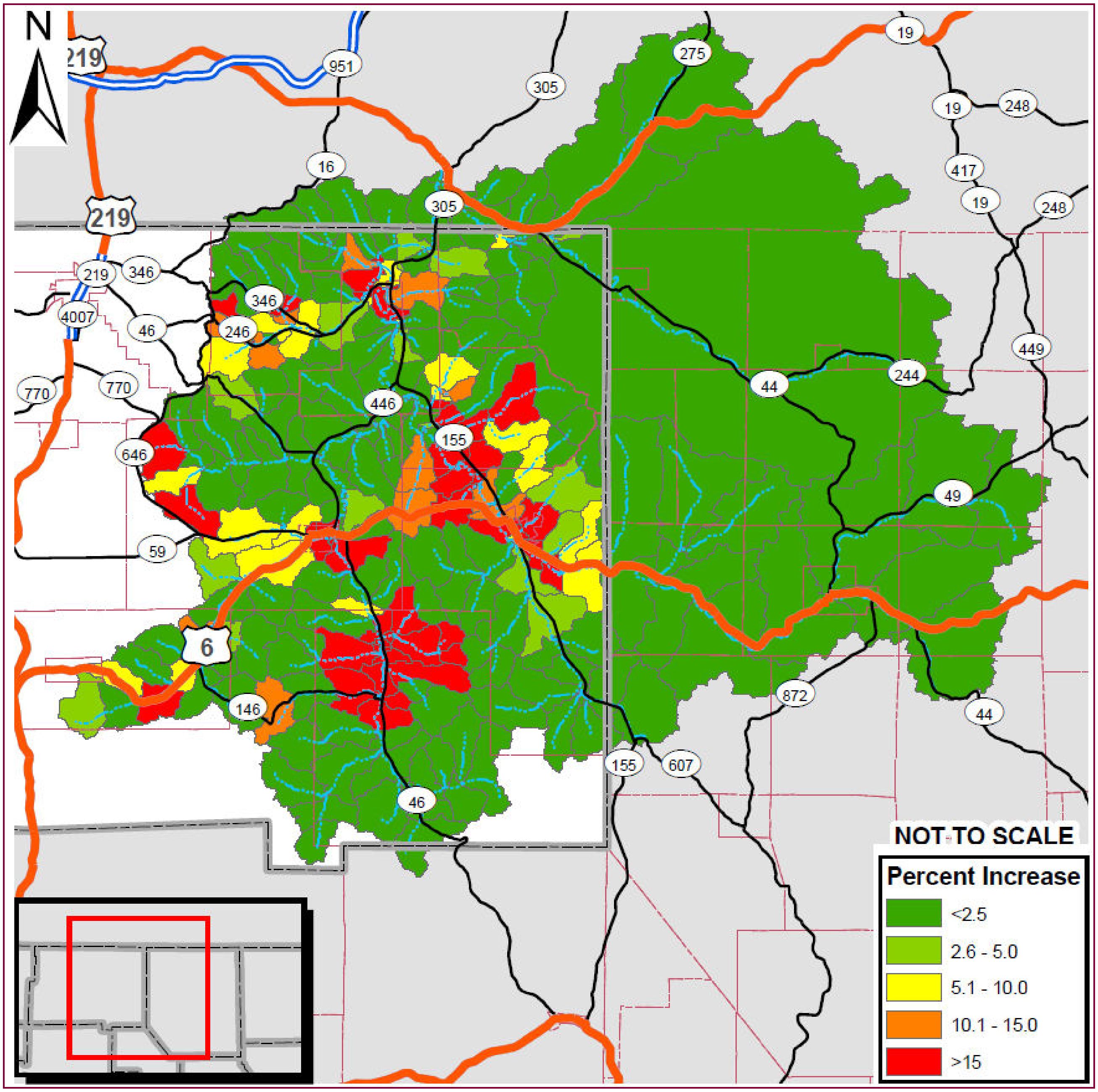


Figure 6.2. Percentage Increase in Peak Flows for the 2-Year Storm Event in the Allegheny River Watershed

STORMWATER MANAGEMENT DISTRICTS

When substantial increases are found in the HEC-HMS model due to additive effects of future development, it may be necessary to restrict post development discharges to a fraction of pre-development flow. The fraction has historically ranged between 50 and 100 percent of the pre-development flow in other Act 167 efforts. For example, a 75% release rate district would indicate that any future development within the district be required to restrict post-development flows to 75% of pre-development flows.

Release rate theory and the designation of stormwater management districts are not substantially supported in stormwater literature. The calculation of release rates is heavily dependent on timing and growth projections, both of which involve a high degree of uncertainty. Additionally, it has been observed that localized stormwater measures do not typically capture and detain entire tributary areas (Emerson, 2003). Given these limitations with release rates, the following criteria were examined before applying release rates to the modeled watersheds:

1. Numerous problem areas exist in a pattern that indicate systemic stormwater problems;

2. Historic, repeated flooding has been observed;

3. Future planning projections indicate growth patterns that have historically contributed to documented problems; and

4. Release rates are to be designated on higher order watersheds only; larger downstream areas with well established bed-and-bank streams are not as affected by relatively small scale development and therefore do not benefit from release rates.

When the above criteria indicate a need for additional stormwater management controls, release rates are considered. The results from hydrologic models are used as guidance to establish appropriate release rates. Ultimately, reasonable hydrologic judgment is used in the final designation of release rates.

Both the Tunungwant Creek and Allegheny River were evaluated on the above criteria for implementation of stormwater management districts. For the Tunungwant Creek Watershed, much of the future development is projected to occur mostly around city of Bradford and the southern portion of the watershed. To prevent the creation of future problems areas and further complicating the existing problems on this watershed, release rates ranging between 70% and 100% were designated in various locations.

For the majority of the Allegheny River, there is only moderate projected growth and the combination of implementing the *PA BMP Manual* volume control guidelines and using 100% peak rate control should be sufficient to limit the impact of the future projected growth. In considering the additional criteria it was determined that stormwater management districts would not be implemented.

The location of the stormwater management districts is shown on *Plate 10 - Stormwater Management Districts*, which also identifies the location for potential regional stormwater facilities.

RECOMMENDATIONS

The modeling results discussed in this and previous sections provide technical guidance on provisions that should be included in the model ordinance. The following recommendations follow from the technical analysis and data collection efforts in preparing this Plan.

Curve number and time of concentration methodologies should be restricted to reflect the observed runoff response in the hydrologic models. For storm events greater than the 10-year storm events, the runoff response to NOAA Atlas 14 rainfall in McKean County was slightly lower than standard NRCS methods predict. This has the potential to allow designers to undersize their stormwater facilities and to increase peak discharges for the higher magnitude events. It is recommended for curve number calculations to assume 'good conditions' when using any curve number table, which is consistent with proposed control guidance. It is recommended for time of concentration computations to use the longest time of concentration provided by 1) the TR-55 segmental method and 2) the NRCS Lag Equation.

Implement a volume control policy in addition to a traditional peak rate methodology. The modeling results show a definite reduction in peak discharge in all storm events with the implementation of the control guidance criteria. The control guidance criteria will provide a direct benefit with volume reduction and also an indirect benefit of channel protection.

Implement and enforce a flexible yet clearly documented release rate policy for specified watershed. The stormwater management districts for Tunungwant Creek are provided on *Plate 10*. These should be used to determine the allowable post-development peak flow rate. The use of strategically placed regional facilities and watershed-scale conservation, drainage way, and critical recharge area easements should also be considered as an alternative to release rate implementation.

Provide a clear alternative volume-control and peak-rate control strategy for areas with poorly drained soils or areas with geologic restrictions. McKean County has a substantial number of potential limitations to infiltration facilities. These limitations include: fragipans, shallow bedrock, Hydrologic Soil Group D soils, floodplains, and documented problem areas. *Section VII* provides a recommended procedure for sites with these limitations.

This page has been left blank intentionally.

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

TECHNICAL STANDARDS FOR STORMWATER MANAGEMENT

The field of stormwater management has evolved rapidly in recent years as additional research has increased our comprehension of how stormwater runoff is interrelated with the rest of our natural environment. Even now this relationship is not completely understood. Stormwater management practices will continue to evolve as additional knowledge becomes available. Effective resource management involves balancing the positive and negative effects of all potential actions. These actions are considered, and the individual management techniques which provide the best known balance are chosen for implementation. The goal of this Plan is to manage stormwater as a valuable resource, and to manage all aspects of thies resource as effectively as possible. This Plan contains technical standards that seek to achieve this goal through four different methods. These standards are summarized as follows:

1. Peak Discharge Rate Standards – Peak discharge rate standards are implemented primarily to protect areas directly downstream of a given discharge by attenuating peak discharges from large storm events. These standards are also intended to attenuate peak flows throughout the watershed during large storm events. Peak discharge rate controls are applied at individual development sites. Controlling peak discharge rates from the sites entails collection, detention, and discharge of the runoff at a prescribed rate. This is an important standard for achieving stable watersheds.

2. Volume Control Standards – The standards in this Plan that address increased stormwater volume are intended to benefit the overall hydrology of the watershed. The increased volume of runoff generated by development is the primary cause of stormwater related problems. Increased on-site runoff volume commonly results in a sustained discharge at the designed peak discharge rate, as well as an increased volume and duration of flows experienced after the peak discharge rate. Permanently removing a portion of the increased volume from a developed site is key in mitigating these problems and maintaining groundwater recharge levels. Meeting this standard generally involves providing and utilizing infiltration capacity at the development site, although alternative methods may be used.

3. Channel Protection Standards – Channel protection standards are designed to reduce the erosion potential from stormwater discharges to the channels immediately downstream. Even though peak discharge rate controls are implemented for larger design storms, they do not provide controls for the smaller storms. These storms account for the vast majority of the annual precipitation volume. Past research has shown that channel formation in developed watersheds is largely controlled by these small storm events. The increased volume and rate of stormwater runoff during small storms forces stream channels to change in order to accommodate the increased flows. Channel protection standards will be achieved through implementation of permanent removal of increased volume from discharges during low flow storm events.

4. Water Quality Standards – The water quality standards contained in this Plan are meant to provide a level of pollutant removal from runoff prior to discharge to receiving streams.

Stormwater runoff can deliver a wide range of contaminants to the receiving stream, which leads to a variety of negetive impacts. Water quality standards can be achieved through reducing the source of pollutants and utilizing natural and engineered systems that are capable of removing the pollutants.

Beyond the standards discussed above, other measures may be taken to ensure that stormwater is properly managed. Some of these measures are discussed later in *Section X, Additional Recommendations*. These measures are included as recommendations because they are beyond the regulatory scope of this Plan. Municipalities should consider these recommendations seriously.

Stormwater management is an issue that is entwined with land use decisions and has social and economic implications. To maximize the effectiveness of a stormwater management program, a holistic approach is needed. Stormwater management should be a consideration in any ordinance decisions that affect how land is used.

CRITERIA FOR CONTROL OF STORMWATER RUNOFF

The principal purpose of this Plan was to develop criteria for control of stormwater runoff that are specific to the watersheds within McKean County. Mathematical modeling techniques, as discussed in the previous chapter, were used to simulate the existing conditions throughout the county and to determine the effects anticipated future development will have on stormwater runoff within these watersheds. The models were used to determine the outcome of a variety of different stormwater control scenarios. These results were then used to determine a group of control criteria that provides the best results on a watershed wide basis. The outcome of each analysis is stormwater control criteria that are appropriate and applicable to that watershed.

The process of developing unique controls for individual watersheds is complicated by the reality that regulations must be implemented and enforced across varying jurisdictions. The more site specific and complicated a regulatory structure is, the more difficult it becomes to implement the regulations. For this reason it is most advantageous to develop a system of controls that are similar in structure but can also be adjusted as necessary to meet the specific needs of each watershed. The need for balance between these two important concepts has lead to the system of stormwater control criteria contained within this Plan.

A broad and uniform approach has been developed for implementation of water quality, volume control, and channel protection controls. These criteria have been developed with adequate latitude in implementation to be applicable to most watersheds statewide. Peak discharge rate control standards, which are unique to each watershed, have been developed to achieve watershed specific controls.

PEAK DISCHARGE RATE CONTROLS

Peak discharge rate controls have been the primary method of implementing stormwater management controls for many years. However, peak rate controls are generally applied to individual sites with little to no consideration given to how the site discharge impacts overall stream flows. It is necessary to consider the cumulative effects of site level peak rate controls, and their contribution to the overall watershed hydrology, in order to control regional peak flows. This is accomplished through mathematical modeling of the watershed. The intent of the modeling is to analyze the flow patterns of the watershed, the impact of development on those patterns, and, if necessary, develop a release rate for various subwatersheds such that the rate of release of the increased volumes of runoff generated is not detrimental to downstream areas.

In some subbasins, it is necessary to implement strict release rates that require sites to discharge at flows much lower than those calculated for pre-development flows. This is due to the timing of the peak flows from all of the subbasins, and how flows from the subbasin in question impact the overall stream flows. Variable release rates for subbasins throughout a watershed are an important part of achieving regional peak flow controls. The proposed release rates calculate no peak flow increase above the existing condition peak flows at any point throughout the county watersheds. Strict release rates for the more frequent design storms are necessary to meet this criterion in some subwatersheds. The proposed release rates for this Plan fall into two categories:

1. Areas not covered by a Release Rate Map:

   Post-development discharge rates shall not exceed the predevelopment discharge rates for the 2-, 10-, 25-, 50-, and 100-year storms. If it is shown that the peak rates of discharge indicated by the post-development analysis are less than or equal to the peak rates of discharge indicated by the pre-development analysis for 2-, 10-, 25-, 50-, and 100-year, 24-hour storms, then the requirements of this section have been met. Otherwise, the applicant shall provide additional controls as necessary to satisfy the peak rate of discharge requirement.

2. Areas covered by a Release Rate Map:

   For the 2-, 10-, 25-, 50-, and 100-year storms, the post-development peak discharge rates will follow the applicable approved release rate maps. For any areas not shown on the release rate maps, the post-development discharge rates shall not exceed the predevelopment discharge rates.

   A. Tunungwant Creek Watershed – 70% and 100% release rate districts have been established.
   B. Allegheny River Watershed - 100% release rate districts have been established.
   C. Potato Creek Watershed - 100% release rate districts have been established.

VOLUME CONTROLS

Developed sites experience an increased volume of runoff during all precipitation events. The increased volume of stormwater is the cause of several related problems such as increased chanel erosion, increased main channel flows, and reduced water available for groundwater recharge. Reducing the total volume of runoff is key in minimizing the impacts of development. Volume reduction can be achieved through reuse, infiltration, transpiration, and evaporation. When infiltration is used as a stormwater management technique, multiple goals are achieved through implementation of a single practice. Infiltrating runoff reduces release rates, reduces release volumes, increases groundwater recharge, and provides a level of water quality improvement. These opportunities will be provided by use of Best Management Practices such as infiltration structures, replacement of pipes with swales, and disconnecting roof drains. Other methods that may be used are decreased impervious cover, maximizing open space, and preservation of soils with high infiltration rates.

The proposed volume controls for this Plan include two pieces:

1. Reduction of runoff generated through utilization of low impact development practices to the maximum extent practicable.

2. Permanent removal of a portion of the runoff volume generated from the total runoff flow.

The permanent removal of runoff volume is to be achieved through one of three available methods:

1. *The Design Storm Method* (CG-1 in the BMP Manual) is applicable to any size of Regulated Activity. This method requires detailed modeling based on site conditions.

   A. Do not increase the post-development total runoff volume for all storms equal to or less than the 2-year 24-hour duration precipitation.

   B. For modeling purposes:

      i) Existing (pre-development) non-forested pervious areas must be considered meadow or its equivalent.

      ii) Twenty (20) percent of existing impervious area, when present, shall be considered meadow in the model for existing conditions.

2. *The Simplified Method* (CG-2 in the BMP Manual) provided below is independent of site conditions and should be used if the Design Storm Method is not followed. This method is not applicable to Regulated Activities greater than one (1) acre or for projects that require design of stormwater storage facilities. For new impervious surfaces:

   A. Stormwater facilities shall capture at least the first two inches (2") of runoff from all new impervious surfaces.

   B. At least the first one inch (1") of runoff from new impervious surfaces shall be permanently removed from the runoff flow -- i.e. it shall not be released into the surface waters of this Commonwealth. Removal options include reuse, evaporation, transpiration, and infiltration.

   C. Wherever possible, infiltration facilities should be designed to accommodate infiltration of the entire permanently removed runoff; however, in all cases at least the first one-half inch (0.5") of the permanently removed runoff should be infiltrated.

   D. Actual field infiltration tests at the location of the proposed elevation of the stormwater BMPs are required. Infiltration test shall be conducted in accordance with the *PA Stormwater BMP Manual*. Notification of the Municipality shall be provided to allow witnessing of the testing.

3. Alternatively, in cases where it is not possible, or desirable, to use infiltration-based best management practices to partially fulfill the volume control requirements the following procedure shall be used:

   A. The following water quality pollutant load reductions will be required for all disturbed areas within the proposed development:

Pollutant Load	Units	Required Reduction (%)
Total Suspended Solids (TSS)	Pounds	85
Total Phosphorous (TP)	Pounds	85
Total Nitrate (NO_3)	Pounds	50

B. The performance criteria for water quality best management practices shall be determined from the *Pennsylvania Stormwater Best Management Practices Manual*, most current version.

WATER QUALITY CONTROLS

Urban runoff is one of the primary contributors to water pollution in developed areas. The most effective method for controlling non-point source pollution is through reduction, or elimination, of the sources. However, it is not reasonable to assume that all sources of pollution can be reduced or eliminated. For this reason, implementation of natural and engineered systems must be used to achieve the desired results. The water quality control standards will be achieved through the use of various Best Management Practices to reduce the sources of water pollution and treat those that cannot be eliminated.

A combination of source reduction measures through non-structural BMPs and water quality treatment through use of structural BMPs is the proposed water quality control strategy of this Plan. Reducing the amount of runoff to be treated is the preferred strategy to meet this goal:

- Minimize disturbance to floodplains, wetlands, natural slopes over 8%, and existing native vegetation.
- Preserve and maintain trees and woodlands. Maintain or extend riparian buffers and protect existing forested buffer. Provide trees and woodlands adjacent to impervious areas whenever feasible.
- Establish and maintain non-erosive flow conditions in natural flow pathways.
- Minimize soil disturbance and soil compaction. Over disturbed areas, replace topsoil to a minimum depth equal to the original depth or 4 inches, whichever is greater. Use tracked equipment for grading when feasible.
- Disconnect impervious surfaces by directing runoff to pervious areas, wherever possible.

Treating the runoff that cannot be eliminated is the secondary strategy for attaining the water quality standards. By directing runoff through one or more BMPs, runoff will receive some treatment for water quality, thereby reducing the adverse impact of contaminants on the receiving body of water.

RECOMMENDED BEST MANAGEMENT PRACTICES

As previously stated, the preferred strategy for achieving the goals of this plan is to reduce, or eliminate, the sources of non-point source pollution. "The treatment of runoff is not as effective as the removal of runoff needing treatment" (Reese, 2009). This is an important concept, in that the most effective way to reduce the number of stormwater runoff problems is to reduce the amount of runoff generated. There are a wide variety of non-structural practices that are used to reduce the amount of runoff generated and to minimize the potential negative impacts of runoff that is generated. All of these BMPs are intended to minimize the interruption of the natural hydrologic cycle caused by development. The relative effectiveness of each non-structural BMP listed in the *Pennsylvania Stormwater Best Management Practices Manual* in *Table 7.1* below. These practices should be used where applicable to decrease the need for less cost effective structural BMPs.

Non-Structural Best Management Practice	Stormwater Functions[1]			
	Peak Rate Control	Volume Reduction	Recharge	Water Quality
Protect Sensitive / Special Value Features	Very High	Very High	Very High	Very High
Protect / Conserve / Enhance Riparian Areas	Low/Med.	Medium	Medium	Very High
Protect / Utilize Natural Flow Pathways in Overall Stormwater Planning and Design	Med./High	Low/Med.	Low	Medium
Cluster Uses at Each Site; Build on the Smallest Area Possible	Very High	Very High	Very High	Very High
Concentrate Uses Areawide through Smart Growth Practices	Very High	Very High	Very High	Very High
Minimize Total Disturbed Area - Grading	High	High	High	High
Minimize Soil Compaction in Disturbed Areas	High	Very High	Very High	Very High
Re-Vegetate and Re-Forest Disturbed Areas using Native Species	Low/Med.	Low/Med.	Low/Med.	Very High
Reduce Street Imperviousness	Very High	Very High	Very High	Medium
Reduce Parking Imperviousness	Very High	Very High	Very High	High
Rooftop Disconnection	High	High	High	Low
Disconnection from Storm Sewers	High	High	High	Low
Streetsweeping	Low/None	Low/None	Low/None	High

NOTES:
[1] All Stormwater function values from *PA Stormwater BMP Manual*

Table 7.1. Stormwater Functions of Structural Best Management Practices

When non-structural practices are unable to achieve the stormwater standards, it may be necessary to employ structural practices. Generally, structural BMPs are chosen to address specific stormwater functions. Some BMPs are better suited for particular stormwater functions than others. The relative effectiveness of structural BMPs at addressing individual stormwater functions varies, as shown in *Table 7.2*. This table contains all of the structural BMPs listed in the *Pennsylvania Stormwater Best Management Practices Manual* and their stated effectiveness for each stormwater function. Additional information on each practice can be found in the *Pennsylvania Stormwater Best Management Practices Manual*.

Structural Best Management Practice	Stormwater Functions[1]			
	Peak Rate Control	Volume Reduction	Recharge	Water Quality
Porous Pavement with Infiltration Bed	Medium	Medium	Medium	Medium
Infiltration Basin	Med./High	High	High	High
Subsurface Infiltration Bed	Med./High	High	High	High
Infiltration Trench	Medium	Medium	High	High
Rain Garden / Bioretention	Low/Med.	Medium	Med./High	Med./High
Dry Well / Seepage Pit	Medium	Medium	High	Medium
Constructed Filter	Low-High*	Low-High*	Low-High*	High
Vegetated Swale	Med./High	Low/Med.	Low/Med.	Med./High

Structural Best Management Practice	Stormwater Functions[1]			
	Peak Rate Control	**Volume Reduction**	**Recharge**	**Water Quality**
Vegetated Filter Strip	Low	Low/Med.	Low/Med.	High
Infiltration Berm and Retentive Grading	Medium	Low/Med.	Low	Med./High
Vegetated Roof	Low	Med./High	None	Medium
Rooftop Runoff - Capture and Reuse	Low	Med./High	Low	Medium
Constructed Wetland	High	Low	Low	High
Wet Pond / Retention Basin	High	Low	Low	Medium
Dry Extended Detention Basin	High	Low	None	Low
Water Quality Filter	None	None	None	Medium
Riparian Buffer Restoration	Low/Med.	Medium	Medium	Med./High
Landscape Restoration	Low/Med.	Low/Med.	Low/Med.	Very High
Soils Amendment and Restoration	Medium	Low/Med.	Low/Med.	Medium

NOTES:
[1] All Stormwater function values from *PA Stormwater BMP Manual*
[2] Depends on if infiltration is used

Table 7.2. Stormwater Functions of Structural Best Management Practices

The table above shows the qualitative effect of individual BMPs when used as stand alone treatment practices. The overall effectiveness of a stormwater system can be improved when several, smaller BMPs are dispersed throughout a given site. The combination of different BMPs enables each BMP to complement each other by providing a particular stormwater function then allowing the runoff to pass downstream to another BMP that is used to address different criteria. This allows designers to better mimic the site's existing hydrologic features, which are not typically isolated to one area of the site. The "treatment train" system of utilizing multiple BMPs on a single site is an effective technique that, in some cases, may be used to meet all of the stormwater criteria.

Several of the structural BMPs are particularly effective at achieving the criteria for control of stormwater presented in this Plan. The following practices should be considered where appropriate:

BIORETENTION & RAIN GARDENS

A rain garden, also referred to bioretention, is an excavated shallow surface depression planted with native, water-resistant, drought and salt tolerant plants with high pollutant removal potential that is used to capture and treat stormwater runoff. Rain gardens treat stormwater by collecting and pooling water on the surface and allowing filtering and settling of suspended solids and sediment prior to infiltrating the water. Rain gardens are generally constructed to provide 12 inches or less of pending depth with shallow side slopes (3:1 max). They are designed to reduce runoff volume, filter pollutants and sediments through the plant material and soil particles, promote groundwater recharge through infiltration, reduce stormwater temperature impacts, and enhance evapotranspiration. Their versatility has proved extremely successful in most applications including urban and suburban areas (DEP, 2006).

Construction of rain gardens varies depending on site specific conditions. However, they all contain the same general components: appropriate native vegetation, a layer of high organic content mulch, a layer of planting soil, and an overflow structure. Often times, an infiltration bed is added under the planting soil to provide additional storage and infiltration volume. Also, perforated pipe can be installed under the rain garden to collect water that has filtered through the soil matrix and convey it to other stormwater facilities. Rain gardens can be integrated into a site with a high degree of flexibility and can be used in coordination with a variety of other structural best management practices. They can also enhance the aesthetic value of a site through the selection of appropriate native vegetation.

DRY WELL / ROOF SUMP

A dry well, sometime referred to as a roof sump, is a subsurface storage facility that temporarily stores and infiltrates stormwater runoff from the roofs of structures. Roof runoff is generally considered "clean" runoff, meaning that it contains few or no pollutants. However, roofs are one of the primary sources of increased runoff volume from developed areas. This runoff is ideal for infiltration and replenishment of groundwater sources due to the relatively low concentration of pollutants. By decreasing the volume of stormwater runoff, dry wells can also reduce runoff rate thereby improving water quality.

Roof drains are connected directly into the dry well, which can be an excavated pit filled with uniformly graded aggregate wrapped in geotextile or a prefabricated storage chamber. Runoff is collected during rain events and slowly infiltrated into the surrounding soils. An overflow mechanism such as an overflow outlet pipe, or connection to an additional infiltration area, is provided as a safety measure in the event that the facility is overwhelmed by extreme storm events or other surcharges (DEP, 2006). Dry wells are not recommended within a specified distance to structures or subsurface sewage disposal systems.

VEGETATED SWALES

Vegetated swales are broad, shallow channels, densely planted with a diverse selection of native, close-growing, water-resistant, drought and salt tolerant plants with high pollutant removal potential. Plant selection can include grasses, shrubs, or even trees. These swales are designed to slow runoff, promote infiltration, and filter pollutants and sediments while conveying runoff to additional stormwater management facilities. Swales can be trapezoidal or parabolic, but should have broad bottoms, shallow side slopes (3:1 to 5:1 ratio), and relatively flat longitudinal slopes (1-6%). Check-dams can be utilized on steeper slopes to reduce flow velocities. Check-dams can also provide limited detention storage and increase infiltration volume. Vegetated swales provide many benefits over conventional curb and gutter conveyance systems. They reduce flow velocities, provide some flow attenuation, provide increased opportunity for infiltration, and providing some level of pretreatment by removing sediment, nutrients and other pollutants from runoff. A key feature of vegetated swales is that they can be integrated into the landscape character of the surrounding area. They can often enhance the aesthetic value of a site through the selection of appropriate native vegetation.

A vegetated swale typically consists of a band of dense vegetation, underlain by at least 24 inches of permeable soil. Swales constructed with an underlying 12 to 24 inch aggregate layer provide significant volume reduction and reduce the stormwater conveyance rate. The permeable soil media should have a minimum infiltration rate of 0.5 inches per hour and contain a high level of organic material to enhance pollutant removal. A nonwoven geotextile should completely wrap the aggregate trench (DEP, 2006). There are several variations of the vegetated swale that include installing perforated pipe under the swale to collect water that has filtered through the soil matrix and convey it to other stormwater facilities or combining the swale with an infiltration bed to provide additional infiltration volume.

EXTENDED DETENTION BASINS

Extended detention basins are created by constructed an earthen impoundment for temporary storage of runoff hydraulically attenuating peak rates. Detention basins are widely used to control the peak rates and have some water quality mitigation through settlement of suspended solids.

The basin outlet structure must be designed to detain runoff from the stormwater quality design storm for extended periods. A sediment foerbay consisting of a separate cell should be incorporated into the design to provide upstream pretreatment. The use of micro-pool storage is recommended for the water quality design storm. Flow paths from inflow points to outlets should be maximized.

IMPLEMENTATION OF STORMWATER MANAGEMENT CONTROLS

From a regulatory perspective, the standards and criteria developed in this Plan will be implemented through municipal adoption of the *Model Stormwater Management* developed as part of the Plan. The *Model Ordinance* contains provisions to realize the standards and criteria outlined in this section. Providing uniform stormwater management standards throughout the county is one of the stated goals of this Plan. This goal will be achieved through adoption of the *Model Ordinance* by all of the municipalities in McKean County.

From the pragmatic development viewpoint, the stormwater management controls will be put into practice through use of comprehensive stormwater management site planning and various stormwater BMPs. Site designs that integrate a combination of source reducing non-structural BMPs and runoff control structural BMPs will be able to achieve the proposed standards. A design example has been included in *Section VIII* and *Appendix B* to demonstrate how to incorporate the various aspects of the *Model Ordinance* into the stormwater management design process.

This page has been left blank intentionally.

Section VIII – Economic Impact of Stormwater Management Planning

IMPLEMENTATION OF STORMWATER STANDARDS

The economic impact of managing urban stormwater runoff is a major concern. For example, the U.S. EPA has estimated the costs of controlling combined sewer overflows (CSO) throughout the U.S. at approximately $56 billion (MacMullan and Reich, 2007). Developing and implementing stormwater management programs and urban-runoff controls will cost an additional $11 to $22 billion (Kloss and Calarusse, 2006). There are direct economic impacts associated with implementation of stormwater management regulations, regardless of the type of stormwater control standards that are proposed. The design example provided in this section has been developed to highlight a site design approach that can reduce the costs of employing the proposed stormwater management control measures and, at the same time, maximize the benefits which they are intended to provide. The design example is then compared to a similar site design that uses traditional peak rate stormwater controls in order to provide an illustration of the direct economic impact of the proposed regulations using initial construction costs.

Site planning that integrates comprehensive stormwater management into the development process from the initial stages often results in efficiencies and cost savings. Examples of efficiencies include reduction in area necessary for traditional detention basins, less redesign to retrofit water quality and infiltration measures into a plan, and reduced costs for site grading and preparation. Planning for stormwater management early in the development process may decrease the size and cost of structural solutions since non-structural alternatives are more feasible early in the process. In the vast majority of cases, the U.S. EPA has found that implementing well-chosen LID practices, like the proposed stormwater management methods, saves money for developers, property owners, and communities while protecting and restoring water quality (EPA, 2007).

DESIGN EXAMPLE 1

The following design example illustrates the methods used to design stormwater management facilities and structural BMPs in accordance with the volume and peak rate control strategies developed within this Plan. The design process encouraged by the *Pennsylvania Stormwater BMP Manual* is used to determine non-structural BMP credits and perform the calculations necessary to determine if the requirements of the *Model Ordinance* have been met. The 2-year design storm is utilized to illustrate the methods used to meet the volume requirements of the Ordinance. The SCS Runoff Curve Number Method is used for runoff volume calculations as suggested by the *Pennsylvania Stormwater BMP Manual* (2006). Refer to this document for additional guidance, rules and limitations applicable to these methods, and the design of structural and non-structural BMPs.

For the following example, Low Impact Design techniques are utilized to address the volume control and rate control requirements of the *Model Ordinance*. The example addresses these requirements for the entire development, not any single lot, thereby superseding the requirements of the *Small Project Stormwater Management Application*.

PRE-DEVELOPMENT CONDITIONS

The design example is a 10-lot single family residential subdivision on an 8.1 acre parcel with a total drainage area of 9.78 acres. The existing land use is partially wooded (2.29 acres) with a fallow agricultural field covering the remaining acreage. The entire site is tributary to Mill Run, which flows near the back of the property. All on-site soils are classified in hydrologic soil group B.

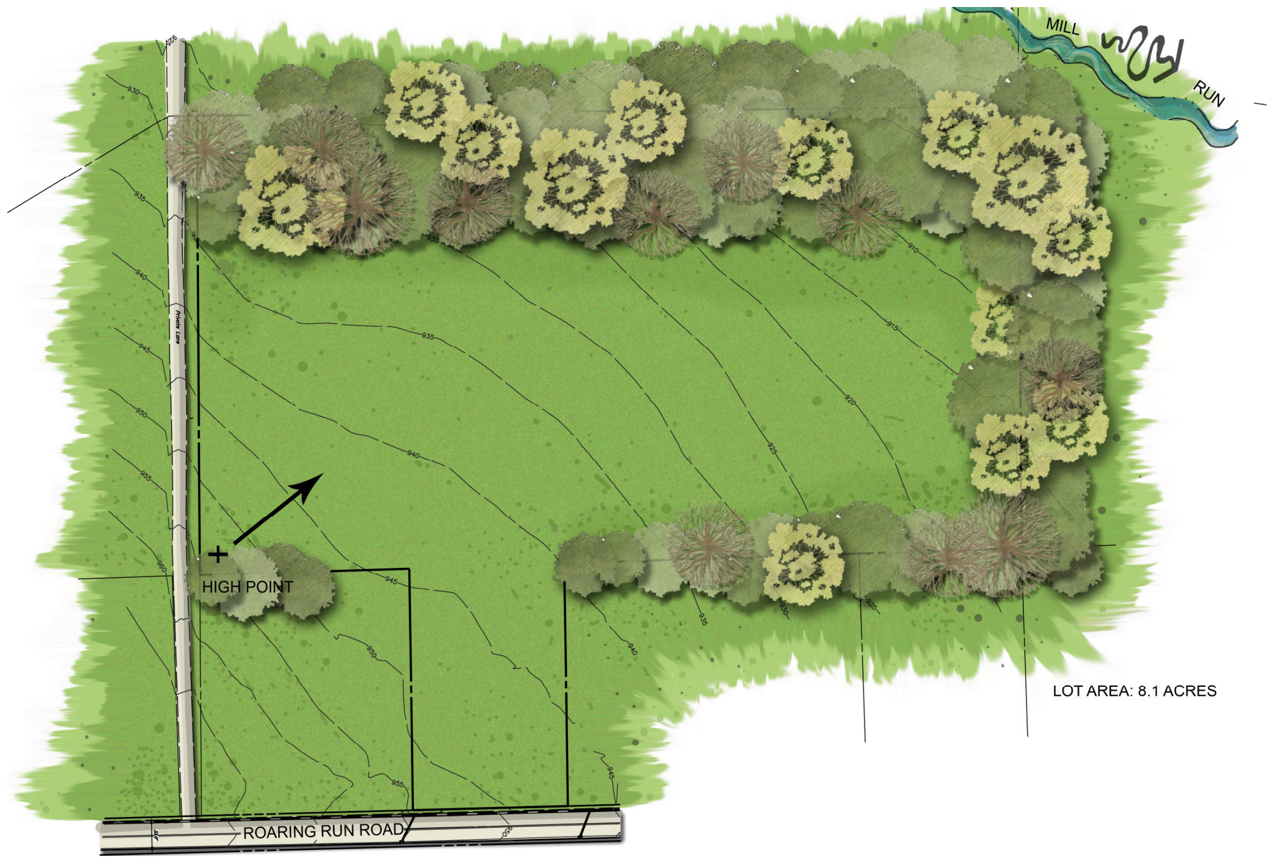


Figure 8.1. Design Example 1 – Pre-Development Conditions

Watershed:	Mill Run
Total Drainage Area:	9.78 acres
Existing Land Use:	Meadow = 7.49 acres
	Woods = 2.29 acres
Hydrologic Soil Group:	'B' – Entire Site
Parcel Size:	8.1 acres
On-Site Sensitive Natural Resources:	Woods (2.18 acres)
Pre-Development Drainage Area:	Meadow = 7.12 acres
	Woods = 0.98 acres
	Total = 8.10 acres

Table 8.1. Pre-Development Data

POST-DEVELOPMENT CONDITIONS

All of the lots will be accessed by a single cul-de-sac road to be constructed for the subdivision. Each house has an assumed 2,150-sf impervious footprint. Various low impact design techniques were used in the site design. A large portion of the existing woodlands (1.31 acres) was preserved during construction and will remain wooded through a permanent easement on lots 6-9, the back portion of lots 9-10 were protected from compaction during construction and will remain protected through an easement, roof drains are disconnected from the storm sewer system and directed to dry wells, and rain gardens will be installed on each lot. Runoff from the roadway is collected by swales and conveyed to a bioretention area.

Figure 8.2. Design Example 1 – Post-Development Conditions

Proposed Land Use:	Meadow = 1.61 acres
	Woods = 1.32 acre
	Open Space = 5.43 acres
	Impervious = 1.13 acres
	Ponds as Impervious = 0.31 acres
Protected Sensitive Natural Resources:	Woods (1.31 acre)
Other Protected Areas:	Minimum Disturbance (0.37 acre)
Post-Development Drainage Area:	SWM Area = 7.74 acres
	Undetained = 0.36 acres
	Total = 8.10 acres
Proposed Lot Impervious Areas:	2,150 ft^2 / house
	1,000 ft^2 / lot

Table 8.2. Post-Development Data

DESIGN PROCESS FOR VOLUME CONTROLS

The following is a summary of the design process used for implementation of the volume control and rate control requirements of the *Model Ordinance*. This is an outline of the sequence of steps that are used to implement the *Design Storm Method* through a combination of Non-Structural BMP Credits and Structural BMPs that remove volume through infiltration. Detailed calculations and example Worksheets are provided in *Appendix B* for additional clarification of the design process.

Step 1

The first task of the design process is to gather the pertinent site information as it relates to stormwater management. This general information determines which Ordinance provisions are applicable to the stormwater management design for the project. *Worksheet 1* is used for this task.

Step 2

The next step is to determine the sensitive natural resources that are present on the site. *Worksheet 2* is used to inventory these resources. These areas should be considered as the site layout is determined, and should be protected to the maximum extent practicable.

Step 3

As the site layout is being completed, thought should be given to which non-structural BMPs are appropriate for the site in order to reduce the need for stormwater management through structural BMPs. Once the site layout has been finalized and non-structural BMPs have been determined, the designer can begin the stormwater management calculations. The first calculation is to determine the "Stormwater Management Area". This is the land area which must be evaluated for volume of runoff in both pre-development and post-development conditions. Sensitive natural resources that have been protected are not used in the ensuing pre or post-development volume calculations, just as one would not incorporate offsite areas into volume calculations. The top of *Worksheet 3* shows this information. In the example, the acre of protected woodland is removed from the Stormwater Management Area. This will reduce cost by reducing the total volume needed in the peak-rate management facility.

Step 4

The next step is to calculate the volume "credits" for the non-structural BMPs that have been incorporated into the design. This reduces the total volume that is required to be infiltrated by structural BMPs. There are three practices used in the example, a meadow area and a lawn area have been protected from soil compaction and roof drains have been disconnected from the storm sewer system. The areas protected from compaction facilitate higher infiltration rates and disconnecting the roof leaders for the storm sewer system allows infiltration of some stormwater as it flows across the pervious surface. These calculations are completed on *Worksheet 3*.

The total non-structural credits are limited to 25% of the total required infiltration volume. This does not limit the amount of practices that can be implemented, only the amount of credit that can be used to reduce the total required infiltration volume. The total credits calculated must be checked to ensure the 25% threshold has not been exceeded.

Step 5

Worksheet 4 is completed to calculate the difference in the 2-year design storm runoff volume from pre-development conditions to post-development conditions. The 2-year volume increase, minus the volume credits for non-structural BMPs, represents the volume that must be managed through structural BMPs.

Step 6

Determine the type of structural BMPs that may be appropriate for the site and decide which practices will be used. Use *Worksheet 5.A* to calculate the volume of water that will be infiltrated by each BMP. Then, *Worksheet 5* is used to summarize the volume that will be infiltrated through structural practices. If the total structural volume is greater than (or equal to) the required volume, the volume control requirements of the *Model Ordinance* have been met.

Summary of Results

The design process outlined above was followed to design the facilities necessary to meet the volume control and peak rate control requirements of the *Model Ordinance*. The total required permanently removed volume is 12,599 ft^3. A summary of the results for Design Example 1 is provided in the table below:

Description of Stormwater Best Management Practice	Size (ft^3)	Volume Credit (ft^3)
Minimum Soil Compaction	16,200	337
Disconnect Non-Roof Impervious to Vegetated Areas	10,000	278
Total Non-Structural Volume:		615
On-Lot Rain Gardens (10)	6,740	5,049
On-Lot Dry Wells (10)	4,400	5,787
Bioretention	5,175	3,778
Total Structural Volume:		14,613
Total Volume Removed:		**15,228**

Table 8.3. Summary of BMP Credits

DESIGN OF PEAK RATE CONTROLS

In this example, additional stormwater control facilities are necessary to manage the increase in peak rate flows that would otherwise result from the development activities. Peak rate control facilities are designed to reduce post-development peak flows to, or below, pre-development peak flows. In release rate districts, post-development flows are further reduced to a given percentage of the pre-development peak flows. Design of peak rate controls necessitates flood routing, for which a flood hydrograph is required (PennDOT, 2008). A suitable hydrologic method is needed to generate runoff hydrographs for flood routing.

The Rational Equation (i.e., Q = C x I x A) was originally developed to estimate peak runoff flows. The Modified Rational Method is an adaptation of the Rational Method which is used to estimate runoff hydrographs and volumes. While, this method is useful for estimating peak flows from relatively small, highly developed drainage areas, various sources document the shortcomings of this method in developing hydrographs and estimating volume (PennDOT, 2008, DEP 2006). For this reason, use of the Rational Method is strongly discouraged for the volume-sensitive routing calculations necessary tor design detention facilities and outlet controls.

The SCS Unit Hydrograph Method was developed to be used in conjunction with the Curve Number Runoff Method of generating runoff depths to estimate peak runoff rates and runoff hydrographs. While these methods have numerous limitations, the principal application of this method is in estimating runoff volume in flood hydrographs, or in relation to flood peak rates (NRCS, 2008). Therefore, the NRCS Rainfall-Runoff Method (i.e. using the Curve Number Runoff Method and SCS Unit Hydrograph Method together to produce rainfall-runoff response estimates) is the preferred method to calculate runoff peak rates and for rate control facility design calculations.

Various computer software programs are available for modeling rainfall-runoff simulations to perform peak rate control analyses for development projects. Most of the available computer modeling software is based on the NRCS Rainfall-Runoff Method. These models include the U.S. Army Corps of Engineers' Hydrologic Modeling System (HEC-HMS), SCS/NRCS Technical Release No. 20: Computer Program for Project Formulation Hydrology (TR-20) and Technical Release 55 (TR-55), NRCS National Engineering Handbook 650, Engineering Field Handbook, Chapter 2 (EFH2), and U.S. Environmental Protection Agency's Storm Water Management Model (SWMM). These modeling packages are further described in the *Pennsylvania Stormwater BMP Manual* (2006). There are also a variety of other commercially available software packages that complete many of the same functions. Designers should be careful when determining which software should be used to model a particular project to ensure that appropriate methods are being used (i.e., review the modeling method restrictions contained in the *Model Ordinance*).

DESIGN PROCESS FOR PEAK RATE CONTROLS

The peak rate analysis is carried out by completing a comparison of the post-development runoff peak rate to the pre-development runoff peak rate to determine if the rate controls of the *Model Ordinance* have been satisfied. Additional stormwater facilities, such as a detention basin and outlet structure, may be necessary to reduce post-development peak flow rates to the required peak flow rates. The volume of runoff removed by BMPs should be removed from the total runoff volume when completing peak rate calculations. This is necessary in order to size peak rate control facilities appropriately.

Step 1

The first step is to delineate the pre-development drainage area. This area should include all areas that will be tributary to any proposed stormwater facilities, including any off-site area. Any areas on site that have no proposed land-use changes, and are not tributary to the proposed stormwater facilities, can be removed from the drainage areas. Once the drainage area has been delineated, determine the soil-cover complex and the corresponding curve number for each subarea. If the drainage area contains multiple soil-cover complexes, the designer must determine the appropriate runoff estimation method. (A comparison of the two most prevalent methods is covered in *Appendix B*).

Step 2

The next step is to determine a time of concentration for the pre-development drainage area(s). The *Model Ordinance* requires use of the NRCS Lag Equation for all pre-development time of concentration calculations unless another method is pre-approved by the Municipal Engineer. The average watershed land slope of the pre-development drainage area(s) must be calculated for use in the Lag Equation.

Step 3

Use the information from the previous two steps to calculate the pre-development peak runoff rates for each design storm. Use design storm rainfall depths from NOAA Atlas 14 specific to the area of interest, or the values provided in the *Model Ordinance*. Any appropriate method of estimating peak runoff rates and runoff hydrographs can be used, however use of hydrologic modeling software is the most common method.

Step 4

Delineate the post-development drainage area(s) and any sub-areas. Post-development sites generally have several drainage sub-areas with multiple soil-cover complex groups in each subarea. The designer must determine a suitable level of detail to be included in the post-development model based on the site design and site conditions. The runoff estimation method chosen for multiple soil-cover complexes should be appropriate for the level of detail that is modeled.

Step 5

Determine time of concentration values for the post-development drainage area(s). The NRCS Segmental Method is the preferred method for all post-development time of concentration calculations. The Segmental Method is used to calculate travel times for individual segments of sheet flow, shallow concentrated flow, and open channel flow which are summed to calculate the time of concentration. The *Model Ordinance* allows the NRCS Lag Equation to be used for residential, cluster, or other low impact designs less than or equal to 20% impervious area.

Step 6

Use the information from the previous two steps and relevant stormwater facility information (e.g. BMP size and outlet configuration, detention facility stage-discharge data, etc.) to calculate the post-development peak runoff rates for each design storm. This is most often done by using hydrologic modeling software to develop a model of the post-development site which is used to estimate peak runoff rates and runoff hydrographs.

The hydrologic model is used to finalize the design of the peak rate control facilities such as the detention basin and the outlet control structure. Steps 4-6 must be revisited whenever additional BMPs are added, or moved, or any change to the site design alters drainage areas.

Summary of Results

For this example, the peak rate control analysis was completed with hydrologic modeling software that is based on TR-20 modeling procedures. Every component of the stormwater design (including each structural BMP) was included in the model. This helped account for peak flow attenuation and permanent volume removal that was provided by the BMPs. The runoff volume removed by the BMPs was removed from the total runoff volume by using an option within the software. A detention basin providing 8,600 ft^3 of storage (plus the required freeboard depth) and associated outlet controls were necessary to reduce the 100-year post-development peak rate flows to the pre-development flow rate. If the effects of the individual BMPs had been ignored in the post-development model, the design would have needed a basin that provided 23,850 ft^3 of storage (plus the required freeboard depth) to achieve the required flow reduction for the 100-year storm. As shown in *Table 8.4* the peak rate control requirements of the *Model Ordinance* have been achieved.

	Design Storm					
	1-year	**2-year**	**10-year**	**25-year**	**50-year**	**100-year**
Pre-Development	0.1	0.6	4.1	7.6	11.1	15.3
Post-Development with No SWM	2.5	5.2	14.5	21.9	28.8	36.6
Post-Development	0.1	0.4	4.1	7.4	10.6	15.3

Table 8.4. Summary of Peak Rate Flows

ECONOMIC IMPACT OF STORMWATER MANAGEMENT STANDARDS

Stormwater management standards are necessary to mitigate the adverse affects of increased stormwater runoff from developing areas. Implementation of these standards comes at a cost to regulators and developers alike. However, these costs are only a fraction of the costs associated with mitigating mis-managed or un-managed runoff. Since activities within a watershed do not always exhibit a direct and measurable cause and effect relationship, identifying some of the costs associated with stormwater management can be difficult and somewhat subjective. It can be similarly difficult to quantify certain costs and altogether impossible to assign an economic value to outcomes such as environmental benefits.

There are three principal methods available to assess the economics of implementing the proposed stormwater management regulations:

1. <u>Cost Comparison</u> – This is the most basic type of analysis. It is completed by comparing initial construction costs and other direct costs such as land value. This type of analysis is incomplete in scope in that it does to capture the benefits of improved stormwater management or variances in life-cycle costs such as operation and maintenance and life expectancy.

2. <u>Life-Cycle Cost Analysis</u> – A life-cycle cost analysis includes all costs throughout the projects period of service. This includes planning, design, installation, operation and maintenance and life expectancy. A life-cycle analysis gives a more complete financial comparison than a cost comparison, but again excludes the environmental and other benefits of improved stormwater management.

3. <u>Cost-Benefit Analysis</u> – This is the most thorough method of analysis and considers the full range of costs and benefits for each alternative. A cost-benefit analysis considers the same project costs as a life-cycle analysis, but includes the environmental and other benefits of improved stormwater management practices in the assessment. This method of analysis is very difficult because it requires valuation of costs and benefits which are not easily measured in monetary terms (i.e. environmental goods and services such as clean air, reduced erosion, or improved aquatic habitat). It is difficult to quantify the value of these non-market goods and services.

The amount of information required to perform a life-cycle cost or cost-benefit analysis makes use of these two methods impractical for this discussion. These methods are also complicated by the fact that costs and benefits are often realized by different parties. As an example, a developer/owner pays for initial construction costs, the owner can benefit from potential life-cycle cost savings, and the general public benefits from potential environmental benefits such as improved water quality. The flexibility, availability of data, and simplicity of cost comparisons make this the most commonly used method of comparison. A cost comparison will give a relatively accurate representation of the economic impact of the initial cost of implementing the proposed stormwater management controls.

A cost comparison has been completed for two conceptual stormwater management designs to provide an example of the direct costs associated with implementation of the standards contained within this Plan. The stormwater designs are based on the site used in the Design Example. The site layout is similar for both designs to reduce the number of variables. The first plan was designed to meet traditional peak-rate stormwater management standards of reducing the post-development peak flow rates to those present in pre-development conditions for all design storms. The second plan follows the design procedures found in this Plan and meets the volume control requirements of the *Model Ordinance*.

TRADITIONAL SUBDIVISION LAYOUT WITH PEAK RATE CONTROL DESIGN

The layout for this example is typical of conventional subdivision designs. All of the existing woodlands were converted to lawns and no measures were taken to reduce impervious area (e.g. front yard setbacks were not reduced to decrease driveway lengths). The roadway has a 24' cartway with concrete curbs, and there is a sidewalk on one side of the street. The traditional cul-de-sac is entirely paved. The stormwater design utilizes a conventional stormwater collection and conveyance system that uses the concrete curb to direct runoff towards inlets, and an HDPE pipe network carries runoff to a detention basin which is located at the low point on the property. A swale is placed near the downstream edge of the property to collect runoff that is not tributary to the storm sewer network and convey it to the detention basin. In the detention basin, a concrete outlet structure is designed to reduce peak flow rates before discharging to an outlet pipe. A rock rip-rap apron energy dissipater is installed at the pipe outfall.

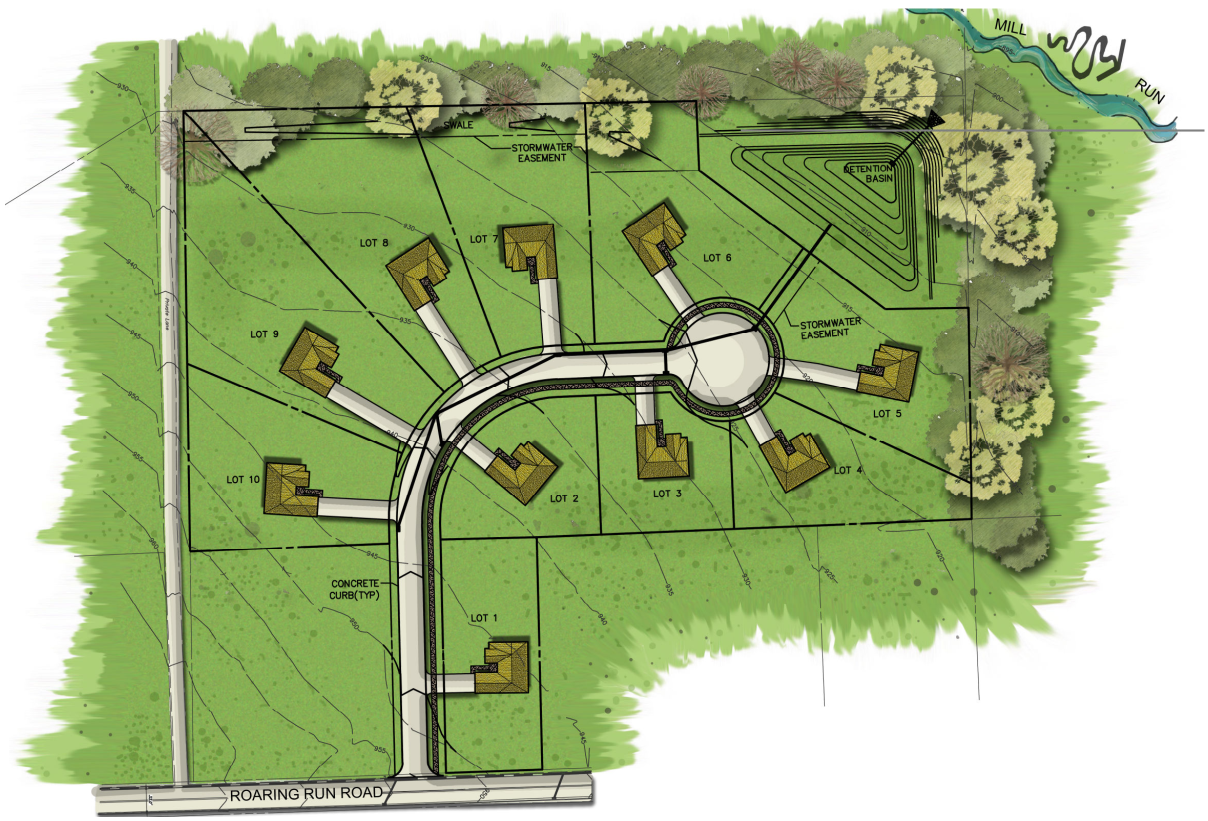


Figure 8.3. Traditional Subdivision Layout (Designed for Peak Rate Control)

LID SUBDIVISION LAYOUT WITH VOLUME CONTROL DESIGN

This design is the post-construction layout that was presented in the Design Example (see *Figure 8.2*). Several LID techniques were used to reduce runoff. This includes reducing impervious area, preserving existing woodlands where possible, and protecting areas from soil compaction. The roadway is reduced to an 18' cartway with 3' gravel shoulders and swales are employed to collect and convey roadway runoff. Roof runoff is directed to dry wells on each lot, rain gardens are installed on each lot to collect the runoff from on-lot impervious areas as well as part of the lawn runoff. A larger bioretention facility is used to treat runoff from common areas such as the roadway and remove additional runoff volume. A detention basin and concrete outlet structure is used to control the peak discharge rates. A level spreader installed at the end of the outfall serves as an energy dissipater and distributes flow.

COST COMPARISON

A cost comparison was completed for the two designs described above. This comparison consists of two components: 1) initial construction costs for the developer, and 2) land value in the form of sale price. Construction costs were calculated for only the design elements which differ between the two examples (i.e. earthwork, paving, and stormwater management facilities). Other construction costs were considered to be similar for both layouts and were omitted from the analysis. An itemized estimate of the initial construction cost is included in *Appendix* B. The results are summarized in *Table 8.5*.

Description	Traditional Layout	LID Layout
Earthwork	$ 23,950	$ 14,925
Storm Drainage	$ 102,769	$ 114,172
Paving & Curbing	$ 138,657	$ 53,790
Initial Construction Cost:	$ 265,376	$ 182,887
Cost / Sellable Acre:	$ 42,734	$ 28,355

Table 8.5. Results of Cost Comparison for Initial Construction Costs

The cost analysis performed for this example shows a cost savings of $14,379 per sellable acre in initial construction cost for the developer. These results must be combined with a land value comparison to provide a more accurate comparison.

The value of land is highly variable depending on various influencing factors. A value of $50,000/acre was assumed for this example as the cost per acre of developed land. This assumed value was used in the cost comparison to provide a more complete cost comparison. For this example, we have also assumed that some of the cost of constructing the stormwater BMPs will result in a dollar for dollar reduction in the market value of the sellable land. *Table 8.6* shows the total land sale value for each layout after subtracting the cost of BMP construction from market value.

Description	Traditional Layout	LID Layout
Total Acres For Sale	6.21	6.45
2009 Market Value / Acre	$ 50,000	$ 50,000
BMP Cost / Acre	$ 0	$ 12,682
Calculated Market Value / Acre	$ 50,000	$ 37,318
Total Land Sale Value:	$ 310,500	$ 240,701

Table 8.6. Land Sale Value

A final cost comparison is completed by subtracting the initial construction cost from the land sale value to determine the cost difference between the two layouts. For this example, the developer realizes an increase in total profit of $12,690 by using the LID layout with no additional cost to individual homeowners.

Description	Traditional Layout	LID Layout
Land Sale Value	$ 310,500	$ 240,701
Initial Construction Cost	$ 265,376	$ 182,887
Total Profit for Project:	$ 45,124	$ 57,814

Table 8.7. Project Profit

Discussion of Costs

The cost comparison completed for the design example resulted in similar initial construction costs for each design, with a small final cost advantage for the volume control design. The proposed methods for implementing the proposed stormwater standards can cost less to install, have lower operations and maintenance (O&M) costs, and provide more cost-effective stormwater management and water quality services than conventional stormwater management controls (MacMullan and Reich, 2007). However, the costs and benefits of implementing the proposed stormwater management standards can be very site specific and will vary based on the BMPs used to meet the standards and site characteristics such as topography, soils, and intensity of the proposed development. In a 2007 report summarizing 17 case studies of developments that include LID practices, U.S. EPA concludes that "applying LID techniques can reduce project costs and improve environmental performance". The report shows total capital cost savings ranged from 15 to 80 percent when LID methods were used, with a few exceptions in which LID project costs were higher than conventional stormwater management costs. All benefits and costs associated with each option must be considered to find the true cost of implementation on a particular site.

Section IX – Water Quality Impairments and Recommendations

The Clean Water Act is a series of federal legislative acts that form the foundation for protection of U.S. water resources. These include the Water Quality Act of 1965, Federal Water Pollution Control Act of 1972, Clean Water Act of 1977, and Water Quality Act of 1987. The goal of the Clean Water Act is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters". Section 305(b) of the Federal Clean Water Act requires each state to prepare a Watershed Assessment Report for submission to the United States Environmental Protection Agency (EPA). The reports include a description of the water quality of all waterbodies in the state and an analysis of the extent to which they are meeting their water quality standards. The report must also recommend any additional action necessary to achieve the water quality standards, and for which waters that action is necessary.

Section 303(d) of the Act requires states to list all impaired waters not meeting water quality standards set by the state, even after appropriate and required water pollution control technologies have been applied (EPA, 2008a). The law also requires that states establish priority rankings for waters on the list and develop Total Maximum Daily Loads (TMDLs) for these waters. A TMDL is the maximum amount of pollutant that a water body can receive and still safely meet the state's water quality standards for that pollutant. TMDLs are a regulatory tool used by states to meet water quality standards in impaired waterbodies where other water quality restoration strategies have not achieved the necessary corrective results.

IMPAIRED STREAMS

Pursuant to the provisions of the Clean Water Act, DEP has an ongoing program to assess the quality of waters in Pennsylvania and identify streams, and other bodies of water, that are not attaining designated and existing uses as "impaired". Water quality standards are comprised of the uses that waters can support, and goals established to protect those uses. Each waterbody must be assessed for four different uses, as defined in DEP's rules and regulations:

1. Aquatic life,
2. Fish consumption,
3. Potable water supply, and
4. Recreation

The established goals are numerical, or narrative, water quality criteria that express the in-stream levels of substances that must be achieved to support the uses. This assessment effort is used to support water quality reporting required by the Clean Water Act. DEP uses an integrated format for the Clean Water Act Section 305(b) reporting and Section 303(d) listing in a biennial report called the "Pennsylvania Integrated Water Quality Monitoring and Assessment Report". The narrative report contains summaries of various water quality management programs including water quality standards, point source control and nonpoint source control. In addition to the narrative, the water quality status of Pennsylvania's waters is presented using a five-part characterization of use attainment status (DEP, 2008). The listing categories are:

Category 1: Waters attaining all designated uses.

Category 2: Waters where some, but not all, designated uses are met. Attainment status of the remaining designated uses is unknown because data are insufficient to categorize the water.

Category 3: Waters for which there are insufficient or no data and information to determine if designated uses are met.

Category 4: Waters impaired for one or more designated use but not needing a total maximum daily load (TMDL). These waters are placed in one of the following three subcategories:

Category 4A: TMDL has been completed.

Category 4B: Expected to meet all designated uses within a reasonable timeframe.

Category 4C: Not impaired by a pollutant and not requiring a TMDL.

Category 5: Waters impaired for one or more designated uses by any pollutant. Category 5 includes waters shown to be impaired as the result of biological assessments used to evaluate aquatic life use. Category 5 constitutes the Section 303(d) list submitted to EPA for final approval.

MCKEAN COUNTY IMPAIRMENTS

If a stream segment is not attaining any one of its designated uses, it is then considered to be "impaired". *Figure 9.1* shows the non-attaining stream segments in McKean County and identifies the primary source of the impairment listing.

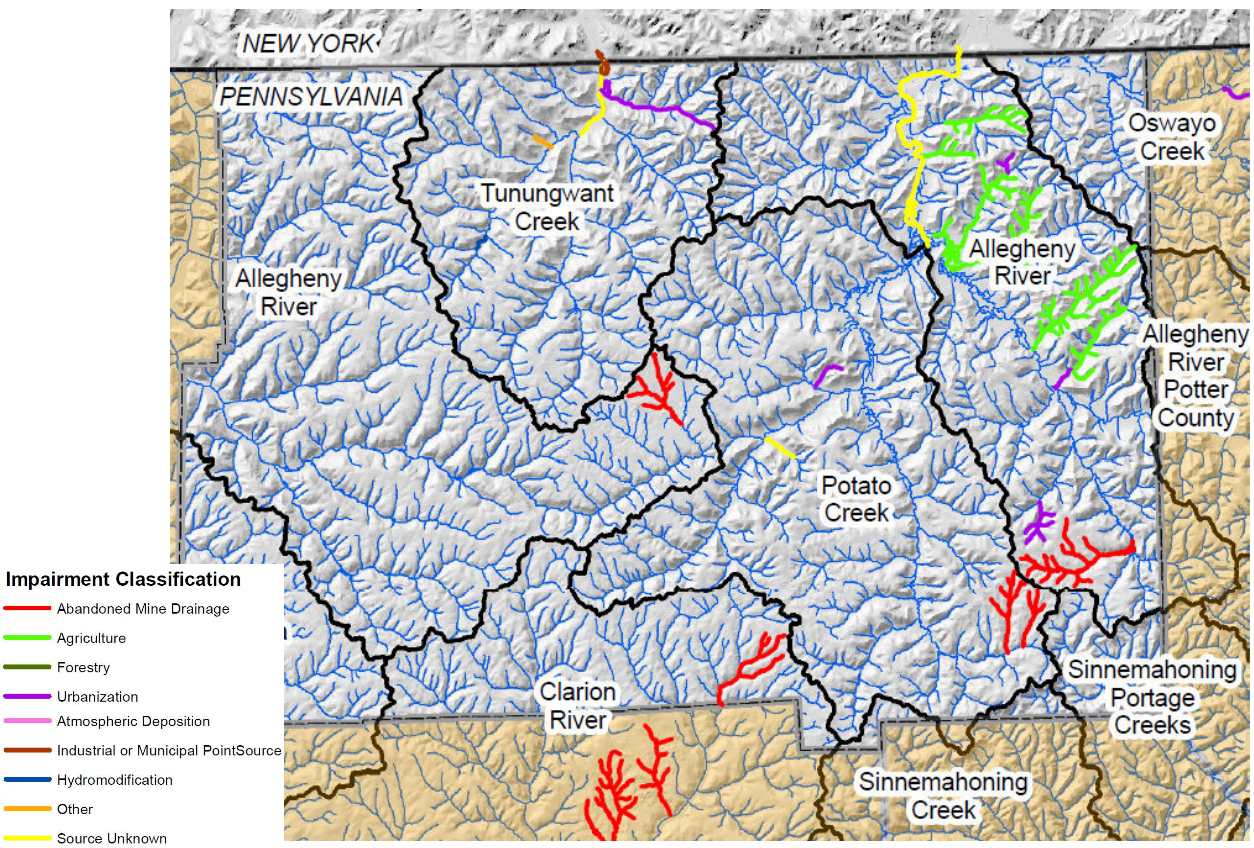


Figure 9.1. Impaired Stream Segments in McKean County

In McKean County, the non-attaining streams were primarily listed for Aquatic Life use attainment, which is reflective of any component of the biological community (i.e. fish or fish food organisms). A few segments are listed as non-attaining for fish consumption hazard due to mercury from unknown sources. The source-cause of impairment varies from stream to stream. Oftentimes, there are multiple source-causes attributed for impairment of a particular stream segment. *Table 9.1* shows a summary of the primary source of impairment in each Act 167 Designated Watershed within the county. This table does not reflect streams that have multiple source-causes of impairment.

		Act 167 Watersheds (stream miles where not indicated) →										
Classification	**Category**	**Allegheny River**	**Allegheny River Potter County**	**Clarion River**	**Oswayo Creek**	**Potato Creek**	**Sinnemahoning Creek**	**Sinnemahoning Portage Creeks**	**Tionesta Creek**	**Tunungwant Creek**	**Entire County**	**Percent of County**
Impaired (miles)	Abandoned Mine Drainage	26.3	--	10.6	--	15.0	--	--	--	1.7	53.5	2.0
	Agriculture	63.9	--	--	--	--	--	--	--	--	63.9	2.4
	Atmospheric Deposition	--	--	--	--	--	--	--	--	--	0.0	0.0
	Forestry	--	--	--	--	--	--	--	--	--	0.0	0.0
	Hydromodification	--	--	--	--	--	--	--	--	--	0.0	0.0
	Industrial or Municipal Point Source	--	--	--	--	--	--	--	--	4.0	4.0	0.2
	Urbanization	7.1	--	--	--	2.1	--	--	--	8.2	17.4	0.7
	Source Unknown	16.2	--	--	--	1.4	--	--	--	3.4	21.0	0.8
	Other	--	--	--	--	--	--	--	--	1.0	1.0	0.0
	Total Impaired	113.4	0.0	10.6	0.0	18.4	0.0	0.0	0.0	18.3	160.8	6.2
	Percent of Total	9.9	0.0	5.3	0.0	3.0	0.0	0.0	0.0	5.8	6.2	6.2

Table 9.1. Summary of Impaired Segments by Watershed

TMDL DISCUSSION

Once a waterbody is listed on the EPA approved 303(d) list, it is required to be scheduled for development of a TMDL. TMDLs are expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a water quality standard. They can be developed to address individual pollutants or groups of pollutants, if it is appropriate for the source of impairment.

A TMDL must identify the link between the use impairment, the cause of the impairment, and the load reductions needed to achieve the applicable water quality standards. However, a precise implementation plan is not part of the approved TMDL. A TMDL is developed by determining how much of the pollutant causing the impairment can enter the waterbody without exceeding the water quality standard for that particular pollutant. The calculated pollutant load is then distributed among all the pollutant sources as follows:

$$TMDL = WLA + LA + MOS$$

Where: TMDL = Total Maximum Daily Load

WLA = Waste Load Allocation; from point sources such as industrial discharges and wastewater treatment plants

LA = Load Allocation; from nonpoint sources such as stormwater, agricultural runoff and natural background levels

MOS = Margin of Safety

TMDL's are developed by the State and submitted to EPA for review and approval. Once a TMDL has been approved, it becomes a tool to implement pollution controls. It does not provide for any new implementation authority. The point source component of the TMDL must be implemented through existing federal programs with enforcement capabilities (e.g. National Pollution Discharge Elimination System, NPDES). Implementation of the Load Allocations for nonpoint sources can happen through a voluntary approach, or by means of existing state or local regulations.

There are currently no waterbodies with approved TMDLs in McKean County.

CRITICAL SOURCES OF IMPAIRMENT

The primary causes of water quality impairment are sediment/siltation, nutrients, metals, and pathogens. Nonpoint source (NPS) pollution is a general term for water pollution generated by diffuse land use activities rather than from an identifiable or discrete facility. In Pennsylvania the leading nonpoint sources of impairment are:

- Abandoned Mine Drainage (AMD)
- Agriculture
- Urban Runoff/Storm Sewers
- Road Runoff
- Forestry
- Small Residential Runoff
- Atmospheric Deposition

Some of these sources are regulated by stormwater ordinances and have been covered in previous section. However, several of these categories are more appropriately addressed by other regulations. Although these activities cannot be regulated by the provisions within the stormwater management ordinance of this Plan, they play a major role in the water quality of surface waters. The following is a summary of the nonpoint sources and causes for impairment that affect McKean County waters:

AGRICULTURAL ACTIVITIES

Agricultural land use has many beneficial effects on a landscapes response to rainfall and properly managed agricultural activities provide many positive environmental benefits. However, when improperly managed, these activities can cause significant degradation of water quality. Agricultural activities that can cause NPS pollution include confined animal facilities, grazing, plowing, pesticide spraying, irrigation, fertilizing, planting, and harvesting. The major pollutants that result from these activities are sediment and siltation, nutrients, pathogens, and pesticides. Agricultural activities can also damage habitat and stream channels.

SEDIMENT/SILTATION

The most common agricultural cause for surface water impairment is sediment and siltation. Of the 160.8 miles of impaired streams in McKean County, sediment/siltation is attributed for all 63.9 miles of impairments attributed to agricultural activities. This pollutant results from typical agricultural practices such as plowing and tilling, livestock grazing, and livestock access to waterbodies. When appropriate conservation practices are implemented, these activities can be continued while reducing erosion and enhancing and protecting water quality.

Controlling sheet and gully erosion is the first step in addressing siltation impairments. The majority of erosion problems are a result of plowing and tilling activities and concentrated livestock areas. In Pennsylvania, a written Erosion and Sediment Control Plan is required for all agricultural plowing or tilling activities that disturb 5,000 square feet or more of land. The implementation and maintenance of erosion and sediment control BMPs to minimize the potential for accelerated erosion and sedimentation is also a requirement for all agricultural activities regardless of disturbed area. In addition to reducing sediment pollution, controlling erosion also decreases the transport factors for other pollutants such as nutrients and pesticides.

ABANDONED MINE DRAINAGE (AMD)

Contaminated water seeping from abandoned coal mine areas (commonly known as abandoned mine drainage, or AMD) is the most prevalent and severe water pollution problem in Pennsylvania. AMD, impairing nearly 54 miles of surface waters within the county, is the second leading cause of impairment in McKean County. Impacting one-third (33.3%) of the impaired waters within the county, AMD is, by far, the principal impairment concern. Abandoned mine sites have left dangerous highwalls, open pits, coal refuse spoil piles, old mine openings, and miles of streams polluted by abandoned mine drainage. Past coal mining practices have led to erosion, landslides, polluted water supplies, destruction of fish and wildlife habitat, and an overall reduction in natural beauty.

Vast bituminous coal deposits underlie western and north-central Pennsylvania, including McKean County. The Pennsylvania bituminous industry peaked in 1918 when the industry started to encounter rising competition from other states and shrinking markets due to competing fuel sources such as petroleum and natural gas. This began a long-term decline in Pennsylvania's coal industry that continues today. Bituminous coal was primarily mined through surface mining techniques or "strip mining". Through this process, the overburden (soils and other bedrock layers) is removed and relocated to expose the coal for extraction. Although this method was usually cheaper, it caused severe environmental problems that went unregulated until state law required land restoration in 1963. Years of coal mining that was conducted before the regulation of the industry, and a sharp decline in production, have left behind a multitude of abandoned mine sites that host a variety of environmental and safety issues.

Many strip mines were not backfilled or re-vegetated, allowing water to infiltrate through acidic spoil, settle into impoundments and contaminate groundwater supplies. Strip mine activities often removed the outcrop barrier allowing groundwater to flow unimpeded to the surface over the old strip pit. The refuse produced from mining activities (consisting of high sulfur material) was usually just stockpiled, another source of pollution. The problems caused by Abandoned Mine Sites can be classified in several categories:

> SAFETY PROBLEMS - Abandoned mine land (AML) sites have contributed to deaths in several states. Highwalls, open shafts, dilapidated mine structures, and water-filled pits present serious health and safety threats.
>
> ECONOMIC PROBLEMS - These lands are often located in the most economically depressed areas of our nation. All that remains in many once populated mining communities are scarred lands and a few residents who are willing to commute to larger cities for employment. The AML sites make it difficult to compete for industry and tourism.
>
> AESTHETIC PROBLEMS - The sparse vegetation (if any), stagnant water and illegal trash dumps characterization of AML sites have a negative effect on everyone. The appearance of the site tends to depress land value and detract from the tax base. The environmental scars contribute to an apathetic attitude toward the condition of these areas.
>
> WATER PROBLEMS - Acid run-off and sedimentation from abandoned mine sites contaminate thousands of miles of streams nationwide. This contaminated water eventually serves as potable water supply; therefore, an increase in water treatment costs is needed. Acid mine drainage also leads to increased road maintenance costs, due to the corrosive effects of this drainage on culverts. Streams and drainage systems are often clogged by sedimentation from abandoned mine sites, which, in turn, may cause flooding as a secondary result.

Pennsylvania has an estimated 2,500 miles of streams polluted by acid mine drainage; 250,000 acres of unreclaimed surface mine land; 100 million cubic feet of burning coal refuse; and potential subsidence problems for hundreds of thousands of acres (DEP, 1996). The majority of AMD water related problems are a product of the reaction between a metal sulfide (often pyrite), water, and oxygen. A series of chemical reactions occur when these three elements are present, resulting in contaminants such as ferrous iron, ferric iron, and hydrogen (H^+) ions which increase the acidity of water.

There are 76 un-reclaimed AML Features in McKean County, which cover 822 acres (DEP, 2010). As shown in *Figure 9.1*, AML features in the county are prevalent in several localized areas.

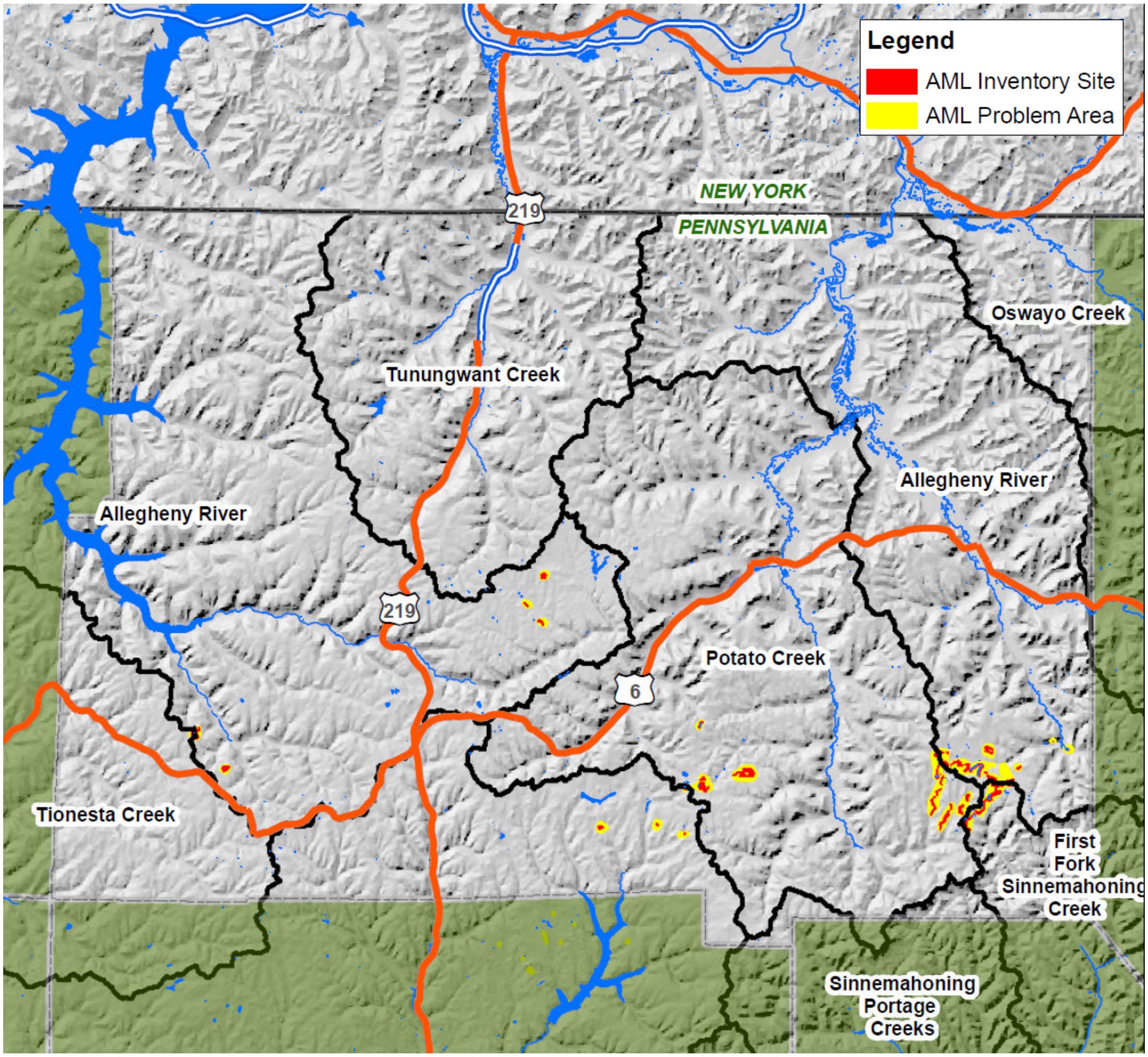


Figure 9.1. McKean County Abandon Mine Land Features

ACIDITY (pH)

Healthy streams, as measured by biodiversity indicators, generally have a pH close (i.e. within one point) to neutral (pH = 7). As the pH drops below 6, the aquatic life diversity within the waterbody decreases as acid intolerant species either die off and other species begin to loose their food supply. **Because pH is measured on a logarithmic scale, each declining unit represents 10 times more acidity.** In AMD impaired waters, oxidation of metal sulfides results in an increase in H^+ ions. As the presence of H^+ ions increase the water becomes more acidic (i.e. the pH becomes lower). Extremely acidic mine waters have been documented with pH values as low as -3.6 (Nordstrom et al., 2000). While this level of extreme acidity is rare, most streams impacted by AMD have some degree of impairment cause by low pH.

METALS

Abandoned mine drainage often contains high concentrations of metals. As the acidity of water increases, more metals (iron, copper, zinc, etc.) can be dissolved from the rocks and go into solution in the water. AMD from coal mines typically contains elevated levels of iron and aluminum, although other metals including manganese and zinc may also be present. Waters with excessive amounts of dissolved metals can be toxic to aquatic organisms.

In addition to dissolved metals, metal precipitates become problematic downstream as AMD mixes with other water sources and in-stream acidity levels decrease. Iron and other metals precipitates out of solution as the pH of the water increase. This metal precipitate, sometimes referred to as "yellowboy", forms the characteristic red, orange, or yellow sediments often seen in the bottom of streams containing mine drainage. Metals degrade water quality and limit the beneficial uses of the surface waters. Beneficial uses that may be affected extend beyond aquatic life support to impact human activities that include drinking water supply, swimming, fishing, and other recreation.

SILTATION AND SUSPENDED SOLIDS

Abandoned mine drainage can result in different forms of suspended solids in receiving waters. Accelerated overland erosion often occurs in mine areas due to vast areas that are unstabilized by vegetation. These areas often remain for many years after active mining operations cease due to the unfavorable conditions for vegetative growth. Erosion of these areas discharges sediment and fine silt particles into receiving streams. Other suspended solids include metal precipitates formed through the chemical processes of oxidation as previously described.

Elevated levels of suspended solids can have a direct negative impact on aquatic species, as well as leading to increased stream temperatures as darker particles absorb heat (EPA, 1997). As water temperatures rise, dissolved oxygen levels (which are critical for many aquatic species) decrease. These changes caused by sediment and siltation are all substantial contributors to aquatic life impairments.

URBANIZATION

Accounting for almost 47% of the listed impaired waters, urbanization is the leading cause of surface water impairment in the county. This is a broad category that includes the following three critical sources of impairment listed earlier in this section: 1) Urban Runoff/Storm Sewers, 2) Road Runoff, and 3) Small Residential Runoff. These sources have been grouped together because they are all types of urbanization, or human development activities. When development activities replace forests, fields, and meadows with impervious surfaces the landscape's capacity for initial abstraction is greatly reduced and surface runoff increases. This topic has been the focus of this Plan. The quantity of runoff from urbanized areas, and the water quality characteristics of the runoff, are the two base causes of surface water impairments. These two primary pollutants translate into surface water impairments in several different forms.

SEDIMENT/SILTATION

As stormwater flows over land it collects silt and sediment and carries them to surface waters. Urbanization decreases the opportunity for natural filtration of runoff through vegetation and often concentrates flow in discharges that cause increased overland erosion. The increased rate of stormwater flow and increased sediment load delivered to the stream combine to raise the in-stream energy. This in turn changes the physical structure of the receiving streams by causing increased bank erosion as well as scour of the streambed and sedimentation when the water finally slows down. Increased sediment loading in a stream contributes to increased total suspended solids and turbidity, which can in turn lead to increased stream temperatures as darker particles absorb heat (EPA, 1997). As water temperatures rise, dissolved oxygen levels (which are critical for many aquatic species) decrease. These changes caused by sediment and siltation are all substantial contributors to aquatic life impairments.

HABITAT ALTERATIONS

Natural channels are composed of alternating sequences of pools, riffles, and runs. The diverse characteristics of each of these features provide unique habitats that allow various aquatic species to live, feed, and reproduce (EPA, 2007). The elevated stream power that occurs when additional runoff and sediment loading are experienced causes physical alterations to the stream channel. The increased energy carries large debris downstream, erodes streambeds and banks, creates scour holes at existing structures, and deposits new sediment in the channel as flows subside. These changes can drastically alter the structure of pools, riffles, and runs and eventually diminish the quality of the habitat to a point where the stream can long longer support aquatic life.

NUTRIENTS AND METALS

As runoff flows over impervious surfaces it picks up various pollutants and transports them to waterbodies. This includes oil and grease from automobiles; fertilizers, herbicides and pesticides from lawns; fecal matter from pet waste and malfunctioning septic tanks; chlorides from winter road maintenance; and heavy metals from tires, shingles, paints, and metal surfaces. These pollutants degrade water quality and limit the beneficial uses of the surface waters. Beneficial uses that may be impacted include drinking water supply, swimming, fishing, other recreation, and aquatic life support.

RECOMMENDATIONS

Addressing water quality impairments is achieved most effectively through watershed wide planning and implementation. The water quality based approach is a common method of addressing impairments. The "Integrated Waters List" identifies impaired streams and identifies source-causes of impairment. The next step towards improving the water quality in these streams is to identify the critical areas within the impacted watershed. Critical areas are the geographic regions within a watershed that directly contribute pollutants to the stream. The primary purpose for identifying critical areas is to develop a strategy that effectively addresses the sources of water quality impairment.

An inventory of each watershed that identifies the critical areas allows time, effort, and funds to be targeted towards those sites that most negatively impact water quality. This stage should be completed by a watershed planner with the technical knowledge necessary to accurately identify critical areas and the ability to provide a technical assessment of the severity of each source. The planner will need to prioritize the inventoried sites within the critical area based on the degree to which the sites contribute to the impairment and the overall objectives of the community.

It is important to involve the stakeholders within the watershed at this point in the form of a steering committee. A group such as a local watershed group or the County Conservation District would be able to assist in identifying the stakeholders and coordinating everyone's efforts. The planner and steering committee will work together to develop a comprehensive watershed plan and an implementation strategy to address the sites within the critical areas. The goal is to address the most severe sources of pollutants in an efficient manner. The next step in developing a comprehensive watershed plan is to set definable water quality goals based on the detailed inventory.

Developing an implementation strategy and determining specific BMPs to treat specific sites is the last step. Existing water quality programs should be considered as the implementation strategy is developed. These programs can be coordinated with the implementation strategy in order to achieve a common goal. Thought must also be given to potential funding sources and how they can be used to implement portions of the overall water quality improvement plans. As projects are implemented, the plan should be reviewed and revised as necessary to ensure that the water quality goals are eventually obtained.

RECOMMENDED AGRICULTURAL CONSERVATION PRACTICES

A variety of agricultural conservation practices are available to help achieve producer's goals while also protecting natural resources. These practices are used to reduce soil erosion and improve and protect water quality. These practices are intended to address specific resource concerns. Individual BMPs are most effective when used together to create a conservation system. A conservation system addresses all of the resource concerns on a particular farm through a combination of different management practices and BMPs that work together. Planning a conservation system ensures that the maximum benefits can be obtained from the individual components, and that the overall management goals are accomplished. Conservation planning services are offered by a variety of private consultants as well as state and federal agencies including the local County Conservation District and USDA Natural Resource Conservation Service staff. The following BMPs have been identified as particularly well suited to address the impairments identified in McKean County:

Streambank Protection

Streambank protection provides direct water quality results by reducing the amount of sediment, animal waste and nutrients entering the stream. Protection is implemented by excluding livestock from the stream and establishing buffer zones of vegetation around the stream (see *Riparian Buffers*). The practice can be implemented with or without fencing; however it is much more effective when fencing is installed. This BMP usually requires installation of an alternate watering source for livestock and an animal crossing to allow animals access to pasture on both sides of the stream. According to the *Chesapeake Bay Program Best Management Practices, Agricultural BMPS – Approved for CBP Watershed Model* (DEP, 2007) the pollutant removal efficiency of this practice, with fencing and off-stream watering applied, is 60% (Nitrogen), 60% (Phosphorus), and 75% (Sediment). Without fencing, the efficiency is reduced to 30%, 30%, and 38% for nitrogen, phosphorus, and sediment respectively. This practice is eligible for several funding programs.

Riparian Buffers

Riparian areas, land situated along the bank of a water source, typically occur as natural buffers between uplands and adjacent water bodies. They act as natural filters of nonpoint source pollutants before they reach surface waters. In agricultural areas many riparian buffers have been removed by agricultural activity to increase tillable acreage and provide animal access to water (see *Streambank Protection*). Re-establishing riparian buffers by planting forest buffer or grass buffers adjacent to water bodies provides significant water quality benefits. In addition to the filtering benefits that grass buffers provide, forested buffers provide shade to the stream helping to reduce negative thermal impacts.

Additionally, wetlands and riparian areas also help decrease the need for costly stormwater and flood protection facilities. The efficiency of riparian buffers varies by hydrologic setting. This practice can be implemented with several funding programs such as CREP.

Riparian buffers are part of a larger group of practices referred to as Conservation Buffers. This general practice is any area or strip of land maintained in permanent vegetation to help reduce erosion and filter nonpoint source pollutants. This group also includes contour buffer strips, field borders, filter strips, vegetative barriers, and windbreaks (NRCS, 1999).

Barnyard Runoff Control

Animal concentration areas (ACA) are a principal source of sediment and nutrient pollution on agricultural operations. Barnyard runoff control is used to manage stormwater runoff from animal concentration areas to reduce the sediment and nutrients that reach surface waters. Runoff control can be achieved with a variety of methods, but the principals are the same for all of the methods. These principals are keeping "clean" water away from the barnyard and collecting runoff from the barnyard and filtering it with an appropriate BMP or storing it in a manure storage facility for field application. Clean water is diverted away from ACAs with roof runoff structures, diversions, and drainage structures. When barnyard runoff control is implemented without storage the pollutant removal efficiency is 20% (Nitrogen), 20% (Phosphorus), and 40% (Sediment) (DEP, 2007). When the practice is implemented in conjunction with a manure storage the nitrogen and phosphorus efficiencies are both reduced to 10% and the sediment efficiency remains the same.

Cover Crops

Cover crops are planted in the fall after the primary crop has been harvested. The cover crop grows through the fall and provides ground cover for the field throughout the winter months and early spring when the soil is extremely susceptible to erosion. The cover crop also provides nitrogen removal benefits as it utilizes excess nitrogen in the soil. The cover crop can either be harvested as a commodity crop in the spring or it can be killed and left as ground cover prior to spring planting. Cover crops provide excellent soil erosion protection when the fields need it most. The County Conservation District has several cost incentive programs to encourage use of cover crops. The efficiency of cover crops varies based on when the crop is planted and whether or not the crop is harvested. The pollutant removal efficiencies and cost incentive programs are identified in the Appendix.

Conservation Tillage

Conservation tillage is a crop production system that results in minimal disturbance of the surface soil. Maintaining soil cover with crop residue is an important part of conservation tillage. Maintaining ground cover throughout the year has many benefits to crop production, but the most significant water quality benefit is reduction in soil erosion. No-till farming is one form of conservation tillage in which crops are planted directly into ground cover with no disturbance of the surface soil. Minimum tillage farming is another method that involves minor disturbance of the soil, but maintains much of the ground cover on the surface. There is no efficiency associated with this practice. The effects of each tillage system can be calculated by the Revised Universal Soil Loss Equation (RUSLE), which will give an estimation of the annual soil loss for each field.

RECOMMENDATIONS FOR ABANDONED MINE DRAINAGE

As discussed previously in this section, the challenges associated with improving AMD impairments are significant. It is generally extremely difficult and cost prohibitive to remediate an AMD source. Because of this, treating the cause of impairment is oftentimes the only option for remediation. Two methods can be used to treat AMD impairments, active treatment and passive treatment. Active treatment methods use alkaline chemicals such as limestone, hydrated lime, soda ash, caustic soda, and ammonia to neutralize acidic AMD impaired water and decrease the solubility of dissolved metals (EPA, 2008b). Active treatment systems are designed and operated to treat specific contaminants at a given site. These treatment systems are very effective at improving water quality, but they are a long-term undertaking. They require ongoing doses of expensive chemicals and are expensive to construct and operate. Passive treatment systems employ chemical and biological reactions (most often employing limestone) in systems that require minimal maintenance to minimize AMD. While passive systems are generally less effective at total treatment than active systems, they are much less expensive to construct and operate. However, they will all accumulate metal precipitates and eventually require maintenance or need to be replaced. Several simple, time-proven passive systems that may be useful in remediating AMD impaired waters are as follows:

Open Limestone Channels/Anoxic Limestone Drains

Open limestone channels can be constructed off-line with mine drainage diverted through the constructed channel, or limestone can simply be placed in the existing stream. This simple passive treatment method uses placed limestone to add alkalinity to the water. The dissolution of the limestone raises the pH of the water. This type of system requires large quantities of limestone for long-term operation (DEP, 2010). One drawback of this system is that iron and aluminum precipitates can coat the limestone and reduce the dissolution of the limestone. This is sometimes referred to as armoring. High flow velocities and turbulent flow can improve the performance of limestone channels by keeping precipitates in suspension and reducing the amount of armoring that can occur. Anoxic drains operate on the same principal as open channels, except they are constructed underground to reduce contact with atmospheric oxygen. Keeping oxygen out of the water prevents oxidation of metals and reduces armoring of the limestone (DEP, 2010). Anoxic drains are also useful for treating subsurface mine water flows.

Diversion Wells

Diversion wells also utilize the technique of using limestone to add alkalinity to contaminated waters. Acidic water is diverted from the stream into a cylindrical well containing limestone aggregate. The water enters the well near the bottom and the hydraulic force of in incoming water agitates and abrades the aggregate. The turbulence in the water increases dissolution and reduces armoring on the limestone. "Treated" water is drawn off the top of the well and directed back into the stream where it mixes with contaminated water. This simple system works well, but requires periodic replenishment of limestone.

Constructed Wetlands

Constructed wetlands are a passive systems that utilize precipitation of metals and natural processes associated with wetland plants to remove dissolved metals from mine drainage within the controlled environment of the treatment system. Constructed wetlands can be aerobic (with oxygen) or anaerobic (without oxygen) which refers to the conditions in which the chemical reactions are occurring. Aerobic wetlands are used primarily for removing metals from contaminated water. They are shallow (1- to 3-foot deep) ponds, that may be lined or unlined, used to facilitate natural oxidation of the metals and precipitate iron, manganese, and other metals (Ford, 2003). Anaerobic wetlands are used to neutralize acidity and reduce metals to the sulfide form. Anaerobic wetlands are shallow ponds filled with organic matter, such as compost, and underlain by limestone gravel. Water percolates through the compost and becomes anaerobic and metals precipitate from the water as sulfides. Microorganisms facilitate this reaction by first consuming oxygen (Ford, 2003).

Initial design and construction of wetland treatment systems can be expensive. However, this step is important as proper initial sizing of wetlands is critical to their success. Constructed wetlands are also sensitive to system stressors such as lack of flow, drastic flow variations, and extreme cold temperatures. These systems are also more maintenance intensive than the previously mentioned treatment systems.

The Surface Mining Conservation and Reclamation Act of 1971, and the Federal Surface Mining Control and Reclamation Act of 1977 have generated regulations intended to eliminate and control adverse conditions resulting from mining operations. Still today, the county lives with the legacy of coal mining. According to DEP (Webb, 2009), there are 28 documented Abandoned Mine Land sites. There have been several reclamation projects completed In McKean County and more are in progress. According to DEP (Webb, 2009), one AML surface mine reclamation, one AMD passive treatment project, and two AMD abatement projects have been completed in the county at a cost of $1,191,996.

POTENTIAL FUNDING SOURCES

A variety of potential sources are available for funding projects and individual practices that will help improve water quality in McKean County. Some of these programs are county-wide and others are targeted specifically at impaired watersheds. This is a review of the major funding programs available for projects addressing water quality impairments, and not an all-inclusive listing. Funding sources available throughout the county include:

Conservation Reserve Enhancement Program (CREP) – This funding program offered by USDA's Farm Service Agency provides financial incentives to protect environmentally sensitive land by removing it from agricultural production and placing it in a conservation easement planted with permanent vegetation. CREP supports installation of conservation buffers, wetlands, and retirement of highly erodible land.

Conservation Security Program (CSP) – The CSP is a program administered by USDA-NRCS that rewards farmers who have already adopted good conservation systems by providing substantial incentives to expand or enhance current conservation efforts.

Environmental Quality Incentive Payment (EQIP) – This is a USDA - NRCS voluntary conservation program that promotes agricultural production and environmental quality as compatible goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land. Most agricultural BMPs are eligible for cost-share payments under this program

Section 319 Funds – This funding source is administered by EPA. Under Section 319 of the Clean Water Act, State, Territories, and Indian Tribes receive grant money which support a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific nonpoint source implementation projects.

This page has been left blank intentionally.

Section X – Additional Recommendations and Considerations

The stormwater management standards developed in this Plan are the basis for sound stormwater management throughout the county. However, there are many activities that fall outside the scope of stormwater management regulations that have a significant impact on stormwater runoff and the goals of sound stormwater management planning. Generally, standards for many of these activities are contained within Zoning Regulations and Subdivision and Land Development Ordinances. Some of these activities and their impact on stormwater management are discussed below.

These measures are included here because they are beyond the regulatory scope of this Plan but may provide valuable tools in obtaining the goals discussed in *Section II*. It is suggested that all municipalities consider these additional recommendations, and determine whether adoption of some of these policies could be beneficial to their respective communities. Municipalities with substantial stormwater problem areas could especially benefit from regulation of some, or all, of these activities. A holistic approach that considers all land use policies, and how they impact stormwater runoff, is necessary to maximize the effectiveness of a stormwater management program.

MUNICIPAL ZONING

Municipal zoning is perhaps the single most influential factor on a stormwater management program. This is because the rainfall-runoff response of a given geographical area is directly linked to land use. In this manner, zoning regulations can help achieve the goals of a stormwater program or they can be a hinderance to successful implentation of the program. Only 34% of rural municpalites have enacted zoning ordinances and the majority of these are located in the southeast portion of the Commonwealth (Lembeck et al., 2001). Instituting new zoning regulations, or even changes to existing regulations, can be very difficult. Potential obstacles may include political backlash from a perceived overreach in municipal regulation, increased enforcement costs, and a lack of professional staffing (often related to a lack of financial resources) in the development of regulations.

Despite the difficulties associated with implementing zoning regulation changes, this is a vital element of a successful stormwater management program. This being said, the impacts of zoning regulation reach far beyond stormwater management. Zoning changes should be developed with careful consideration of all of the potential effects of the ordinance changes.

<u>Recommendations for Improved Municipal Zoning</u>

The following zoning tools are recommended by the Center for Watershed Protection that, if possible to implement, may aid in achieving the stated goals of this Plan (Center for Watershed Protection, 1999):

- **Watershed Based Zoning** –Master planning efforts and zoning incorporate recommendations for individual watershed, with watershed specific regulations. Long-term monitoring and evaluation of the effectiveness of the regulations should be part of the program.

- **Overlay Zoning** – With this option, specific criteria can be applied to isolated areas without the limitations of underlying base zoning. Overlay zoning superimposes additional regulatory standards, specifies permitted uses, or applies specific development criteria onto existing zoning provisions. Overlay zones may take up only part of an underlying zone or may encompass several underlying zones. An example of watershed-releated overlay zoning may be "Impervious Overlay Zoning" in areas with documented stormwater problems, which sets a maximum impervious area cap.
- **Performance Zoning** – This technique requires a proposed development to ensure a desired level of performance within a given area. This method has been used to control traffic or noise limits, light requirements, and architectual styles. Watershed-related performance zoning might provide precise limits on storwater quality and quantity. This may be one option to address impaired waters.
- **Large Lot Zoning** – This type of zoning district requires development to occur at very low densities to disperse impervious cover. This helps disperse the stormwater impacts of future development, but may contribute to urban sprawl.
- **Urban Growth Boundaries** – Growth boundaries set dividing lines for areas designated for urban and suburban development and areas appropriate for traditionally rural land uses, such as agriculture and forest preservation. Growth boundaries are typically set for up a specific time period (e.g. 10 to 20 years) and re-evaluated at appropriate intervals.
- **Infill Community Redevelopment** – This strategy encourages use of vacant or under-used land within existing growth centers for urban redevelopment. This practice is one method used to reduce the negative impacts of urban sprawl and minimize additional impervious area by miximizing utilization of existing infrastructure.
- **Transfer of Development Rights** – This allows transfer of development rights from sensitive subwatersheds (where the potential for adverse impacts is relatively high) to other watersheds designated for growth (where the potential for adverse impacts are relatively low).

RIVER CORRIDOR PROTECTION

River corridor protection is a very broad term that encompasses several closely related river (the term river is used loosely here to include all rivers, streams, creeks, etc.) management approaches. River corridors provide an important spatial context for maintaining and restoring the river processes and dynamic equilibrium associated with high quality aquatic habitats (Kline and Dolan, 2008). The river corridor includes the existing channel, the floodplain, and the adjacent riparian zone. The basic concept behind river corridor protection is recognizing the natural functions of rivers and streams and managing them to resolve conflicts between the natural systems and human land use.

Rivers and streams adjust over time through dynamic fluvial processes in response to the varying inputs of water, sediment, and debris. Natural adjustments to these inputs are occuring continually in rivers and streams. These adjustments are generally minor and occur over long time periods. The result of these processes is evidenced in streambank erosion, channel incision, meadering stream channels, and the inevitable conflict between the stream and nearby human infrastructure. The more significant changes, such as channel relocation, usually occur during large flood events. River corridor protection includes the following management strategies to complement a stormwater management program:

FLOODPLAIN MANAGEMENT

There is a direct relationship between stormwater management and floodplain management. Stormwater management policy focuses on future development and reducing the likelihood of increased flooding while floodplain management focuses on preventive and corrective measures to reduce flood damage. Implementation of the *Model Stormwater Management Ordinance* will reduce the probability of new flooding problems, but will have only minor impacts on existing problems. Examples of these problems are documented in *Section V – Significant Problem Areas and Obstructions*. Many of these problems are due to historic development that has occurred in the floodplain and inadequately sized infrastructure. Floodplains are necessary to convey and attenuate the natural peak flows that occur during major hydrologic events.

As discussed in *Section III*, McKean County incurs a substantial economic loss in major hydrologic events (as much as $81.3 million in a 10-year storm event). Floodplain management policy serves to minimize the impact of such events by reducing the conflicts between human infrastructure and floodplains. While improved stormwater management will greatly reduce the occurrence of nuisance flooding, floodplains are necessary to attenuate flood waters from events that exceed the intended scope of stormwater policy. The most effective floodplain management policy provides preventive provisions that restrict future development within floodplains and corrective measures that reduce flood damage in existing problem areas.

<u>Recommendations for Floodplain Management</u>

- **Adopt and enforce the Pennsylvania Department of Community and Economic Development (DCED) Model Floodplain Ordinance.** When the FIRMs in McKean County are updated, it is strongly recommended that each municipality adopt the DCED model ordinance. This will ensure that the local ordinance addresses the minimum state and federal requirements of the NFIP and provide a consistent basis of floodplain management between all of the municipalities in the county.
- **Participate in the Community Rating System.** The CRS gives communities credit for reducing the risk of flood hazards. By implementing many of the same principles that are discussed in this Plan, municipalities can reduce flood insurance rates for residents inside of floodplains by up to 45%.
- **Provide open space preservation in floodplain areas.** Open space preservation may also provide credits to future developments by reducing impervious area and thereby reducing stormwater requirements.
- **Acquire and relocate flood-prone buildings so they are no longer within the floodplain.** Repetitive loss properties (properties for which two or more claims of at least $1000 have been paid by the NFIP within any 10-year period since 1978) constitute a large portion of the NFIP flood insurance claims. Nationally, less than 1% of all properties with flood insurance have accounted for 30% of flood insurance claims between 1978 and 2004 (U.S. General Accounting Office, 2004). Removing these and any other structure that incurs flood risk on an annual basis reduces the overall risk of the NFIP and reduces the community's exposure to flood damage. It is usually more economical to remove properties, particularly in rural areas, than to install structural alternatives such as levies, diversion projects, or dams.
- **Implement a drainage system maintenance program.** As noted in *Section V*, there are numerous locations where clogged or poorly maintained facilities result in flooding of areas not normally prone to flooding. Most engineering design calculations for stormwater detention and conveyance facilities, assume full function of a bridge or culvert. Implement a systematic inspection and maintenance program where periodic

inspections are conducted on all channels, conveyance and storage facilities and remove debris and perform maintenance as necessary.

RIVER CORRIDOR PLANNING

River corridor planning is a process for selecting and implementing river corridor management alternatives in which all aspects of the river are considered. The process is accomplished through river specific assessments and planning that is able to characterize the river and identify important features as well as the areas that are susceptible to potential threats to those features. This is a form of land use planning that focuses on the impacts of land use on the river system.

One particularly useful aspect of river corridor planning is to use the assessment information to designate corridors along the rivers where natural river changes are most likely to occur resulting in accelerated erosion or bank failures. These areas are sometimes referred to as "fluvial erosion hazard zones" and are responsible for a large portion of the damage to human infrastructure during flood events (Dolan and Kline, 2008). Once these areas are identified and mapped, land use planning mechanisms are used to protect identified sensitive areas and limit future development within this zone. Keeping infrastructure, such as roads and utilities, out of the high risk areas greatly reduces the cost of protecting and maintaining this infrastructure.

Recommendations for River Corridor Planning

- **Identify areas that could benefit river corridor planning and initiate the planning process.** Identifying areas that could benefit from improved river corridor management can protect river resources and greatly reduce the economic impact caused by major hydrologic events. River corridor planning can be especially beneficial in areas with special value, areas that are likely to receive considerable future development near the river, or areas that currently experience persistent flood damage.
- **Identify and protect fluvial erosion hazard zones.** Flood damage may also occur as a stream channel changes course and meanders. The channel changes may result from either naturally occurring geologic processes or human-induced changes to watershed hydrology or hydraulics. A geomorphic assessment can identify the areas that are most likely to experience channel changes through erosion. These areas can then form the basis for an overlay zoning district or area with specified stream buffers for additional protection. Another option that has been implemented in the state of Vermont, is to integrate Fluvial Erosion Zones into the floodplain mapping process, so that all of the tools of floodplain management are available for the specified areas (Dolan and Kline, 2008).

RIPARIAN ZONE PROTECTION

The riparian zone is the transitional zone between the aquatic zone and adjacent uplands. It generally includes the streambanks, flood plain, and any adjacent wetlands. The riparian zone is often overlapping with the river corridor, but has a slightly different connotation. The term riparian zone does not refer to an explicit width, rather a width that varies along the length of a given stream depending on the geography of the area. Natural riparian zones are typically covered with trees, shrubs, and other types of local vegetation, all of which provide a natural buffer between waterways and human land use as well as providing vital and unique natural habitat.

Riparian zones provide two principal benefits in regards to stormwater management. They offer flood protection by providing temporary storage area, slowing the velocity of flood waters, and provide a small amount of volume reduction through infiltration and permanent retention of water by disconnected low lying areas. The second primary benefit of riparian zones is the water quality functions they offer. The vegetation in the riparian zone provides shade that reduces water temperature, traps and removes pollutants from stormwater, and provides protection from streambank erosion.

Recommendations for Riparian Zone Protection

- **Adopt and enforce the riparian buffer provisions of the Model Stormwater Management Ordinance.** The *Model Ordinance* includes provisions to require establishment of riparian buffers on all new development that occurs near watercourses. These requirements are in accord with the recently proposed changes to the statewide erosion and sediment pollution control regulations (The Pennsylvania Code, Title 25, Chapter 102). This will provide riparian zone protection by creating buffers between stream segments and all future development.
- **Establish a riparian zoning overlay district.** Identify critical riparian areas in which existing land uses may not be achieving water quality, floodplain management, and stormwater management objectives. Use this inventory of critical riparian zones to create a riparian zoning overlay district that establishes regulations on activities inside the zoning district.
- **Adopt stream specific guidelines where appropriate.** Where numerous problems areas have been identified and a riparian buffer is identified as a potential solution, a municipality may wish to adopt a stream specific set of guidelines that consider the specific fluvial geomorphological processes of that stream. A stream corridor study may be prepared that designates varying widths along a reach of stream. An ordinance that uses a stream corridor study as it basis will establish buffer widths using the best available scientific data. Some buffer ordinances have zones that vary between 75' and 1000' depending on the scientific and economic justification (Wenger and Fowler, 2000).
- **Encourage voluntary establishment of riparian buffers.** A regulatory approch will limit future development within the riparian zone, but will have little affect on existing land uses in critical riparian areas. There are numerous existing incentive programs that offer technical and/or financial assistance to encourage land owners to alter existing land uses and establish riparian buffers. These include agricultural land retirement programs such as USDA's Conservation Reserve Enhancement Program (CREP) program, cost-share programs such as USDA's Environmental Quality Incentives Program (EQIP), as well as grant and loan programs.

WETLAND PROTECTION

Wetlands play an essential role in stormwater management and water quality protection, as well as providing other valuable ecological and cultural functions. Some of the functions wetlands provide relevant to stormwater include: storm flow modification, erosion reduction, flood control, water quality protection, sediment and nutrient retention, and groundwater replenishment. Wetlands associated with lakes and streams provide temporary storage of floodwater by spreading the water over large flat areas, essentially acting as natural detention basins. This decreases peak flows, reduces flow velocity, and increases the time period for the water to reach the watersheds outlet. Research by R.P. Novitzki found that basins with 30 percent or more areal coverage by lakes and wetlands have flood peaks that are 60 to 80 percent lower than the peaks in basins with no lake or wetland area (Carter, 1997).

Wetlands can also maintain good quality water and improve degraded water. Wetland vegetation also decreases water velocities causing suspended solids to drop out of suspension, thus decreasing the erosive power of the water. Wetlands also trap, precipitate, transform, recycle, and export sediment, as well as nutrients, trace metals, and organic material. Water leaving a wetland can differ noticeably from that entering (Mitsch and Gosselink, 1993).

Recommendations for Wetland Protection

- **Identify and protect special value wetlands.** Due to the diversity of the benefits provided by wetlands, they are protected through various levels of federal and state regulations. These regulations protect wetlands from development, however, they permit minor wetland encroachments for certain activities. Some wetlands provide specific ecological or stormwater related benefits to an area. These wetlands should be identified and further protected through municipal regulations.

LOW-IMPACT DEVELOPMENT SITE DESIGN

The basic principles and concepts of LID were covered in *Section I* along with some of the benefits of implementing LID stormwater management practices. These concepts have been further developed throughout this Plan. This information has primarily discussed LID concepts as they relate to stormwater management. However, there are many non-stormwater LID practices that can have a very positive impact on a stormwater management program.

Development alters the natural landscape with human infrastructure like buildings, roads, sidewalks, parking lots, and other impervious surfaces. As previously discussed, all of these "improvements" alter the natural hydrology of a site and generate increased runoff. LID site design concepts include reducing impervious surface area, minimizing the amount of natural area disturbed during development, decentralizing stormwater management facilities, and generally attempting to minimize the effects of development on natural resources. Stormwater management can be improved by encouraging use of additional LID practices.

LIMIT IMPERVIOUS COVER

Increased impervious area within a watershed is a direct contributor to increased storm flows and decreased water quality. Research in recent years has consistently shown a strong relationship between the percentage of impervious cover in a watershed and the health of the receiving stream (EPA, 2010). Various studies have indicated that as overall watershed imperviousness approaches 10% biological indicators of stream quality begin to show degradation. Limiting impervious cover is one method of reducing the impact of development on the hydrologic cycle.

Recommendations to Limit Impervious Cover

Some alternative development approaches within the LID approach include cluster development, reduction in street widths, reduction in parking space requirements (number and/or sizes), and creating a maximum impervious percentage on individual lots. Some specific elements within the LID framework include the following:

- **Road Widths** – These are usually specified based on the anticipated road use category (e.g., major, minor, collector). Most ordinances assume a standard 12-foot wide travel lane and then add width for shoulders, parking lanes, bicycle lanes, and other considerations. Reducing the travel lane width to 11 feet for minor roads (e.g., roads within a subdivision development) could reduce the impervious cover of those roadways by up to 8 percent.

- **On-Street Parking** – Parking lanes are often specified to be 8 or 10 feet wide. Standardizing the maximum width of these lanes to 8 feet would reduce runoff. Also, limiting parking to one side of a street, particularly in subdivisions, could result in a significant reduction in total runoff. Another option would be to require that the parking lanes be constructed of pervious pavement, grid blocks or another pervious surface.
- **Sidewalks** – In instances where ordinances require sidewalks, consideration should be given to only requiring them on one side of the street in order to reduce impervious cover. Also, sidewalks should be separated from the roadway surface by a "green strip" (e.g., grass or shrubs) to allow runoff from the impervious surface an opportunity to infiltrate before entering the roadway drainage system. In fact, the sidewalks could, in some instances, be laid out so that they do not parallel the roadway, providing even greater opportunity for infiltration.
- **Curb and Gutter Systems With Storm Sewers** – In heavy residential areas, many ordinances require the developer to install curb and gutters along roadways and to use inlets and storm sewers to remove and transport the runoff from the roads. Ordinances should be modified to allow roadside swales that would provide additional infiltration opportunity and some water quality benefit through filtration. This option would have the added benefits of significantly reducing development costs and minimizing future maintenance requirements.
- **Parking Requirements and Parking Stall Dimensions** – Consideration should be given to reducing the number of parking spaces that must be provided on-street or in parking lots for residential, commercial, educational, and industrial developments. Furthermore, stall sizes in parking lots should be set to 8-feet wide by 18-feet long. In addition, consideration could be given to requiring that larger parking lots establish special areas for compact cars with stall sizes reduced to 7-feet wide by 15-feet long. Finally, the ordinances should include requirements for a minimum amount of "green space" in parking lots which should allow runoff from the impervious surfaces to flow over them so that infiltration and water quality filtration would be enhanced.
- **Lot Sizes and Total Impervious Cover** – Most ordinances establish minimum lot sizes for various types of development and the number of "units" permitted on each lot. However, the ordinances do not always limit the amount of impervious cover that can be built on a specific lot, particularly in residential developments. Limits should be established and those limits should be used in determining the "post-development" runoff condition when designing the proposed storm water management systems. In addition, requirements should be established for the minimum amount of "green space" that should be provided in commercial, educational, and industrial developments and these "green spaces" should be designed so that runoff from the impervious surfaces can flow over them to the maximum extent practical.
- **Lot Setbacks** – There are at least two schools of thought regarding lot setbacks as they relate to stormwater management: 1) Minimizing lot setbacks will reduce driveway lengths and, thereby, reduce total impervious cover and 2) Maximizing lot setbacks will allow runoff from impervious surfaces (e.g., roof tops) greater opportunity to infiltrate prior to reaching roadway drainage systems. Either method could be beneficial as long as the method works in coordination with the other Ordinance requirements.

LIMIT DISTURBANCE OR COMPACTION OF TOPSOIL

Topsoil is an absorbant top layer that provides significant stormwater management functions through initial abstraction. During rainfall events, no runoff occurs until the topsoil becomes saturated and the initial holding capacity of the soil is exceeded. The void spaces in undisturbed topsoil can provide significant water storage. The ability for initial abstraction can alter drastically from one soil type to another or because of varied site conditions. However, soil compaction plays a significant role in the ability of a given soil type to hold water. As topsoil is disturbed, or compacted, the holding capacity of the soil is drastically reduced, thus limiting its effectiveness in reducing runoff. Previous studies (Gregory et al., 2006) have shown that compacted pervious area effectively approaches the infiltration behavior of an impervious surface.

Recommendations for Topsoil Management

- **Adopt ordinance language that discourages the common practice of removing all topsoil from development sites during construction.** The area of disturbance during a project should be limited to the minimum area necessary to complete the project. This provides the dual benefit of limiting erosion during construction and improving post construction stormwater management.
- **Adopt ordinance provisions that limit soil compaction where possible.** Areas that are not disturbed should be protected from compaction by construction activities to the maximum extent practicable. These areas should be designated on site plans and demarcated and protected by in-field measures. This is especially important for areas intended for infiltration based stormwater management facilities.

IMPEDIMENTS TO LID IMPLEMENTATION

The LID concept has been around for a long time, but has been slow to catch on in mainstream implementation. In an effort to assess the impediments to LID in Chesapeake Bay portion of Virginia, Lassiter (2007) identified and ranked several impediments to LID implementation. The two most important impediment identified were 1) lack of education about the LID concept and 2) existing development rules that conflict with LID principles.

Other recent studies have found that existing municipal regulations are often a significant impediment to LID implementation (Kerns, 2002). Many existing municipal regulations were developed to provide adequate infrastructure to meet the needs of growing communities. Often times these standards encourage use of unnecessary impervious surfaces such as extra wide streets in small residential areas, parking spaces for "worst-case scenarios" that get used only a few times a year, and dead-end sidewalks. Municipalities are encourage to review their ordinances for regulations that conflict with low-impact development and revise them to encourage the use of LID site design. There are many direct economic, environmental, aesthetic, and social benefits for a municipality adopting LID-friendly Ordinances.

Recommendations to Remove LID Impediments

- **Provide education activities and training workshops to various stakeholder groups.** As decision makers, and the group responsible for setting policy, municipal and county officials should be encouraged to obtain additional education on LID practices. Other stakeholders such as developers, builders, and homeowners should also have educational resources available to increase awareness and encourage implementation of LID practices. Education is the key to successful implementation of LID practices.

- **Promote guidance documents such as this Plan and included references.** There are a variety of publications and internet sites that discuss LID and offer design solutions: Low Impact Development Center (2009), DEP (2006), and Prince George's County (1999). These resources should be made available through municipal offices, websites, or trainings.
- **Alter existing Subdivision and Land Development Ordinances and Zoning Ordinances to allow for successful LID implementation.** Adoption of the *Model Stormwater Management Ordinance* in this Plan is an important tool in accomplishing the goals of LID. However, it is recommended that municipalities modify and enhance ordinances in order to provide enough flexibility to allow these innovative design methods to be employed by developers in order to advance the goals of this Plan. Potential alterations that may help create flexibility include: 1) creation of overlay zoning, 2) providing amendments to Ordinances to support LID efforts (i.e. reducing impervious cover and limiting topsoil compaction), or 3) creating an expedited waiver process for LID-specific requests.
- **Provide incentives for LID implementation.** Lassiter (2007) identifies tax credits, allowing for higher density developments, mitigation credits, and reduced land development fees for sites with LID developments as potential incentives to encourage developers to use LID.
- **Keep an inventory of LID efforts to help provide County-specific recommendations and successful BMP installation.** While considerable documentation exists on specific BMPs (e.g. National Research Council, 2008; DEP, 2006), very little scientific data exists within this region, and particularly this County. A valuable part of LID, one that is too often neglected, is the component of encouraging debate and expanding the LID knowledge base. Having an agency with a central role in land development permitting, such as the County Conservation District, would be invaluable to developers and design professional in determining what works in McKean County – and what may not.

SUMMARY

Implementation of the standards developed in this Plan are a necessary step towards developing a holistic stormwater management plan, but much more can be done to improve how we manage water resources. There are many opportunities for local governments to improve the way this resource is managed, and protected, and the benefits are vast for those who undertake the challenge. There is a substantial number of technical resources available to guide development of regulations for proactive thinking municipalities.

This page has been left blank intentionally.

Section XI – Plan Adoption, Implementation and Update Procedures

PLAN REVIEW AND ADOPTION

The opportunity for local review of the draft Stormwater Management Plan is a prerequisite to county adoption of the Plan. Local review of the Plan is composed of several parts, namely the Plan Advisory Committee review (with focused assistance from others including Legal Advisors and Municipal Engineer's review, Municipal review), and County review. Local review of the draft Plan is initiated with the completion of the Plan by the County and distribution to the aforementioned parties. Presented below is a chronological listing and brief narrative of the required local review steps through county adoptions.

1. Plan Advisory Committee Review - This body has been formed to assist in the development of the McKean County Act 167 Stormwater Management Plan. Municipal members of the Committee have provided input data to the process in the form of storm drainage problem area documentation, storm sewer documentation, proposed solutions to drainage problems, etc. The Committee met on six occasions to review the progress of the Plan. Municipal representatives on the Committee have the responsibility to report on the progress of the Plan to their respective municipalities. Review of the draft Plan by the Plan Advisory Committee will be expedited by the fact that the members are already familiar with the objectives of the Plan, the runoff control strategy employed, and the basic contents of the Plan. The output of the Plan Advisory Committee review will be a revised draft Plan for Municipal and County consideration.

    a. Municipal Engineers Review - This body has been formed to focus on the technical aspects of the Plan and to educate the Municipal Engineers on the ordinance adoption and implementation requirements of the Plan. The group was invited to Plan Advisory Committee meetings to solicit input as well as to receive comments and direction in the development of the model ordinance. The result of this is a revised draft model ordinance for Municipal and County consideration.

    b. Legal Advisory Review - This body has been formed to focus on the legal aspects of the Plan and to educate the Municipal solicitors on the ordinance adoption and implementation requirements of the Plan. The group was invited to Plan Advisory Committee meetings to provide input as well as to receive comments and direction in the development of the model ordinance.

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

3. County Review and Adoption - Upon completion of the review by the Plan Advisory Committee, with assistance from the Municipal Engineer and Legal Advisory focus groups,

and each municipality, the draft Plan will be submitted to the County Board of Commissioners for their consideration.

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

The County will then submit the adopted Plan to DEP for their consideration for approval. The review comments of the municipalities will accompany the submission of the adopted Plan to DEP.

IMPLEMENTATION OF THE PLAN

Upon final approval by DEP, each municipality within the county will become responsible for implementation of the Plan. Plan implementation, as used here, is a general term that encompasses the following activities:

- Adoption of municipal ordinances that enable application of the Plans provisions.
- Review of Drainage Plans for all activities regulated by the Plan and the resulting ordinances.
- Enforcement of the municipal regulations.

Each municipality will need to determine how to best implement the provisions of this Plan within their jurisdiction. Three basic models for Plan implementation are presented in *Table 11.1* below. In some cases it may be advantageous for multiple municipalities to implement the Plan cooperatively, or even on a county-wide basis.

Individual Municipal Model	Each municipality passes, implements, and enforces the SWM ordinance individually.
Multi-Municipal Model	Several municipalities cooperate through a new, or existing, service-sharing agreement (COG, Sewage Association, etc.)
County Service Provider Model	County department, or office, (e.g. County Planning Entity or County Conservation District) provides SWM ordinance implementation and enforcement services to municipalities.

Table 11.1. Models for Municipal Plan Implementation

Regardless of what model is used for implementation, each municipality will need to adopt regulations that enable the chosen implementation strategy. For municipalities that choose the Individual Municipal Model, this means municipal adoption of the Model Ordinance or integration of the Plan’s provisions into existing municipal regulations. For the other two models, this will require ordinance provisions that designate the regulatory authority and adoption of an inter-municipal agreement or service-sharing agreement.

It is important that the standards and criteria contained in the Plan are implemented correctly, especially if the municipality chooses to integrate the standards and criteria into existing regulations. In either case, it is recommended that the resulting regulatory framework be reviewed by the local planning commission, the municipal solicitor, the McKean County Planning Commission and/or the McKean County Conservation District for compliance with the provisions of the Plan and consistency among the various related regulations. Additionally, the adopted regulations may be reviewed by DEP for compliance with this Plan.

PROCEDURE FOR UPDATING THE PLAN

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

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

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

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

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

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

This page has been left blank intentionally.

Works Cited

SECTION I

(Bedan and Clausen, 2009) Bedan, Eric S. and John C. Clausen, "Stormwater Runoff Quality and Quantity from Traditional and Low Impact Development Watersheds." *Journal of the American Water Resources Association (JAWRA),* Vol. 45.4 (2009): 998-1008. Print.

(DEP, 2006) Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. *Pennsylvania Stormwater Best Management Practices Manual*. Document Number 363-0300-002. n.p.: 30 December 2006. Print.

(EPA, 2000) United States Environmental Protection Agency, Office of Water. *Low Impact Development (LID): A Literature Review*. Document Number EPA-841-B-00-005. October 2000. Print.

(Hood et. al., 2007) Hood, M., J.C. Clausen, and G. Warner, "Comparison of Stormwater Lag Times for Low Impact and Traditional Residential Development." *Journal of the American Water Resources Association (JAWRA)*, Vol. 43.4 (2007): 1036-1047. Print.

(HUD, 2003) United States Department of Housing and Urban Development, Office of Policy Development and Research. *The Practice of Low Impact Development.* Washington: GPO, 2003. PDF File.

(Low Impact Development Center, 2007) Low Impact Development Center, Inc.. *LID Urban Design Tools.* Low Impact Development Center, Inc., 2007. Web. 19 January, 2010. <http://www.lid-stormwater.net/background.htm>

(Low Impact Development Center, 2009) Low Impact Development Center, Inc.. *Publications – LID Center Project Websites*. Low Impact Development Center, Inc., 8 December 2009. Web. 19 January, 2010. <http://www.lowimpactdevelopment.org/publications.htm#LID_Center_Websites>

(Prince George's County, 1999) Prince George's County, Maryland, Department of Environmental Resources, Programs and Planning Division. *Low Impact Development Design Strategies: An Integrated Design Approach*. Largo, MD: June 1999. Print.

SECTION III

(Barnes and Sevon, 2002)) Barnes, J. H., and W. D. Sevon, *The Geological Story of Pennsylvania (3rd ed.): Pennsylvania Geological Survey, 4th ser., Educational Series 4.* Pennsylvania Department of Conservation and Natural Resources. Harrisburg, PA: 2002. PDF File.

Works Cited

(Berg et al., 1980) Berg, T.M., W.E. Edmunds, A.R. Geyer. *"Geologic Map of Pennsylvania (2nd ed.)", Pennsylvania Geological Survey, 4th ser., Map 1*. Pennsylvania Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey. Harrisburg: 1980. Web. 11 February, 2010. <http://www.dcnr.state.pa.us/topogeo/map1/bedmap.aspx>

(Ciolkosz and Waltman, 2000) Ciolkosz, E.J. and W.J. Waltman. *Pennsylvania's Fragipans, Agronomy Series Number 147*. The Pennsylvania State University Agronomy Department. University Park, PA: August 2000. PDF File.

(DEP, 2009) "Pennsylvania's Major River Basins." Image. n.d.. Pennsylvania Department of Environmental Protection, n.d.. Web. 11 May, 2009. <http://www.dep.state.pa.us/river/Maps/PAbasins.htm>

(DEP, 2010) Pennsylvania Department of Environmental Protection. Abandoned Mine Land Inventory Polygons. 2 April 2010. Web. 28 April. 2010. <http://www.pasda.psu.edu>

(FEMA, 2007) Federal Emergency Management Agency. *Guidelines for Identifying Provisional Accredited Levees, FEMA MT-RA-EM*. United States Department of Homeland Security, Federal Emergency Management Agency : 16 March 2007. PDF File.

(Geyer and Bolles, 1979) Geyer, Alan R. and William H. Bolles, *Outstanding Scenic Geological Features of Pennsylvania, Environmental Geology Report No 7*. Pennsylvania Geological Survey. Harrisburg, PA: 1979. Print.

(McKean County Planning Commission, 2007) McKean County Planning Commission. *McKean County Comprehensive Plan*. McKean County Planning Commission, Smethport, PA: December 18, 2007. PDF File.

(NH Floodplain, 2007) "Cross-section showing the Floodway and Flood Fringe." Image. New Hampshire Floodplain Learning on Demand – Floodplain 101. 2007. Web. 8 December 2009. <http://www.nhflooded.org/flood_plains101.php>

(NRCS, 2007) United States Department of Agriculture, Natural Resource Conservation Service. *National Soil Survey Handbook, Title 430-VI.* United States Department of Agriculture: 2007. Web. 23 September, 2008. <http://soils.usda.gov/technical/handbook/>

(NRCS, 2008) United States Department of Agriculture, Natural Resource Conservation Service. *Soil Survey Geographic (SSURGO) database for McKean County, Pennsylvania*. 31 January, 2008. Web. <http://soildatamart.nrcs.usda.gov/>

Works Cited

(NRCS, 2009) *Web Soil Survey*. United States Department of Agriculture, Natural Resource Conservation Service, 11 November, 2009. Web. 6 April, 2010. <http://websoilsurvey.nrcs.usda.gov/app/>

(NRCS, 2010) "National Hydric Soils List by State." *Soils*. United States Department of Agriculture, Natural Resource Conservation Service, 19 March, 2010. Web. 21 April, 2010. <http://soils.usda.gov/>

(PEMA, 2009) *Programs and Services, County Flood Study GIS Maps*. Pennsylvania Emergency Management Agency, n.d. Web. 9 September 2009. <http://www.portal.state.pa.us/portal/server.pt?open=512&objID=4547&&PageID=488615&mode=2>

(Reese and Risser, 2010) Reese, Stuart and Dennis Risser. "*Summary of Groundwater-Recharge Estimates for Pennsylvania*", *Pennsylvania Geological Survey, 4th ser., Water Resources Report 70*. Pennsylvania Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey. Harrisburg, PA: 2010. PDF File.

(SCS, 1987) United States Department of Agriculture, Soil Conservation Service. *Soil Survey of McKean County, Pennsylvania*. n.p.: August 1987. Print.

(Sevon, 2000) Sevon, W.D.. "*Physiographic Provinces of Pennsylvania", Pennsylvania Geological Survey, 4th ser., Map 13*. Pennsylvania Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey. Harrisburg, PA: 2000. PDF File.

(Socolow, 1973) Socolow, Arthur. "*Elevations of Pennsylvania*", *Pennsylvania Geological Survey, 4th ser., Information Circular 4*. Commonwealth of Pennsylvania Department of Environmental Resources, Bureau of Topographic and Geologic Survey. Harrisburg, PA: 1973. PDF File.

SECTION IV

(DEP, 2003) Pennsylvania Department of Environmental Protection, Bureau of Water Supply and Wastewater Management. *Water Quality Antidegradation Implementation Guidance, Document No. 391-0300-002*. 29, November 2003. PDF File.

The Pennsylvania Code, Title 25, Chapter 93, 93.1-93.9 (1971 and as amended).

SECTION VI

(DEP, 2006) Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. *Pennsylvania Stormwater Best Management Practices Manual*. Document Number 363-0300-002. n.p.: 30 December 2006. Print.

(Emerson, 2003) Emerson, Clay Hunter. *Evaluation of the Additive Effects of Stormwater Detention Basins at the Watershed Scale*. MS thesis. Drexel University, 2003. PDF File.

(NRCS, 2008a) United States Department of Agriculture, Natural Resource Conservation Service. *National Engineering Handbook, Part 630, Hydrology*. United States Department of Agriculture: May 2008. Web. 7 July 2009. <http://directives.sc.egov.usda.gov/viewerFS.aspx?hid=21422>

(NRCS, 2008b) *Soil Data Mart*. United States Department of Agriculture, Natural Resource Conservation Service, n.d.. Web. October, 2008. <http://soildatamart.nrcs.usda.gov/>

SECTION VII

(DEP, 2006) Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. *Pennsylvania Stormwater Best Management Practices Manual*. Document Number 363-0300-002. n.p.: 30 December 2006. Print.

(Reese, 2009) Reese, Andrew J., "Volume-Based Hydrology." *Stormwater – The Journal for Surface Water Quality Professionals*, Vol. 10.6 (2009): 54-67. Print.

SECTION VIII

(DEP, 2006) Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. *Pennsylvania Stormwater Best Management Practices Manual*. Document Number 363-0300-002. n.p.: 30 December 2006. Print.

(EPA, 2007) United States Environmental Protection Agency, Nonpoint Source Control Branch. *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices*. EPA 841-F-07-006. Washington, DC: December, 2007. PDF File.

(Kloss and Calarusse, 2006) Kloss, C. and C. Calarusse. *Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows*. Natural Resources Defense Council, New York: June 2006. PDF File.

(MacMullan and Reich, 2007) MacMullan, Ed, Sarah Reich. *The Economics of Low-Impact Development: A Literature Review*. ECONorthwest. November 2007. PDF File.

(NRCS, 2008) United States Department of Agriculture, Natural Resource Conservation Service. *National Engineering Handbook, Part 630, Hydrology*. United States Department of

Agriculture: May 2008. Web. 7 July 2009. <http://directives.sc.egov.usda.gov/viewerFS.aspx?hid=21422>

(PennDOT, 2008) Pennsylvania Department of Transportation. PennDOT *Drainage Manual, Publication 584*. Pennsylvania Department of Transportation, Bureau of Design: August 29, 2008. Print.

SECTION IX

(DEP, 1996) *Pennsylvania's Abandoned Mines*. Pennsylvania Department of Environmental Protection, Bureau of Abandoned Mine Reclamation, 1996. Web. 5 March, 2010.

(DEP, 2007) Pennsylvania Department of Environmental Protection, Water Planning Office. *Chesapeake Bay Program Best Management Practices, Agricultural BMPs – Approved for CBP Watershed Model*. Pennsylvania Department of Environmental Protection, Harrisburg, PA: 2007. PDF File.

(DEP, 2008) Pennsylvania Department of Environmental Protection. *2008 Pennsylvania Integrated Water Quality Monitoring and Assessment Report*. Harrisburg, PA: 2008. PDF File.

(DEP, 2010) *Science of Acid Mine Drainage and Passive Treatment*. Pennsylvania Department of Environmental Protection, 2010. Web. 4 March, 2010. <http://www.depweb.state.pa.us/portal/server.pt/community/publications/13962/science_of_acid_mine_drainage_and_passive_treatment/588922>

(EPA, 1997) United States Environmental Protection Agency, Office of Water. *Volunteer Stream Monitoring: A Methods Manual.* EPA 841-B-97-003. Washington: November 1997. PDF File.

(EPA, 2007) United States Environmental Protection Agency, Office of Water, Assessment and Watershed Protection Division. *National Management Measures to Control Nonpoint Source Pollution from Hydromodification.* EPA 841-B-07-002. Washington: July 2007. PDF File.

(EPA, 2008a) *TMDL Primer*. United States Environmental Protection Agency, Mid-Atlantic Water, 10 July 2008. Web. 25 January, 2010. <http://www.epa.gov/reg3wapd/tmdl/primer.htm>

(EPA, 2008b) *Treatment for Acid Mine Drainage*. United States Environmental Protection Agency, Mid-Atlantic Water, 23 December 2008. Web. 4 March 2010. <http://www.epa.gov/reg3wapd/nps/mining/treatment.htm>

Works Cited

(Ford, 2003) Ford, K.L.. *Passive Treatment Systems for Acid Mine Drainage, Technical Note 409*. United States Department of the Interior, Bureau of Land Management, National Science and Technology Center, Denver, CO: April 2003. PDF File.

(Nordstrom et al., 2000) Nordstrom, D.K., C. N. Alpers, C. J. Ptacek, D. W. Blowes. "Negative pH and Extremely Acidic Mine Waters from Iron Mountain, California". *Environmental Science and Technology*, Vol. 34.2 (2000): 254-258. Print.

(NRCS, 1999) United States Department of Agriculture, Natural Resource Conservation Service. *A Conservation Catalog: Practices for the Conservation of Pennsylvania's Natural Resources*. n.p. 1999. Print.

(Webb, 2009) Webb, Patrick. "RE: AML." Message to Adam R. Zahniser. 30 January 2009. E-mail.

SECTION X

(Carter, 1997) Carter, Virginia. "Technical Aspects of Wetlands: Wetland Hydrology, Water Quality, and Associated Functions." *water.usgs.gov*. United States Department of the Interior, United States Geological Survey, National Water Summary on Wetland Resources. 7 March 1997. Web. 4 September 2009. <http://water.usgs.gov/nwsum/WSP2425/hydrology.html>

(Center for Watershed Protection, 1999) Center for Watershed Protection. "Approaches to the Eight Tools of Watershed Protection Slideshow". 1999. *Microsoft PowerPoint* File.

(DEP, 2006) Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. *Pennsylvania Stormwater Best Management Practices Manual*. Document Number 363-0300-002. n.p.: 30 December 2006. Print.

(Dolan and Kline, 2008) Dolan, Keri and Michael Kline, 2008. *Municipal Guide to Fluvial Erosion Hazard Mitigation*. Vermont Agency of Natural Resources, November 12, 2008. PDF File.

(EPA, 2010) *Impervious Cover*. United State Environmental Protection Agency, Ecosystems Research Division. 13 January 2010. Web. 3 February 2010. <http://www.epa.gov/ATHENS/research/impervious/>

(Gregory et al., 2006) Gregory, J.H., M.D. Dukes, P.H. Jones, and G.L. Miller, "Effect of urban soil compaction on infiltration rate." *Journal of Soil and Water Conservation*, Vol. 61.3 (2006): 117-124. Print.

(Kerns, 2002) Kerns, Waldon R., ed. *Proceedings of Three Workshops on Impediments to Low Impact Development and Environmental Sensitive Design*. Chesapeake Bay Program's Scientific and Technical Advisory Committee, December 2002. PDF File.

Works Cited

(Kline and Dolan, 2008) Kline, Michael and Keri Dolan, 2008. *Vermont Agency of Natural Resources River Corridor Protection Guide.* Vermont Agency of Natural Resources, November 12, 2008. PDF File.

(Lassiter, 2007) Lassiter, Rebecca. An *assessment of Impediments to Low-Impact Development in the Virginia Portion of the Chesapeake Bay Watershed*. MS thesis. Virginia Commonwealth University, May 2007. PDF File.

(Lembeck et al., 2001) Lembeck, Stanford M., Timothy W. Kelsey, and George W. Fasic. *Measuring the Effectiveness of Municipal and Land Use Planning Regulations in Pennsylvania*. The Center for Rural Pennsylvania, Harrisburg, PA: June 2001. PDF File.

(Low Impact Development Center, 2009) Low Impact Development Center, Inc.. "Publications." Low Impact Development Center, Inc., 8 December 2009. Web. 19 January, 2010. <http://www.lowimpactdevelopment.org/publications.htm>

(Mitsch and Gosselink, 1993) Mitsch, W.J., and J.G. Gosselink. *Wetlands*. New York: Van Nostrand Reinhold, 1993. Print.

(National Research Council, 2008) National Research Council of the National Academies, Division on Earth and Life Studies, Water Science and Technology Board. *Urban Stormwater Management in the United States*. The National Academies Press, Washington: 2008. PDF File.

(Prince George's County, 1999) Prince George's County, Maryland, Department of Environmental Resources, Programs and Planning Division. *Low Impact Development Design Strategies: An Integrated Design Approach*. Largo, MD: June 1999. Print.

(U.S. General Accounting Office, 2004) United States General Accounting Office. *National Flood Insurance Program: Actions to Address Repetitive Loss Properties, GAO Report GAO-04-401T*. United States General Accounting Office, Washington: 25 March 2004. PDF File.

(Wenger and Fowler, 2000) Wenger, Seth J. and Laurie Fowler. *Protecting Stream and River Corridors: Creating Effective Local Riparian Buffer Ordinances*. The University of Georgia, Carl Vinson Institute of Government, April 2000. PDF File.

APPENDIX A

(DEP, 2006) Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. *Pennsylvania Stormwater Best Management Practices Manual*. Document Number 363-0300-002. n.p.: 30 December 2006. Print.

Works Cited

(ERRI, 1996) Environmental Resources Research Institute. Areas of carbonate lithology (limestone.zip). October 2008. Web. <http://www.pasda.psu.edu/pub/pasda/compendium/>

(Maryland Hydrology Panel, 2006) Maryland Hydrology Panel. *Application of Hydrologic Methods in Maryland*. 2nd Edition. Maryland State Highway Administration and Maryland Department of the Environment, Baltimore: October 2006. PDF File.

(NOAA, 2008) Office of Hydrologic Development Webmaster. *Hydrometeorological Design Studies Center, Precipitation Frequency Data Service, NOAA Atlas 14, Volume 2, Version 3*. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Office of Hydrologic Development. Web. 1 December 2008. <http://hdsc.nws.noaa.gov/hdsc/pfds/index.html>

(NRCS, 2008) United States Department of Agriculture, Natural Resource Conservation Service. *Soil Survey Geographic (SSURGO) database for Juniata and Mifflin Counties, Pennsylvania*. 31 January, 2008. Web. <http://soildatamart.nrcs.usda.gov/>

(PennDOT, 2009) Pennsylvania Department of Transportation. Pennsylvania state roads and Pennsylvania local roads. 2009. Web. <http://www.pasda.psu.edu>

(SCS, 1986) United States Department of Agriculture, Soil Conservation Service, Engineering Division. *Urban Hydrology for Small Watersheds, 2nd ed., Technical Release No. 55*. Washington: GPO, June 1986. Print.

(Tomlinson, et al., 2009) Tomlinson, Ed, Bill Kappel, and Dwight Hoare. "Evaluation of the Rainfall Reports and Storm Analysis of the Smethport, Pennsylvania Storm July 17-18, 1942". Northeast Association of State Dam Safety Officials Conference. State College, PA. 14-16 June, 2009. Lecture.

(USGS, 1982) United States Department of Interior, United States Geological Survey, Interagency Advisory Committee on Water Data. *Guidelines for Determining Flood Flow Frequency, Bulletin 17B of the Hydrology Subcommittee*. n.p., Reston, VA: March, 1982. Print.

(USGS, 2005) Chaplin, Jeffrey J., United States Department of the Interior, United States Geological Survey. Development of Regional Curves Relating Bankfull-Channel Geometry and Discharge to Drainage Area for Streams in Pennsylvania and Selected Areas of Maryland Scientific Investigations Report 2005-5147. n.p., Reston, VA: 2005. Print.

Works Cited

(USGS, 2008a) United States Department of Interior, United States Geological Survey. Pennsylvania Digital Elevation Model – 10-meter. 2008. Web. <http://www.pasda.psu.edu>

(USGS, 2008b) United States Department of Interior, United States Geological Survey. *The National Hydrography Dataset*. 2008. Web. <http://nhd.usgs.gov/chapter1/index.html>

(USGS, 2008c) United States Department of Interior, United States Geological Survey. *The National Land Cover Dataset*. 4 September 2008. Web. *<http://landcover.usgs.gov/uslandcover.php>*

(USGS, 2008d) United States Department of the Interior, United States Geological Survey, Pennsylvania Water Science Center. *Percent Storage in Pennsylvania*, 4 September 2008. Web. <http://pa.water.usgs.gov/digit/pass_storage.zip>

(USGS, 2008e) Roland, M. A. and M. H. Stuckey. United States Department of the Interior, United States Geological Survey. *Regression Equations for Estimating Flood Flows at Selected Recurrence Intervals for Ungaged Streams in Pennsylvania. Scientific Investigations Report 2008-5102*. n.p., Reston, VA: 2008. Print.

(USGS, 2010) United States Department of the Interior, United States Geological Survey. *USGS Water Data for USA*. United States Department of the Interior, United States Geological Survey, 16 April, 2010. Web. 16 April, 2010. <http://waterdata.usgs.gov/nwis?>

APPENDIX B

(DEP, 2006) Pennsylvania Department of Environmental Protection, Bureau of Watershed Management. *Pennsylvania Stormwater Best Management Practices Manual*. Document Number 363-0300-002. n.p.: 30 December 2006. Print.

(NRCS, 1986) United States Department of Agriculture, Soil Conservation Service, Engineering Division. *Urban Hydrology for Small Watersheds, 2nd ed., Technical Release No. 55*. Washington: GPO, June 1986. Print.

(NRCS, 2008) United States Department of Agriculture, Natural Resource Conservation Service. *National Engineering Handbook, Part 630, Hydrology*. United States Department of Agriculture: May 2008. Web. 7 July 2009. <http://directives.sc.egov.usda.gov/viewerFS.aspx?hid=21422>

APPENDIX D

(Curtis et al., 1990) Curtis, J.G., D.W. Pelren, D.B. George, V.D. Adams, and J.B. Layzer. *Effectiveness of Best Management Practices in Preventing Degradation of Streams*

Caused by Silvicultural Activities in Pickett State Forest, Tennessee. Tennessee Technological University, Center for the Management, Utilization and Protection of Water Resources. Cookeville, TN: 1990. Print.

(DOE, 2009a) United States Department of Energy, Office of Fossil Energy, National Energy Technology Laboratory. *State Oil and Natural Gas Regulations Designed to Protect Water Quality*. Washington: May, 2009. PDF File.

(DOE, 2009b) United States Department of Energy, Office of Fossil Energy, National Energy Technology Laboratory. *Modern Shale Gas Development in the united States: A Primer*. Washington: April, 2009. PDF File.

(EPA, 1996) United States Environmental Protection Agency, Nonpoint Source Control Branch. *Managing Nonpoint Source Pollution from Forestry*. EPA841-F-96-004H. Washington: 1996. Web. <http://www.epa.gov/owow/nps/facts/>

(EPA, 1997) United States Environmental Protection Agency, Office of Water. *Volunteer Stream Monitoring: A Methods Manual.* EPA 841-B-97-003. Washington: November, 1997. PDF File.

(EPA, 2005) United States Environmental Protection Agency, Office of Water, Office of Wetlands, Oceans, and Watersheds, Nonpoint Source Control Branch. *National Management Measures to Control Nonpoint Source Pollution from Forestry.* EPA 841-B-05-001. Washington: April, 2005. PDF File.

(Gaudlip et al., 2008) Gaudlip, A.W., L.O. Paugh and T. D. Hayes. "Marcellus Shale Water Management Challenges in Pennsylvania." Society of Petroleum Engineers Shale Gas Production Conference, 16-18 November, 2008. Fort Worth, Texas. Society of Petroleum Engineers. n.p., 2008. Print.

(Harper, 1998) Harper, John A. "Why the Drake Well?" *Pennsylvania Geology*, v. 29, no. 1/4. Pennsylvania Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey. Harrisburg, PA: Spring 1998: 2-4. PDF File.

(Harper, 2008) Harper, John A. "The Marcellus Shale - An Old "New" Gas Reservoir in Pennsylvania." *Pennsylvania Geology*, v. 38, no. 1/4. Pennsylvania Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey. Harrisburg, PA: Spring 2008: 2-13. PDF File.

Works Cited

(Harper and Kostelnik, 2010) Harper, John A. and Jaime Kostelnik. "The MARCELLUS SHALE Play in Pennsylvania." Pennsylvania Department of Conservation and Natural Resources, Pennsylvania Geological Survey. n.p.: 2010. PDF File.

(McWilliams et al., 2007) McWilliams, William H., Seth P. Cassell, Carol L. Alerich, Brett J. Butler, Michael L. Hoppus, Stephen B. Horsley, Andrew J. Lister, Tonya W. Lister, Randall S. Morin, Charles H. Perry, James A. Westfall, Eric H. Wharton, Christopher W. Woodall. *Pennsylvania's Forest 2004, Resource Bulletin NRS-20*. United States Department of Agriculture, United States Forest Service. Newton Square, PA: October, 2007. PDF File.

(NaturalGas.org, 2004) "Overview of Natural Gas – History." *NaturalGas.org*. Natural Gas Supply Association, 2004. Web. 21 May, 2010. <http://www.naturalgas.org/overview/history.asp>

(Pennsylvania Forest Products Association, 2008) *Pennsylvania Forests and You: Pennsylvania Hardwoods Leading the Nation*. Harrisburg, PA: Pennsylvania Forest Products Association, September 2008. PDF File.

(Soeder and Kappel, 2009) Soeder, Daniel J. and William M. Kappel. .United States Department of the Interior, United States Geological Survey. *Water Resources and Natural Gas Production from the Marcellus Shale*. Fact Sheet 2009-3032. Washington: GPO, May, 2009. PDF File.

(Swistock, 2010) Swistock, Bryan. *Water Facts #28: Gas Well Drilling and your Private Water Supply*. The Pennsylvania State University, College of Agricultural Sciences, School of Forest Resources, Cooperative Extension. University Park, PA: 2 March, 2010. PDF File.

(The Pennsylvania State University, 2004) *Timber Harvesting in Pennsylvania: Information for Citizens and Local Government Officials*. The Pennsylvania State University, College of Agricultural Sciences, School of Forest Resources, Cooperative Extension. University Park, PA: 2004. PDF File.

(UPI, 2008) "Natural gas reservoir may hike U.S. output." *United Press International, Inc.*. 17 January, 2008: Web. <http://www.upi.com/Science_News/2008/01/17/Natural-gas-reservoir-may-hike-US-output/UPI-42921200590015/>

(U.S. Census Bureau, 2008) United States Census Bureau, Electronic Products Development Branch, Administrative and Customer Services Division. *CenStats Databases*. United States Census Bureau: 14 March, 2008. Web. 18 May, 2010. <http://censtats.census.gov/>

Works Cited

(USGS, 2003) Appalachian Basin Province Assessment Team. United States Department of the Interior, United States Geological Survey. *USGS Assessment of Undiscovered Oil and Gas Resources of the Appalachian Basin Province, 2002*. Fact Sheet 009-03. Washington: GPO, February, 2003. PDF File.

GENERAL REFERENCES

Pennsylvania Department of Conservation and Natural Resource Act 18 of 1995, P.L. 89, No. 18 (Section 502(c))

Pennsylvania Flood Plain Management Act; Act 166 of 1978; P.L. 851; 32 P.S. (679.10).

Pennsylvania Stormwater Management Act. Act 167 of 1978, P.L. 864.

The Pennsylvania Code, Title 25.

The Purdue OWL. Purdue U Writing Lab, 2008. Web. 27 Dec. 2008.

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

Model Stormwater Management Ordinance

McKean County
Act 167 County-Wide
Stormwater Management Plan

October 2010

474 Windmere Drive• State College, Pennsylvania 16801 • 814.238.7117 [phone]

Using The Model Stormwater Management Ordinance

Municipal Requirements: This Model Stormwater Management Ordinance was developed during the *McKean County Act 167 Stormwater Management Plan*. The Pennsylvania Stormwater Management Act (Act 167) requires that each municipality adopt a stormwater management ordinance to implement the stormwater management plan. Section 11(b) of Act 167 states:

> "Within six months following the DEP's approval of the this plan, each municipality is required to adopt new and/or amend existing stormwater ordinances or other ordinances, including zoning, subdivision and development, building code, and erosion and sedimentation ordinances, as are necessary to regulate development in a manner consistent with plan."

Any ordinance(s) adopted or amended by the municipality to comply with the stormwater management standards and criteria of the *McKean County Act 167 Stormwater Management Plan* must be sent by a municipal official to the DEP with the municipal ordinance number and including the date the ordinance was enacted.

Enacting and Amending Municipal Ordinances: It is recommended that municipalities enact the Model Ordinance as a stand-alone ordinance. In addition, it is recommended that municipalities review existing ordinances (subdivision and land development, zoning, etc.) and consider amending them to refer to and coordinate with the new municipal stormwater management ordinance.

Ordinance Provisions: Ordinances adopted by municipalities are the legal instrument that implements the standards and criteria of this stormwater management plan.

- The text ***[Municipality]*** in the Model Ordinance should be replaced by the name of the individual municipality.
- Provisions with **[OPTIONAL]** are found in Appendix G. These provisions are recommended but may be modified or not used by the municipality. When using an **[OPTIONAL]** Article, the municipality should insert the provision in the appropriate location.
- *The text before some **[OPTIONAL]** provisions is provided as guidance to consider when deciding upon inclusion of the **[OPTIONAL]** provision. The box and text should be deleted in the final adopted ordinance.*

The final ordinance adopted by the municipality should be developed in conjunction with, reviewed by, and agreed upon by the municipal solicitor, engineer, and governing body.

STORMWATER MANAGEMENT MODEL ORDINANCE

Implementing the Requirements of the

McKean County Stormwater Management Plan

ORDINANCE NO. _________ OF_________

[Municipality], MCKEAN COUNTY, PENNSYLVANIA

Adopted at a Public Meeting Held on
__________________, 2011

TABLE OF CONTENTS

ARTICLE I - GENERAL PROVISIONS

Section 101. Short Title

This Ordinance shall be known and may be cited as the "***Municipality*** Stormwater Management Ordinance."

Section 102. Statement of Findings

The governing body of ***Municipality*** finds that:

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

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

C. Inadequate planning and management of stormwater runoff resulting from land development and redevelopment throughout a watershed can also harm surface water resources by changing the natural hydrologic patterns; accelerating stream flows (which increase scour and erosion of streambeds and stream banks thereby elevating sedimentation); destroying aquatic habitat; and elevating aquatic pollutant concentrations and loadings such as sediments, nutrients, heavy metals, and pathogens. Groundwater resources are also impacted through loss of recharge.

D. Stormwater is an important water resource which provides groundwater recharge for water supplies and base flow of streams, which also protects and maintains surface water quality.

E. Public education on the control of pollution from stormwater is an essential component in successfully addressing stormwater issues.

F. Federal and state regulations require certain municipalities to implement a program of stormwater controls. These municipalities are required to obtain a permit for stormwater discharges from their separate storm sewer systems under the National Pollutant Discharge Elimination System (NPDES).

G. Non-stormwater discharges to municipal separate storm sewer systems can contribute to pollution of Waters of the Commonwealth.

Section 103. Purpose

The purpose of this Ordinance is to promote health, safety, and welfare within ***[Municipality]***, McKean County, by minimizing the harms and maximizing the benefits described in Section 102 of this Ordinance through provisions intended to:

A. Meet legal water quality requirements under state law, including regulations at 25 PA Code Chapter 93 to protect, maintain, reclaim, and restore the existing and designated uses of the Waters of the Commonwealth.

B. Manage accelerated runoff and erosion and sedimentation problems close to their source, by regulating activities that cause these problems.

C. Preserve the natural drainage systems as much as possible.

D. Maintain groundwater recharge, to prevent degradation of surface and groundwater quality, and to otherwise protect water resources.

E. Maintain existing flows and quality of streams and watercourses.

F. Preserve and restore the flood-carrying capacity of streams and prevent scour and erosion of stream banks and streambeds.

G. Manage stormwater impacts close to the runoff source, with a minimum of structures and a maximum use of natural processes.

H. Provide procedures, performance standards, and design criteria for stormwater planning and management.

I. Provide proper operations and maintenance of all temporary and permanent stormwater management facilities and Best Management Practices (BMPs) that are constructed and implemented.

J. Provide standards to meet the NPDES permit requirements.

Section 104. Statutory Authority

A. Primary Authority: ***[Municipality]*** is empowered to regulate these activities by the authority of the Act of October 4, 1978, 32 P.S., P.L. 864 (Act 167), 32 P.S. Section 680.1 et seq., as amended, the "Storm Water Management Act", and the ***[applicable Municipal Code]***.

B. Secondary Authority: ***[Municipality]*** also is empowered to regulate land use activities that affect runoff by the authority of the Act of July 31, 1968, P.L. 805, No. 247, The Pennsylvania Municipalities Planning Code, as amended.

Section 105. Applicability

In ***(Municipality***), all regulated activities and all activities that may affect stormwater runoff, including land development and earth disturbance activity, are subject to regulation by this ordinance.

Earth disturbance activities and associated stormwater management controls are also regulated under existing state law and implementing regulations. This Ordinance shall operate in coordination with those parallel requirements; the requirements of this Ordinance shall be no less restrictive in meeting the purposes of this Ordinance than state law.

"Regulated Activities" are any earth disturbance activities or any activities that involve the alteration or development of land in a manner that may affect stormwater runoff. "Regulated Activities" include, but are not limited to, the following listed items:

A. Earth Disturbance Activities
B. Land Development
C. Subdivision
D. Construction of new or additional impervious or semi-pervious surfaces
E. Construction of new buildings or additions to existing buildings
F. Diversion or piping of any natural or man-made stream channel
G. Installation of stormwater management facilities or appurtenances thereto
H. Installation of stormwater BMPs

See Section 302 of this Ordinance for Exemption/Modification Criteria.

Section 106. Repealer

Any ordinance, ordinance provision(s), or regulation of ***[Municipality]*** inconsistent with any of the provision(s) of this Ordinance is hereby repealed to the extent of the inconsistency only.

Section 107. Severability

In the event that a court of competent jurisdiction declares any section(s) or provision(s) of this Ordinance invalid, such decision shall not affect the validity of any of the remaining section(s) or provision(s) of this Ordinance.

Section 108. Compatibility with Other Ordinance Requirements

Approvals issued and actions taken pursuant to this Ordinance do not relieve the Applicant of the responsibility to comply with or to secure required permits or approvals for activities regulated by any other applicable codes, laws, rules, statutes, or ordinances. To the extent that this Ordinance imposes more rigorous or stringent requirements for stormwater management, the specific requirements contained in this Ordinance shall be followed.

Section 109. Duty of Persons Engaged in the Development of Land

Notwithstanding any provision(s) of this Ordinance, including exemptions, any landowner or any person engaged in the alteration or development of land which may affect stormwater runoff characteristics shall implement such measures as are reasonably necessary to prevent injury to health, safety, or other property. Such measures also shall include actions as are required to manage the rate, volume, direction, and quality of resulting stormwater runoff in a manner which otherwise adequately protects health, property, and water quality.

Section 110. Municipal Liability Disclaimer

A. Neither the granting of any approval under this Ordinance, nor the compliance with the provisions of this Ordinance, or with any condition imposed by a municipal official hereunder, shall relieve any person from any responsibility for damage to persons or property resulting there from, or as otherwise imposed by law nor impose any liability upon the Municipality for damages to persons or property.

B. The granting of a permit which includes any storm water management facilities shall not constitute a representation, guarantee or warranty of any kind by the Municipality, or by an official or employee thereof, of the practicability or safety of any structure, use or other plan proposed, and shall create no liability upon or cause of action against such public body, official or employee for any damage that may result pursuant thereto.

ARTICLE II - DEFINITIONS

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

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

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

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

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

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

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

Agricultural Activities - Activities associated with agriculture such as agricultural cultivation, agricultural operation, and animal heavy use areas. This includes the work of producing crops, tillage, land clearing, plowing, disking, harrowing, planting, harvesting crops, or pasturing and raising of livestock and installation of conservation measures. Construction of new buildings or impervious area is not considered an Agricultural Activity.

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

Applicant - A landowner, developer, or other person who has filed an application for approval to engage in any Regulated Activities at a project site within the municipality.

Best Management Practices (BMPs) - Activities, facilities, designs, measures or procedures used to manage stormwater impacts from Regulated Activities, to meet State Water Quality Requirements, to promote groundwater recharge and to otherwise meet the purposes of this Ordinance. Stormwater BMPs are commonly grouped into one of two broad categories or measures: "non-structural" or "structural". "Non-structural" BMPs are measures referred to as operational and/or behavior-related practices that attempt to minimize the contact of pollutants with stormwater runoff whereas "structural" BMPs are measures that consist of a physical device or practice that is installed to capture and treat stormwater runoff. "Structural" BMPs include, but are not limited to, a wide variety of practices and devices, from large-scale retention ponds and constructed wetlands, to small-scale underground treatment systems, infiltration facilities, filter strips, low impact design, bioretention, wet ponds, permeable paving, grassed swales, riparian or forested buffers, sand filters, detention basins, and manufactured devices. "Structural" stormwater BMPs are permanent appurtenances to the project site.

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

Cistern - An underground reservoir or tank used for storing rainwater.

Conservation District - The McKean County Conservation District. The McKean County Conservation District has the authority under a delegation agreement executed with the Department of Environmental Protection to administer all or a portion of the regulations promulgated under 25 PA Code Chapter 102.

Culvert - A structure with appurtenant works that carries a stream and/or stormwater runoff under or through an embankment or fill.

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

Design Storm - The magnitude and temporal distribution of precipitation from a storm event measured in probability of occurrence (e.g., a 25-year storm) and duration (e.g., 24-hours), used in the design and evaluation of stormwater management systems. Also see Return Period.

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

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

Detention Volume - The volume of runoff that is captured and released into Waters of the Commonwealth at a controlled rate.

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

Development Site - **(Site)** - The specific tract of land for which a Regulated Activity is proposed. Also see Project Site.

Disturbed Area - An unstabilized land area where an Earth Disturbance Activity is occurring or has occurred.

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

Drainage Conveyance Facility - A stormwater management facility designed to convey stormwater runoff and shall include streams, channels, swales, pipes, conduits, culverts, storm sewers, etc.

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

Drainageway - Any natural or artificial watercourse, trench, ditch, pipe, swale, channel, or similar depression into which surface water flows.

Earth Disturbance Activity - A construction or other human activity which disturbs the surface of the land, including, but not limited to, clearing and grubbing, grading, excavations, embankments, land development, agricultural plowing or tilling, timber harvesting activities, road maintenance activities, mineral extraction, and the moving, depositing, stockpiling, or storing of soil, rock or earth materials.

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

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

Exceptional Value Waters - Surface waters of high quality, which satisfies PA Code Title 25 Environmental Protection, Chapter 93 Water Quality Standards 93.4b(b) (relating to anti-degradation).

Existing Conditions - The initial condition of a project site prior to the proposed construction. If the initial condition of the site is undeveloped land and not forested, the land use shall be considered as "meadow" unless the natural land cover is documented to generate lower Curve Numbers or Rational "C" Coefficient.

FEMA - The Federal Emergency Management Agency.

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

Flood Fringe - The remaining portions of the 100-year floodplain outside of the floodway boundary.

Floodplain - Any land area susceptible to inundation by water from any natural source or delineated by applicable Department of Housing and Urban Development, Federal Insurance Administration Flood Hazard Boundary - mapped as being a special flood hazard area. Included are lands adjoining a river or stream that have been or may be inundated by a 100-year flood. Also included are areas that comprise Group 13 Soils, as listed in Appendix A of the Pennsylvania Department of Environmental Protection (PADEP) Technical Manual for Sewage Enforcement Officers (as amended or replaced from time to time by PADEP).

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

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

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

Grade - A slope, usually of a road, channel or natural ground specified in percent and shown on plans as specified herein.

(To) Grade - To finish the surface of a roadbed, top of embankment or bottom of excavation.

Groundwater Recharge - Replenishment of existing natural underground water supplies.

HEC-HMS Model Calibrated - (Hydrologic Engineering Center Hydrologic Modeling System) A computer-based hydrologic modeling technique adapted to the watershed(s) in McKean County for the Act 167 Plan. The model has been calibrated by adjusting key model input parameters.

High Quality Waters - Surface water having quality, which exceeds levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water by satisfying PA Code Title 25 Environmental Protection, Chapter 93 Water Quality Standards 93.4b(a).

Hydrologic Soil Group (HSG) - Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into one of four HSG (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. The Natural Resource Conservation Service (NRCS) of the US Department of Agriculture defines the four groups and provides a list of most of the soils in the United States and their group classification. The soils in the area of interest may be identified from a soil survey report from the NRCS office or their website (http://websoilsurvey.nrcs.usda.gov.local).

Impervious Surface (Impervious Area) - A surface that prevents the infiltration of water into the ground. Impervious surface (or areas) include, but is not limited to: roofs, additional indoor living spaces, patios, garages, storage sheds and similar structures, parking or driveway areas, and any new streets and sidewalks. Any surface areas proposed to initially be gravel or crushed stone shall be assumed to be impervious surfaces.

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

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

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

Karst - A type of topography or landscape characterized by surface depressions, sinkholes, rock pinnacles/uneven bedrock surface, steep-sided hills, underground drainage and caves. Karst is formed on carbonate rocks, such as limestone or dolomites and sometimes gypsum.

Land Development (Development) - (1) The improvement of one lot or two or more contiguous lots, tracts or parcels of land for any purpose involving:

> (i) a group of two or more residential or nonresidential buildings, whether proposed initially or cumulatively, or a single nonresidential building on a lot or lots regardless of the number of occupants or tenure; or
>
> (ii) the division or allocation of land or space, whether initially or cumulatively, between or among two or more existing or prospective occupants by means of, or for the purpose of streets, common areas, leaseholds, condominiums, building groups or other features.

(2) A subdivision of land.
(3) Development in accordance with section 503(1.1) of the PA Municipalities Planning Code.

Main Stem (Main Channel) - Any stream segment or other runoff conveyance facility used as a reach in the McKean County Act 167 watershed hydrologic model(s).

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

Municipality - ***[Municipality]***, McKean County, Pennsylvania.

National Pollutant Discharge Elimination System (NPDES) - The federal government's system for issuance of permits under the Clean Water Act, which is delegated to PADEP in Pennsylvania.

NOAA Atlas 14: - Precipitation-Frequency Atlas of the United States, Atlas 14, Volume 2, US Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Hydrometeorological Design Studies Center, Silver Spring, Maryland (2004). NOAA's Atlas 14 can be accessed at Internet address: http://hdsc.nws.noaa.gov/hdsc/pfds/.

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

NRCS - Natural Resource Conservation Service (previously Soil Conservation Service (SCS)).

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

Outfall - (i) Point where water flows from a conduit, stream, or drain; (ii) "Point Source" as described in 40 CFR § 122.2 at the point where the Municipality's storm sewer system discharges to surface Waters of the Commonwealth.

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

PADEP - The Pennsylvania Department of Environmental Protection.

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

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

Person - An individual, partnership, public or private association or corporation, or a governmental unit, public utility or any other legal entity whatsoever which is recognized by law as the subject of rights and duties.

Pervious Area - Any area not defined as impervious.

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

Planning Commission - The Planning Commission of ***[Municipality]***.

Point Source - Any discernible, confined, or discrete conveyance, including, but not limited to: any pipe, ditch, channel, tunnel, or conduit from which stormwater is or may be discharged, as defined in State regulations at 25 Pennsylvania Code § 92.1.

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

Project Site - The specific area of land where any Regulated Activities in the Municipality are planned, conducted, or maintained.

Qualified Professional - Any person licensed by the Pennsylvania Department of State or otherwise qualified by law to perform the work required by the Ordinance.

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

Redevelopment - Earth disturbance activities on land, which has previously been developed.

Regulated Activities - Any earth disturbance activities or any activities that involve the alteration or development of land in a manner that may affect stormwater runoff.

Regulated Earth Disturbance Activity - Activity involving Earth Disturbance subject to regulation under 25 PA Code Chapter 92, Chapter 102, or the Clean Streams Law.

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

Release Rate District - Those subwatershed areas in which post-development flows must be reduced to a certain percentage of pre-development flows as required to meet the plan requirements and the goals of Act 167.

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

Retention Volume/Removed Runoff - The volume of runoff that is captured and not released directly into the surface Waters of this Commonwealth during or after a storm event.

Return Period - The average interval, in years, within which a storm event of a given magnitude can be expected to recur. For example, the 25-year return period rainfall would be expected to recur on the average once every twenty-five years; or stated in another way, the probability of a 25-year storm occurring in any one given year is 0.04 (i.e. a 4% chance).

Riparian Buffer - A vegetated area bordering perennial and intermittent streams and wetlands, that serves as a protective filter to help protect streams and wetlands from the impacts of adjacent land uses.

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

Road Maintenance - Earth disturbance activities within the existing road right-of-way, such as grading and repairing existing unpaved road surfaces, cutting road banks, cleaning or clearing drainage ditches, and other similar activities. Road maintenance activities that do not disturb the subbase of a paved road (such as milling and overlays) are not considered earth disturbance activities.

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

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

Runoff Capture Volume - The volume of runoff that is captured (retained) and not released into surface Waters of the Commonwealth during or after a storm event.

Sediment - Soils or other materials transported by surface water as a product of erosion.

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

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

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

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

Separate Storm Sewer System - A conveyance or system of conveyances (including roads with drainage systems, Municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) primarily used for collecting and conveying stormwater runoff.

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

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

Spillway (Emergency) - A depression in the embankment of a pond or basin, or other overflow structure, that is used to pass peak discharges greater than the maximum design storm controlled by the pond or basin.

State Water Quality Requirements - The regulatory requirements to protect, maintain, reclaim, and restore water quality under Title 25 of that Pennsylvania Code and the Clean Streams Law.

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

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

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

Stormwater - Drainage runoff from the surface of the land resulting from precipitation, snow, or ice melt.

Stormwater Hotspot - A land use or activity that generates higher concentrations of hydrocarbons, trace metals, or toxicants than are found in typical stormwater runoff.

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

Stormwater Management Plan - The McKean County Stormwater Management Plan for managing stormwater runoff in McKean County as required by the Act of October 4, 1978, P.L. 864, (Act 167) and known as the "Storm Water Management Act".

Stormwater Management Site Plan (SWM Site Plan) - The plan prepared by the Applicant or his representative indicating how stormwater runoff will be managed at the project site in accordance with this Ordinance.

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

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

Subdivision - the division or redivision of a lot, tract or parcel of land by any means into two or more lots, tracts, parcels or other divisions of land including changes in existing lot lines for the purpose, whether immediate or future, of lease, partition by the court for distribution to heirs or devisees, transfer of ownership or building or lot development: Provided, however, That the subdivision by lease of land for agricultural purposes into parcels of more than ten acres, not involving any new street or easement of access or any residential dwelling, shall be exempted{Pennsylvania Municipalities Planning Code, Act of July 31, 1968, P.L. 805, No. 247}.

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

Timber Operations - See "Forest Management".

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

USDA - The United States Department of Agriculture.

Watercourse - A channel or conveyance of surface water, such as a stream or creek, having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

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

Watershed - Region or area drained by a river, watercourse, or other surface water, whether natural or artificial.

Wetland - Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas. (The term includes but is not limited to wetland areas listed in the State Water Plan, the United States Forest Service Wetlands Inventory of Pennsylvania, the Pennsylvania Coastal Zone Management Plan and a wetland area designated by a river basin commission. This definition is used by the United States Environmental Protection Agency and the United States Army Corps of Engineers.)

ARTICLE III - STORMWATER MANAGEMENT STANDARDS

Section 301. General Requirements

A. For all Regulated Activities, unless specifically exempted in Section 302:

1. Preparation and implementation of an approved SWM Site Plan is required.
2. No Regulated Activities shall commence until the municipality issues written approval of a SWM Site Plan, which demonstrates compliance with the requirements of this Ordinance.
3. The SWM Site Plan shall demonstrate that adequate capacity will be provided to meet the Volume and Rate Control Requirements, as described under Sections 304 and 305 of this Ordinance.
4. The SWM Site Plan approved by the municipality, shall be on-site throughout the duration of the Regulated Activities.

B. For all Regulated Earth Disturbance Activities, erosion and sediment control BMPs shall be designed, implemented, operated, and maintained during the Regulated Earth Disturbance Activities (e.g., during construction) to meet the purposes and requirements of this Ordinance and to meet all requirements under Title 25 of the Pennsylvania Code (including, but not limited to Chapter 102 Erosion and Sediment Control) and the Clean Streams Law. Various BMPs and their design standards are listed in the *Erosion and Sediment Pollution Control Program Manual* (E&S Manual), No. 363-2134-008 (April 15, 2000), as amended and updated.

C. For all Regulated Activities, stormwater BMPs shall be designed, installed, implemented, operated, and maintained to meet the purposes and requirements of this Ordinance and to meet all requirements under Title 25 of the Pennsylvania Code and the Clean Streams Law, conform to the State Water Quality Requirements, meet all requirements under the Storm Water Management Act and any more stringent requirements as determined by the municipality.

D. The municipality may, after consultation with PADEP, approve measures for meeting the State Water Quality Requirements other than those in this Ordinance, provided that they meet the minimum requirements of, and do not conflict with state law, including, but not limited to, the Clean Streams Law.

E. All Regulated Activities shall include, to the maximum extent practicable, measures to:

1. Protect health, safety, and property.
2. Meet the water quality goals of this Ordinance by implementing measures to:
    a. Minimize disturbance to floodplains, wetlands, natural slopes, existing native vegetation and woodlands.
    b. Create, maintain, or extend riparian buffers and protect existing forested buffers.
    c. Provide trees and woodlands adjacent to impervious areas whenever feasible.
    d. Minimize the creation of impervious surfaces and the degradation of Waters of the Commonwealth and promote groundwater recharge.
    e. Protect natural systems and processes (drainageways, vegetation, soils, and sensitive areas) and maintain, as much as possible, the natural hydrologic regime.
    f. Incorporate natural site elements (wetlands, stream corridors, mature forests) as design elements.
    g. Avoid erosive flow conditions in natural flow pathways.

h. Minimize soil disturbance and soil compaction.
i. Minimize thermal impacts to Waters of the Commonwealth.
j. Disconnect impervious surfaces by directing runoff to pervious areas, wherever possible and decentralize and manage stormwater at its source.

F. Impervious Areas:
  1. The measurement of impervious areas shall include all of the impervious areas in the total proposed development, even if development is to take place in stages.
  2. For developments taking place in stages, the entire development plan must be used in determining conformance with this Ordinance.

G. If diffused flow is proposed to be concentrated and discharged onto adjacent property, the Applicant must document that adequate downstream conveyance facilities exist to safely transport the concentrated discharge, or otherwise prove that no erosion, sedimentation, flooding, or other harm will result from the concentrated discharge.
  1. Applicant must provide an easement for proposed concentrated flow across adjacent properties.

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

I. Where watercourses traverse a development site, drainage easements (with a minimum width of 20 feet) shall be provided conforming to the line of such watercourses. The terms of the easement shall prohibit excavation, the placing of fill or structures, and any alterations that may adversely affect the flow of stormwater within any portion of the easement. Also, maintenance, including mowing of vegetation within the easement may be required, except as approved by the appropriate governing authority.

J. When it can be shown that, due to topographic conditions, natural drainageways on the site cannot adequately provide for drainage, open channels may be constructed conforming substantially to the line and grade of such natural drainageways. Work within natural drainage ways shall be subject to approval by PADEP under regulations at 25 PA Code Chapter 105 through the Joint Permit Application process, or, where deemed appropriate by PADEP, through the General Permit process.

K. Any stormwater management facilities or any facilities that constitute water obstructions (e.g., culverts, bridges, outfalls, or stream enclosures, etc.) that are regulated by this Ordinance, that will be located in or adjacent to Waters of the Commonwealth (including wetlands), shall be subject to approval by PADEP under regulations at 25 PA Code Chapter 105 through the Joint Permit Application process, or, where deemed appropriate by PADEP, the General Permit process. When there is a question whether wetlands may be involved, it is the responsibility of the Applicant or his agent to show that the land in question cannot be classified as wetlands; otherwise, approval to work in the area must be obtained from PADEP.

L. Should any stormwater management facility require a dam safety permit under PADEP Chapter 105, the facility shall be designed in accordance with Chapter 105 and meet the regulations of Chapter 105 concerning dam safety.

M. Any stormwater management facilities regulated by this Ordinance that will be located on, or discharged onto State highway rights-of-ways shall be subject to approval by the Pennsylvania Department of Transportation (PENNDOT).

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

O. Infiltration BMPs should be dispersed throughout the site, made as shallow as practicable, and located to maximize use of natural on-site infiltration features while still meeting the other requirements of this Ordinance. Soil compaction must be avoided or minimized in those areas.

P. The design of facilities over karst shall include an evaluation and implementation of measures to minimize adverse effects.

Q. Roof drains shall not be connected to streets, sanitary or storm sewers, or roadside ditches in order to promote overland flow and infiltration/percolation of stormwater where it is advantageous to do so. When it is more advantageous to connect directly to streets or storm sewers, then the Municipality shall permit it on a case-by-case basis.

R. Applicants are encouraged to use Low Impact Development Practices to reduce the costs of complying with the requirements of this Ordinance and the State Water Quality Requirements.

S. When stormwater management facilities are proposed within 1,000 feet of a downstream Municipality, the Developer shall notify the downstream municipality (and provide a copy of the SWM Plan if requested).

Section 302. Exemptions/Modifications

A. Under no circumstance shall the Applicant be exempt from implementing such measures as necessary to:

1. Meet State Water Quality Standards and Requirements.
2. Protect health, safety, and property.
3. Meet special requirements for High Quality (HQ) and Exceptional Value (EV) watersheds.

B. The Applicant must utilize the following BMPs to the maximum extent practicable to receive consideration for the exemptions:

1. Design around and limit disturbance of Floodplains, Wetlands, Natural Slopes over 15%, existing native vegetation, and other sensitive and special value features.
2. Maintain riparian and forested buffers.
3. Limit grading and maintain non-erosive flow conditions in natural flow paths.
4. Maintain existing tree canopies near impervious areas.
5. Minimize soil disturbance and reclaim disturbed areas with topsoil and vegetation.
6. Direct runoff to pervious areas.

C. The Applicant's proposed development/additional impervious area may not adversely impact the following:

1. Capacities of existing drainageways and storm sewer systems.
2. Velocities and erosion.
3. Quality of runoff if direct discharge is proposed.
4. Existing known problem areas.
5. Safe conveyance of the additional runoff.
6. Downstream property owners.

D. An Applicant proposing Regulated Activities, may be eligible for exemption from Rate Control, Volume Control, or Stormwater Management Site Plan requirements in this Ordinance according to the following table:

Table 302.1 Exemptions and Submission Requirements

New Impervious Area[1, 2] (square footage)	Applicant Must Provide
0 < 5,000	No submission is required[3]
5,000 and greater	Rate Controls, Volume Controls & SWM Site Plan

NOTES:

[1] New Impervious Area since the date of Adoption of this Ordinance.

[2] Gravel in existing condition shall be considered pervious and gravel in proposed condition shall be considered impervious.

[3] The Small Project Stormwater Management Application included in Appendix E shall be used to document new impervious surface.

E. Single Family Residential activities are exempt from these requirements provided the construction:
   1. Comply with Sections 301.G, 302.A, 302.B, 302.C, and
   2. Have building setback 75 feet from downstream property lines, and
   3. Driveways:
      a. Runoff must discharge onto pervious surface with a gravel strip or other spreading device.
      b. No more than 1,000 square feet of paved surface may discharge to any one point.
      c. The length of flow on the pervious must exceed the length of the paved surface flow.

F. The municipality can require more information or require mitigation of certain impacts through installation of stormwater management BMP's if there is a threat to property, health, or safety.

G. An Applicant proposing Regulated Activities, after demonstrating compliance with Sections 302.A, 302.B, and 302.C, may be exempted from various requirements of this Ordinance if documentation can be provided that a downstream man-made water body (i.e., reservoir, lake, or man-made wetlands) has been designed or modified to address the potential stormwater flooding impacts of the proposed development.

H. The purpose this section is to ensure consistency of stormwater management planning between local ordinances and NPDES permitting (when required) and to ensure that the Applicant has a single and clear set of stormwater management standards to which the Applicant is subject. The Municipality may accept alternative stormwater management controls under this section provided that:

   1. The Municipality, in consultation with the PADEP, determines that meeting the Volume Control requirements (See Section 304) is not possible or places an undue hardship on the Applicant.
   2. The alternative controls are documented to be acceptable to PADEP, for NPDES requirements pertaining to post construction stormwater management requirements.
   3. The alternative controls are in compliance with all other sections of this ordinance, including but not limited to Sections 301.D and 302.A-C.

I. Agricultural activity is exempt from the rate control and SWM Site Plan preparation requirements of this Ordinance provided the activity is performed according to the requirements of 25 PA Code Chapter 102.

J. Forest management and timber operations are exempt from the Rate and Volume Control requirement and SWM Site Plan preparation requirement of this Ordinance provided the activities are performed according to the requirements of 25 PA Code Chapter 102. It should be noted that temporary roadways are not exempt.

K. Linear roadway improvement projects that create additional impervious area are not exempt from the requirements of this Ordinance. However, innovative and alternative stormwater management strategies may be applied at the joint approval of the Municipality and the McKean County Conservation District (if an NPDES permit is required) when site limitations (such as limited right-of-way) and constraints (as shown and provided by the Applicant), preclude the ability of the Applicant to meet the enforcement of the stormwater management standards in this Ordinance. All strategies must be consistent with PADEP's regulations, including NPDES requirements.

L. The Municipality may deny or revoke any exemption pursuant to this Section at any time for any project that the Municipality believes may pose a threat to public health, safety, property or the environment.

Section 303. Waivers

A. The provisions of this Ordinance are the minimum standards for the protection of the public welfare.

B. All waiver requests must meet the provisions of Section 303.G. and H. Waivers shall not be issued from implementing such measures as necessary to:

1. Meet State Water Quality Standards and Requirements.
2. Protect health, safety, and property.
3. Meet special requirements for High Quality (HQ) and Exceptional Value (EV) watersheds.

Municipalities will then consider waivers in accordance with Section 301.D; except that waiver requests for relief from the design requirements of Sections 801.B and 801.C will be processed by the Municipality at its sole discretion.

C. If an Applicant demonstrates to the satisfaction of the governing body of the Municipality that any mandatory provision of this Ordinance is unreasonable or causes unique or undue unreasonableness or hardship as it applies to the proposed Project, or that an alternate design may result in a superior result within the context of Section 102 and 103 of this Ordinance, the governing body of the Municipality upon obtaining the comments and recommendations of the Municipal Engineer and Conservation District may grant a waiver or relief so that substantial justice may be done and the public interest is secured; provided that such waiver will not have the effect of nullifying the intent and purpose of this Ordinance.

D. The Applicant shall submit all requests for waivers in writing and shall include such requests as a part of the plan review and approval process. The Applicant shall state in full the facts of unreasonableness or hardship on which the request is based, the provision or provisions of the Ordinance that are involved, and the minimum waiver or relief that is necessary. The Applicant shall state how the requested waiver and how the Applicant's proposal shall result in an equal or better means of complying with the intent or Purpose and general principles of this Ordinance.

E. The Municipality shall keep a written record of all actions on waiver requests.

F. The Municipality may charge a fee for each waiver request, which shall be used to offset the administrative costs of reviewing the waiver request. The Applicant shall also agree to reimburse the Municipality for reasonable and necessary fees that may be incurred by the Municipal Engineer in any review of a waiver request.

G. In granting waivers, the Municipality may impose reasonable conditions at will, in its judgment, secure substantially the objectives of the standards or requirements that are to be modified.

H. The Municipality may grant applications for waivers when the following findings are made, as relevant:

1. That the waiver shall result in an equal or better means of complying with the intent of this Ordinance.
2. That the waiver is the minimum necessary to provide relief.
3. That the applicant is not requesting a waiver based on cost considerations.
4. That existing down gradient stormwater problems will not be exacerbated.
5. That runoff is not being diverted to a different drainage area.
6. That increased flooding or ponding on off-site properties or roadways will not occur.
7. That potential icing conditions will not occur.
8. That increase of peak flow or volume from the site will not occur.
9. That erosive conditions due to increased peak flows or volume will not occur.
10. That adverse impact to water quality will not result.
11. That increased 100-Year Floodplain levels will not result.
12. That increased or unusual municipal maintenance expenses will not result from the waiver.
13. That the amount of stormwater generated has been minimized to the greatest extent allowed.
14. That infiltration of runoff throughout the proposed site has been provided where practicable and pre-development ground water recharge protected.
15. That peak flow attenuation of runoff has been provided.
16. That long term operation and maintenance activities are established.
17. That the receiving streams and/or water bodies will not be adversely impacted in flood carrying capacity, aquatic habitat, channel stability and erosion and sedimentation.

Section 304. Volume Controls

A. The Low Impact Development Practices provided in the BMP Manual and in Appendix B of this Ordinance shall be utilized for all Regulated Activities to the maximum extent practicable.

B. Stormwater runoff Volume Controls shall be implemented using the *Design Storm Method* or the *Simplified Method* as defined below. For Regulated Activity areas equal or less than one (1) acre that do not require hydrologic routing to design the stormwater facilities, this Ordinance establishes no preference for either method; therefore, the Applicant may select either method on the basis of economic considerations, the intrinsic limitations on applicability of the analytical procedures associated with each methodology, and other factors.

1. The *Design Storm Method* (CG-1 in the BMP Manual) is applicable to any sized Regulated Activity. This method requires detailed modeling based on site conditions.

a. Do not increase the post-development total runoff volume when compared to the pre-development total runoff volume for the 2-year/24-hour storm event.

b. For hydrologic modeling purposes:

   i. Existing non-forested pervious areas must be considered meadow (good condition) for pre-development hydrologic calculations.
   ii. Twenty (20) percent of existing impervious area, when present within the proposed project site, shall be considered meadow (good condition) for pre-development hydrologic calculations for re-development.

2. The *Simplified Method* (CG-2 in the BMP Manual) is independent of site conditions and should be used if the *Design Storm Method* is not followed. This method is not applicable to Regulated Activities greater than 1 acre or for projects that require detailed design of stormwater storage facilities. For new impervious surfaces:

   a. Stormwater facilities shall capture at least the first 2 inches of runoff from all new impervious surfaces.

   b. At least the first 1 inch of runoff from new impervious surfaces shall be permanently removed from the runoff flow, i.e. it shall not be released into surface Waters of the Commonwealth. Removal options include reuse, evaporation, transpiration, and infiltration.

   c. Wherever possible, infiltration facilities should be designed to accommodate infiltration of the entire permanently removed runoff; however, in all cases at least the first 0.5 inch of the permanently removed runoff should be infiltrated.

   d. Actual field infiltration tests at the location of the proposed elevation of the stormwater BMPs are required. Infiltration test shall be conducted in accordance with the BMP Manual. Notification of the Municipality shall be provided to allow witnessing of the testing.

C. The applicable Worksheets from the BMP Manual must be used in calculations to establish Volume Control.

Section 305. Rate Controls

A. Lands contained within McKean County that have not had release rates established under an approved Act 167 Stormwater Management Plan:

   1. Post-development discharge rates shall not exceed the pre-development discharge rates for the 1-year, 2-year, 10-year, 25-year, 50-year, and 100-year storms.

B. Lands contained within McKean County that have had release rates established under an approved Act 167 Stormwater Management Plan:

   1. The post-development peak discharge rates shall be in accordance with the approved release rate map for the individual watershed.
      a. Tunungwant Creek Watershed – 70% and 100% release rate districts have been established; refer to Appendix F.
      b. Allegheny River Watershed - 100% release rate districts have been established; refer to Appendix F.

ARTICLE IV - E&S STANDARDS

Section 401. Erosion and Sedimentation Requirements During Earth Disturbance Activities

A. The applicant shall meet requirements as contained in 25 PA Code, Chapters 92 and 102 as required and applicable as follows:

   1. The implementation and maintenance of erosion and sediment control BMPs.
   2. Development of written plans.
   3. Submission of plans for approval.
   4. Obtaining Erosion and Sediment Control and NPDES permits.
   5. Maintaining plans and permits on site.

B. Evidence of any necessary plan or permit approval for Earth Disturbance activities from PADEP or the McKean County Conservation District must be provided to the Municipality.

C. A copy of the approved Erosion and Sediment Control Plan and any other permit, as required by PADEP or the McKean County Conservation District, shall be available at the project site at all times if required under Chapter 102.

D. Construction of temporary roadways (e.g., for utility construction, timber harvesting, etc.) shall comply with all applicable standards for erosion and sedimentation control and stream crossing regulations under 25 PA Code, Chapters 102 and 105. The Erosion and Sedimentation Control Plan shall be submitted to the McKean County Conservation District for approval and shall address the following, as applicable:

   1. Design of the roadway system, including haul roads, skid roads, landing areas, trails, and storage and staging areas.
   2. Runoff control structures (e.g., diversions, culverts, detention ponds, etc.).
   3. Stream crossings for both perennial and intermittent streams.
   4. Access to public roadways, including design of rock construction entrance for mud and debris control.
   5. A remediation plan for restoring the disturbed area through re-grading, topsoil placement, reseeding, and other stabilization techniques, as required.

E. Additional erosion and sedimentation control design standards and criteria that must be applied where infiltration BMPs are proposed include the following:

   1. Areas proposed for infiltration BMPs shall be protected from sedimentation and compaction during the construction phase, as to maintain their maximum infiltration capacity.
   2. Infiltration BMPs shall be protected from receiving sediment-laden runoff.
   3. The source of protection for infiltration BMPs shall be identified (i.e. orange construction fence surrounding the perimeter of the BMP).

ARTICLE V – PROTECTED WATERSHED STANDARDS

Section 501. Reserved

ARTICLE VI – RIPARIAN BUFFER STANDARDS

Section 601. Reserved

ARTICLE VII - SWM SITE PLAN & REPORT REQUIREMENTS

Section 701. General Requirements

For any of the activities regulated by this Ordinance and not eligible for the exemptions provided in Section 302, the final approval of subdivision and/or land development plans, the issuance of any building or occupancy permit, or the commencement of any land disturbance activity, may not proceed until the Applicant has received written approval of a SWM Site Plan from the Municipality.

Section 702. SWM Site Plan & Report Contents

The SWM Site Plan & SWM Site Report shall consist of all applicable calculations, maps, and plans. All SWM Site Plan materials shall be submitted to the Municipality in a format that is clear, concise, legible, neat and well organized; otherwise, the SWM Site Plan shall be rejected.

Appropriate sections from the County and/or Municipal Subdivision and Land Development Ordinance, and other applicable local ordinances, shall be followed in preparing the SWM Site Plan.

A. SWM Site Plan shall include, but not be limited to:

1. Plans shall be of one size and in a form that meets the requirements for recording in the Office of the Recorder of Deeds of McKean County.
    a. Plans for tracts of less than 20 acres shall be drawn at a scale of one inch equals no more than 50 ft.;
    b. Plans for tracts of 20 acres or more, plans shall be drawn at a scale of one inch equals no more than 100 ft;
    c. All lettering shall be drawn to a size to be legible if the plans are reduced to half size.

2. The name of the development; name and location address of the property site; name, address, and telephone number of the Applicant/Owner of the property; and name, address, telephone number, email address, and engineering seal of the individual preparing the SWM Site Plan.

3. The date of submission and dates of all revisions.

4. A graphical and written scale on all drawings and maps.

5. A north arrow on all drawings and maps.

6. A location map at a minimum scale of one (1) inch equals one-thousand (1,000) feet and illustrates the project relative to highways, municipalities or other identifiable landmarks.

7. Metes and bounds description of the lot(s) being developed.

8. Existing and final contours at intervals:
    a. Slopes less than 5%: no greater than one (1) foot;
    b. Slopes between 5 and 15%: no greater than two (2) feet;
    c. Steep slopes (greater than 15%), 5-foot contour intervals may be used.

9. Perimeters of existing waterbodies within the project area including stream banks, lakes, ponds, springs, field delineated wetlands or other bodies of water, sinkholes, flood

hazard boundaries (FEMA delineated floodplains and floodways), areas of natural vegetation to be preserved, the total extent of the upstream area draining through the site, and overland drainage paths. In Addition, any areas necessary to determine downstream impacts, where required for proposed stormwater management facilities must be shown.

10. The location of all existing and proposed utilities, on-lot wastewater facilities, water supply wells, sanitary sewers, and water lines on and within fifty (50) feet of property lines including inlets, manholes, valves, meters, poles, chambers, junction boxes, and other utility system components.

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

12. Soil names and boundaries with identification of the Hydraulic Soil Group classification including rock outcroppings.

13. Proposed impervious surfaces (structures, roads, paved areas, and buildings), including plans and profiles of roads and paved areas and floor elevations of buildings.

14. Existing and proposed land use(s).

15. Horizontal alignment, vertical profiles, and cross sections of all open channels, pipes, swales and other BMPs.

16. The location and clear identification of the nature of permanent stormwater BMPs.

17. The location of all erosion and sedimentation control facilities, shown on a separate from the SWM Site Plan (typically an E&S Plan).

18. A minimum twenty (20) foot wide access easement around all stormwater management facilities that would provide ingress to and egress from a public right-of-way. In lieu of providing an easement to the public right-of-way, a note may be added to the plan granting the Municipality or their designees access to all easements via the nearest public right-of-way.

19. Construction details for all drainage and stormwater BMPs.

20. Identification of short-term and long-term ownership, operations, and maintenance responsibilities.

21. Notes and Statements:

    a. A statement, signed by the landowner, acknowledging that the stormwater BMPs are fixtures that cannot be altered or removed without prior approval by the Municipality.
    b. A statement referencing the Operation and Maintenance (O&M) Agreement and stating that the O&M Agreement is part of the SWM Site Plan.
    c. A note indicating that Record Drawings will be provided for all stormwater facilities prior to occupancy, or the release of the surety bond.
    d. The following signature block for the registered professional preparing the Stormwater Management Plan:

"I, ____________________________, hereby certify that the Stormwater Management Plan meets all design standards and criteria of the ***[Municipality's]*** Stormwater Management Ordinance."

e. The following signature block for the Municipal Engineer reviewing the Stormwater Management Plan:

"I, _____________________________, have reviewed this Stormwater Management Plan in accordance with the Design Standards and Criteria of the ***[Municipality's]*** Stormwater Management Ordinance."

B. SWM Site Report shall include (but not limited to):

1. General data including:
    a. Project Name
    b. Project location - address of the property site
    c. Name, address, and telephone number of the Applicant/Owner of the property;
    d. Name, address, telephone number, email address, and engineering seal of the individual preparing the SWM Site Report;
    e. Date of submission and revisions.

2. Project description narrative that clearly discusses the project and provides the following information:
    a. Narrative
        - Statement of the regulated activity describing what is being proposed. Overall stormwater management concept with description of permanent stormwater management techniques, including construction specifications and materials to be used for stormwater management facilities.
        - Expected project schedule
        - Location map showing the project site and its location relative to release rate districts.
        - Detailed description of the existing site conditions including a site evaluation completed for projects proposed in areas of carbonate geology or karst topography, and other environmentally sensitive areas such as brownfields.
        - Total site area – pre and post, which must be equal or have an explanation as to why it is not
        - Total site impervious area
        - Total off-site areas
        - Number and description of stormwater management facilities
        - Type of development
        - Pre-development land use
        - Types of water quality and recharge systems used, if applicable
        - Complete hydrologic, hydraulic, and structural computations for all stormwater management facilities.
        - A written maintenance plan for all stormwater features including detention facilities and other stormwater management elements.
        - Identification of ownership and maintenance responsibility for all permanent stormwater management facilities.
        - Other pertinent information, as required

    b. Summary Tables

- Pre-development Hydrologic soil group (HSG) assumptions, curve numbers (CN), Computation of average slope, hydraulic length, computed time of concentration
- Existing conditions runoff volume & peak rate of runoff
- Post-development runoff volume & peak rate of runoff
- Undetained areas, areas to ponds
- Land use for each subarea
- Hydrologic soil group (HSG) assumptions, curve numbers (CN)
- Time of concentration computed for each subarea
- Post-development peak rate of runoff routed to ponds and out
- Pond maximum return period design data including: maximum water surface elevation, berm elevation, and emergency spillway elevation
- Water quality depth and volume requirements

c. Calculations
   - Complete hydrologic, hydraulic and structural computations, calculations, assumptions, and criteria for the design of all stormwater BMPs.
   - Details of the berm embankment and outlet structure indicating the embankment top elevation, embankment side slopes, top width of embankment, emergency spillway elevation, perforated riser dimensions, pipe barrel dimensions and dimensions and spacing of antiseep collars.
   - Design computations for the control structures (pipe barrel and riser, etc).
   - A plot or table of the stage-storage (volume vs. elevation) and all supporting computations.
   - Routing computations.

d. Drawings
   - Drainage area maps for all watersheds and inlets depicting the time of concentration path for both existing conditions and post developed condition.
   - All stormwater management facilities must be located on a plan and described in detail including easements and buffers boundaries.

3. Reports that do not clearly indicate the above information may be rejected for review by the Municipal Engineer and will be returned to the applicant.
4. Description of, justification, and actual field results for infiltration testing with respect to the type of test and test location for the design of infiltration BMPs.
5. The effect of the project (in terms of runoff volumes, water quality, and peak flows) on surrounding properties and aquatic features and on any existing municipal stormwater collection system that may receive runoff from the project site.
6. Description of the proposed changes to the land surface and vegetative cover including the type and amount of impervious area to be added.
7. Identification of short-term and long-term ownership, operation, and maintenance responsibilities as well as schedules and costs for inspection and maintenance activities for each permanent stormwater or drainage BMP, including provisions for permanent access or maintenance easements.

C. Supplemental information to be provided prior to the approval of the SWM Site Plan, as applicable:

1. Signed and executed Operations and Maintenance Agreement (Appendix A).
2. Signed and executed easements, as required for all on-site and off-site work.

3. An Erosion and Sedimentation Control Plan & approval letter from the McKean County Conservation District.
4. A NPDES Permit.
5. Permits from PADEP and ACOE.
6. Geologic Assessment.
7. Soils investigation report, including boring logs, compaction requirements, and recommendations for construction of detention basins.
8. A Highway Occupancy Permit from PENNDOT when utilization of a PENNDOT storm drainage system is proposed or when proposed facilities would encroach onto a PENNDOT right-of-way.

Section 703. SWM Site Plan & Report Submission

A. The Applicant shall submit the SWM Site Plan & Report for the Regulated Activity.

B. Five (5) copies of the SWM Site Plan & Report shall be submitted and be distributed as follows:

   1. Two (2) copies to the Municipality accompanied by the requisite executed Review Fee Reimbursement Agreement, as specified in this Ordinance
   2. One (1) copy to the Municipal Engineer
   3. One (1) copy to the McKean County Planning Commission
   4. One (1) copy to the McKean County Conservation District

C. Additional copies shall be submitted as requested by the Municipality or PADEP.

Section 704. SWM Site Plan & Report Review

A. The Municipality shall require receipt of a complete SWM Site Plan & Report as specified in this Ordinance. The Municipality shall review the SWM Site Plan & Report for consistency with the purposes, requirements, and intent of this Ordinance.
   1. If appropriate, the Plan will be reviewed by a qualified professional for the Municipality. The Developer will be responsible for paying the municipal review fee upon completion of Plan review by the qualified professional.
   2. If appropriate, the Plan will be reviewed by the McKean County Planning Commission for consistency with the purposes, requirements, and intent of the County Stormwater Management Plan

B. The Municipality shall not approve any SWM Site Plan & Report that is deficient in meeting the requirements of this Ordinance. At its sole discretion and in accordance with this Article, when a SWM Site Plan & Report is found to be deficient, the Municipality may disapprove the submission and require a resubmission, or in the case of minor deficiencies, the Municipality may accept submission of modifications.

C. The Municipality shall notify the Applicant in writing within forty-five (45) calendar days whether the SWM Site Plan & Report is approved or disapproved if the SWM Site Plan & Report is not part of a Subdivision or Land Development Plan. If the SWM Site Plan & Report involves a Subdivision or Land Development Plan, the timing shall following the Subdivision and Land Development process according to the Municipalities Planning Code.

D. The Municipal Building Permit Office shall not issue a building permit for any Regulated Activity if the SWM Site Plan & Report has been found to be inconsistent with this Ordinance, as determined by the Municipality. All required permits from PADEP must be obtained prior to issuance of a building permit.

Section 705. Modification of Plans

A. A modification to a submitted SWM Site Plan & Report for a development site that involves a change in stormwater management facilities or techniques, or that involves the relocation or re-design of stormwater management facilities, or that is necessary because soil or other conditions are not as stated on the SWM Site Plan as determined by the Municipality, shall require a resubmission of the modified SWM Site Plan in accordance with this Ordinance.

Section 706. Resubmission of Disapproved SWM Site Plan & Report

A. A disapproved SWM Site Plan & Report may be resubmitted with the revisions addressing the Municipality's concerns documented in writing, to the Municipality in accordance with this Ordinance. The developer will be responsible for paying the municipal review fee upon completion of Plan review by the qualified professional.

Section 707. Authorization to Construct and Term of Validity

A. The Municipality's approval of a SWM Site Plan & Report authorizes the Regulated Activities contained in the SWM Site Plan for a maximum term of validity of five (5) years following the date of approval. The Municipality may specify a term of validity shorter than five (5) years in the approval for any specific SWM Site Plan. Terms of validity shall commence on the date the Municipality signs the approval for a SWM Site Plan. If stormwater management facilities included in the approved SWM Site Plan have not been constructed, or if an Record Drawing of these facilities has not been approved within this time, then the Municipality may consider the SWM Site Plan disapproved and may revoke any and all permits or approvals.

Section 708. Record Drawings, Completion Certificate and Final Inspection

A. The Applicant shall be responsible for providing Record Drawings of all stormwater BMPs included in the approved SWM Site Plan. The Record Drawing and an explanation of any discrepancies with the approved SWM Site Plan shall be submitted to the Municipality as a prerequisite for the release of the guarantee or issuance of an occupancy permit.

B. The Record Drawing shall include a certification of completion signed by a Qualified Professional verifying that all permanent stormwater BMPs have been constructed according to the approved SWM Site Plan & Report. Drawings shall show all approved revisions and elevations and inverts to all manholes, inlets, pipes, and stormwater control facilities.

C. After receipt of the Record Drawing and certification of completion by the Municipality, the Municipality may conduct a final inspection.

D. If appropriate, the Plan will be reviewed by a qualified professional for the Municipality. The Developer will be responsible for paying the municipal review fee upon completion of Plan review by the qualified professional.

ARTICLE VIII - DESIGN CRITERIA

Section 801. Design Criteria for Stormwater Management & Drainage Facilities

A. General Design Guidelines:

1. Stormwater shall not be transferred from one watershed to another, unless (1) the watersheds are sub-watersheds of a common watershed which join together within the perimeter of the property; (2) the effect of the transfer does not alter the peak rate discharge onto adjacent lands; or (3) easements from the affected landowner(s) are provided.

2. Consideration shall be given to the relationship of the subject property to the drainage pattern of the watershed. A concentrated discharge of stormwater to an adjacent property shall be within an existing watercourse or confined in an easement or returned to a pre-development flow type condition.

3. Stormwater BMPs and recharge facilities are encouraged (e.g., rooftop storage, drywells, cisterns, recreation area ponding, diversion structures, porous pavements, holding tanks, infiltration systems, in-line storage in storm sewers, and grading patterns). They shall be located, designed, and constructed in accordance with the latest technical guidance published by PADEP, provided they are accompanied by detailed engineering plans and performance capabilities and supporting site specific soils, geology, runoff and groundwater and infiltration rate data to verify proposed designs. Additional guidance from other sources may be accepted at the discretion of the Municipal Engineer (a pre-application meeting is suggested).

4. All existing and natural watercourses, channels, drainage systems and areas of surface water concentration shall be maintained in their existing condition unless an alteration is approved by the appropriate regulatory agency.

5. The design of all stormwater management facilities shall incorporate sound engineering principles and practices. The Municipality shall reserve the right to disapprove any design that would result in the continuation or exacerbation of a documented adverse hydrologic or hydraulic condition within the watershed, as identified in the Plan.

6. The design and construction of multiple use stormwater detention facilities are strongly encouraged. In addition to stormwater management, facilities should, where appropriate, allow for recreational uses including ball fields, play areas, picnic grounds, etc. Consultation with the Municipality, and prior approval are required before design. Provision for permanent wet ponds with stormwater management capabilities may also be appropriate.

   a. Multiple use basins should be constructed so that potentially dangerous conditions are not created.
   b. Water quality basins or recharge basins that are designed for a slow release of water or other extended detention ponds are not permitted for recreational uses, unless the ponded areas are clearly separated and secure.

7. Should any stormwater management facility require a dam safety permit under PADEP Chapter 105, the facility shall be designed in accordance with Chapter 105 and meet the regulations of Chapter 105 concerning dam safety.

B. Stormwater Management Facility Design Considerations: All stormwater management facilities shall meet the following design requirements:

1. No outlet structure from a stormwater management facility, or swale, shall discharge directly onto a Municipal or State roadway.

2. The top, or toe, of any slope shall be located a minimum of 10 feet from any property line.

3. The minimum horizontal distance between any structure and any stormwater facility shall be 25 feet. The lowest floor elevation of any structure constructed immediately adjacent to a detention basin or other stormwater facility shall be a minimum of 2 feet above the 100-year water surface elevation.

4. Stormwater management facility bottom (or surface of permanent pool) elevations must be greater than adjacent floodplain elevations (FEMA or HEC-RAS analysis). If no floodplain is defined, bottom elevations must be greater than existing ground elevations 50 feet from top of stream bank in the facilities' vicinity.

5. Basin outflow culverts discharging into floodplains must account for tailwater. Tailwater corresponding to the 100-year floodplain elevation must be used for all design storms, or the Applicant may elect to determine flood elevations of the adjacent watercourse for each design storm. The floodplain is assumed to be 50 feet from top of stream bank in areas where a floodplain is not designated, or no other evidence is provided.

6. The invert of all stormwater management facilities and underground infiltration/storage facilities shall be located a minimum of 2 feet above the seasonal high groundwater table. The invert of stormwater facilities may be lowered if adequate sub-surface drainage is provided.

7. Whenever possible the side slopes and basin shape shall be amenable to the natural topography. Vertical side slopes and rectangular basins shall be avoided whenever possible.

8. Exterior slopes of compacted soil shall not exceed 3:1, and may be further reduced if the soil has unstable characteristics.

9. Interior slopes of the basin shall not exceed 3:1.

10. Unless specifically designed as a volume control facility, all stormwater management facilities shall have a minimum slope of 1% extending radially out from the principal outlet structure. Facilities designed as water quality / infiltration BMPs may have a bottom slope of zero.

11. Impervious low-flow channels are not permitted within stormwater management facilities.

12. Unless specifically designed as a Volume Control or water quality facility, all stormwater management facilities must empty over a period of time not less than 24 hours and not more than 72 hours from the end of the facility's inflow hydrograph. Infiltration tests performed at the facility locations and proposed basin bottom depths, in accordance with the BMP Manual, must support time-to-empty calculations if infiltration is a factor.

13. Energy dissipators and/or level spreaders shall be installed at points where pipes or drainageways discharge to or from basins. Discharges to drainage swales shall be dissipated, or piped, to an acceptable point.

14. Landscaping and planting specifications must be provided for all stormwater management basins and be specific for each type of basin.

    a. Minimal maintenance, saturation tolerant vegetation must be provided in basins designed as water quality / infiltration BMPs.

15. A safety fence may be required, at the discretion of the Municipality, for any stormwater management facility. The fence shall be a minimum of 4 feet high, and of a material acceptable to the Municipality. A gate with a minimum opening of 10 feet shall be provided for maintenance access.

16. <u>Principal Outlet Structures</u>: The primary outlet structure shall be designed to pass all design storms (up to and including the 100-year event) without discharging through the emergency spillway. All principal outlet structures shall:
    a. Be constructed of reinforced concrete or an alternative material approved by the Municipal Engineer. When approved for use, all metal risers shall:
        i. Be suitably coated to prevent corrosion.
        ii. Have a concrete base attached with a watertight connection. The base shall be sufficient weight to prevent flotation of the riser.
        iii. Provide a trash rack or similar appurtenance to prevent debris from entering the riser.
        iv. Provide an anti-vortex device, consisting of a thin vertical plate normal to the basin berm.
    b. Provide trash racks to prevent clogging of primary outflow structure stages for all orifices equivalent to 12 inches or smaller in diameter.
    c. Provide outlet aprons and shall extend to the toe of the basin slope at a minimum.
    d. Where spillways will be used to control peak discharges in excess of the 10-year storm, the control weirs shall be constructed to withstand the pressures of impounded waters and convey flows at computed outlet velocities without erosion.

17. <u>Emergency Spillways</u>: Any stormwater management facility designed to store runoff shall provide an emergency spillway designed to convey the 100-year post-development peak rate flow with a blocked primary outlet structure. The emergency spillway shall be designed per the following requirements:
    a. The top of embankment elevation shall provide a minimum 1 foot of freeboard above the maximum water surface elevation. This is to be calculated when the spillway functions for the 100-year post-development inflow, with a blocked outlet structure.
    b. Avoid locating on fill areas, whenever possible.
    c. The spillway shall be armored to prevent erosion during the 100-year post-development flow, with a blocked primary outlet structure.
        i. Synthetic liners or riprap may be used, and calculations sufficient to support proposed armor must be provided. An earthen plug must be used to accurately control the spillway invert if riprap is the proposed armoring material. Emergency spillway armor must extend up the sides of the spillway, and continue at full width to a minimum of 10 feet past the toe of slope.

d. Municipal Engineer may require the use of additional protection when slopes exceed 4:1 and spillway velocities might exceed NRCS standards for the particular soils involved.
e. Any underground stormwater management facility (pipe storage systems) must have a method to bypass flows higher than the required design (up to a 100-year post-development inflow) without structural failure, or causing downstream harm or safety risks.

18. Stormwater Management Basins: Design of stormwater management facilities having 3 feet or more of water depth (measured vertically from the lowest elevation in the facility to the crest of the emergency spillway) shall meet the following additional requirements:

    a. The maximum water depth within any stormwater management facility shall be no greater than 8 feet when functioning through the primary outlet structure.

    b. The top of embankment width shall be at least 10 feet.

    c. A 10 foot wide access to the basin bottom must be provided with a maximum longitudinal slope of 10%.

    d. Berms shall be constructed using soils that conform to the unified soil classification of CH, MH, CL or ML. The embankments will be constructed in a maximum of 6 inch lifts. The lifts will each be compacted to a density of 98% of a standard proctor analysis as per each layer of compacted fill shall be tested to determine its density analysis per ASTM 698. Each layer of compacted fill shall be tested to determine its density per ASTM 2922 or ASTM 3017.

    e. A cutoff and key trench of impervious material shall be provided under all embankments 4 feet or greater in height. The cutoff trench shall run the entire length of the embankment and tie into undisturbed natural ground.

    f. Design details for placement of all outflow pipes and culverts must include measures to prevent seepage (piping) through the fill.

19. Construction of Stormwater Management Facilities:

    a. Basins used for rate control only shall be installed prior to or concurrent with any earthmoving or land disturbances, which they will serve. The phasing of their construction shall be noted in the narrative and on the plan.

    b. Basins that include water quality or recharge components shall have those components installed in such a manner as to not disturb or diminish their effectiveness.

    c. Compaction test reports shall be kept on file at the site and be subject to review at all times with copies being forwarded to the Municipal Engineer upon request.

    d. Temporary and permanent grasses or stabilization measures shall be established on the sides and base of all earthen basins within 15 days of construction.

20. Exceptions to these requirements may be made at the discretion of the Municipality for BMPs that retain or detain water, but are of a much smaller scale than traditional stormwater management facilities.

C. Stormwater Carrying Facilities:

1. All storm sewer pipes, grass waterways, open channels, swales and other stormwater carrying facilities that service drainage areas within the site must be able to convey post-development runoff from the 10-year design storm.

2. Stormwater management facilities that convey off-site water through the site shall be designed to convey the 25-year storm event (or larger events, as determined by the Municipal Engineer).

3. All developments shall include provisions that allow for the overland conveyance and flow of the post-development 100-year storm event without damage to public or private property.

4. Storm Sewers:

   a. Storm sewers must be able to convey post-development runoff without surcharging inlets for the 10-year storm event.

   b. When connecting to an existing storm sewer system, the Applicant must demonstrate that the proposed system will not exacerbate any existing stormwater problems and that adequate downstream capacity exists.

   c. Inlets, manholes, pipes, and culverts shall be constructed in accordance with the specifications set forth in PENNDOT's Publication 408, and as detailed in the PENNDOT's Publication 72M - Standards for Roadway Construction (RC) or other detail approved by the Municipal Engineer. All material and construction details (inlets, manholes, pipe trenches, etc.), must be shown on the SWM Site Plan, and a note added that all construction must be in accordance with PENNDOT's Publication 408 and PENNDOT's Publication 72M, latest edition. A note shall be added to the plan stating that all frames, concrete top units, and grade adjustment rings shall be set in a bed of full mortar according to Publication 408.

   d. A minimum pipe size of eighteen (18) inches in diameter shall be used in all roadway systems (public or private) proposed for construction in the Municipality. Pipes shall be designed to provide a minimum velocity of 2-1/2 feet per second when flowing full, but in all cases, the slope shall be no less then 0.5%. Arch pipe of equivalent cross-sectional area may be substituted in lieu of circular pipe where cover or utility conflict conditions exist.

   e. All storm sewer pipes shall be laid to a minimum depth of 1 foot from subgrade to the crown of pipe.

   f. In curbed roadway sections, the maximum encroachment of water on the roadway pavement shall not exceed half of a through travel lane or one (1) inch less than the depth of curb during the ten (10) year design storm of five (5) minute duration. Gutter depth shall be verified by inlet capture/capacity calculations that account for road slope and opening area.

i. Inlets shall be placed at a maximum of 600 feet apart.

ii. Inlets shall be placed so drainage cannot cross intersections or street centerlines.

g. Standard Type "C" inlets with 8 inch hoods shall be used along curbed roadway networks. Type "C" inlets with 10 inch hoods that provide a 2 inch sump condition may be used with approval of the Municipal Engineer when roadway longitudinal slopes are 1.0% or less.

h. For inlets containing a change in pipe size, the elevation for the crown of the pipes shall be the same or the smaller pipe's crown shall be at a higher elevation.

i. All inlets shall provide a minimum 2 inch drop between the lowest inlet pipe invert elevation and the outlet pipe invert elevation.

j. On curbed sections, a double inlet shall be placed at the low point of sag vertical curves, or an inlet shall be placed on each side of the low point at a distance not to exceed 100 feet, or at an elevation not to exceed 0.2 feet above the low point.

k. At all roadway low points, swales and easements shall be provided behind the curb or swale and through adjacent properties to channelize and direct any overflow of stormwater runoff away from dwellings and structures.

l. All inlets in paved areas shall have heavy duty bicycle safe grating. A note to this effect shall be added to the SWM Site Plan or inlet details therein.

m. Inlets must be sized to accept the specified pipe sizes without knocking out any of the inlet corners. All pipes entering or exiting inlets shall be cut flush with the inside wall of the inlet. A note to this effect shall be added to the SWM Site Plan or inlet details therein.

n. Inlets shall have weep holes covered with geotextile fabric placed at appropriate elevations to completely drain the sub grade prior to placing the base and surface course on roadways.

o. Inlets, junction boxes, or manholes greater then five (5) feet in depth shall be equipped with ladder rungs and shall be detailed on the SWM Site Plan.

p. Inlets shall not have a sump condition in the bottom (unless designed as a water quality BMP). Pipe shall be flush with the bottom of the box or concrete channels shall be poured.

q. Accessible drainage structures shall be located on continuous storm sewer system at all vertical dislocations, at all locations where a transition in storm sewer pipe sizing is required, at all vertical and horizontal angle points exceeding 5 degrees, and at all points of convergence of 2 or more storm sewer pipes.

r. All storm drainage piping shall be provided with either reinforced concrete headwalls or end sections compatible with the pipe size involved at its entrance and discharge.

s. Outlet protection and energy dissipaters shall be provided at all surface discharge points in order to minimize erosion consistent with the PennDOT Publication 13M, or with FHWA Publication HEC 14.
    i. Flow velocities and volumes from any storm sewer shall not result in a degradation of the receiving channel.

t. Stormwater roof drains and pipes shall not be connected to storm sewers or discharge onto impervious areas without approval by the Municipal Engineer.

5. Swale Conveyance Facilities:
    a. Swales must be able to convey post-development runoff from a 10-year design storm with 6 inches of freeboard to top of the swale.

    b. Swales shall have side slopes no steeper than 3:1.

    c. All swales shall be designed, labeled on the SWM Site Plan, and details provided to adequately construct and maintain the design dimension of the swales.

    d. Swales shall be designed for stability using velocity or shear criteria. Velocity criteria may be used for channels with less than 10% slope. Shear criteria may be used for all swales. Documentation must be provided to support velocity and/or shear limitations used in calculations.

    e. Where swale bends occur, the computed velocities or shear stresses shall be multiplied by the following factor for the purpose of designing swale erosion protection:
        i. 1.75 – When swale bend is 30 to 60 degrees
        ii. 2.00 – When swale bend is 60 to 90 degrees
        iii. 2.50 – When swale bend is 90 degrees or greater

        Design of channels to handle flow around bends also should include consideration of super-elevation of the water surface and wave runup using HEC-11.

    f. Manning's "n" values used for swale capacity design must reflect the permanent condition.

Section 802. Calculation Methodology

A. All calculations shall be consistent with the guidelines set forth in the BMP Manual, as amended herein.

B. Stormwater runoff from all development sites shall be calculated using either the Rational Method or the NRCS Rainfall-Runoff Methodology. Methods shall be selected by the design professional based on the individual limitations and suitability of each method for a particular site.

C. Rainfall Values:

1. Rational Method – The Pennsylvania Department of Transportation Drainage Manual, Intensity-Duration-Frequency Curves, Publication 584, Chapter 7A, latest edition, shall be used in conjunction with the appropriate time of concentration and return period.

2. NRCS Rainfall-Runoff Method – The Soil Conservation Service Type II, 24-hour rainfall distribution shall be used in conjunction with rainfall depths from NOAA Atlas 14 or be consistent with the following table:

Return Interval (Year)	24-hour Rainfall Total (inches)
1	2.06
2	2.46
10	3.46
25	4.11
50	4.64
100	5.21

D. Runoff Volume:

1. Rational Method – Not to be used to calculate runoff volume.

2. NRCS Rainfall-Runoff Method – This method shall be used to estimate the change in volume due to Regulated Activities. Combining Curve Numbers for land areas proposed for development with Curve Numbers for areas unaffected by the proposed development into a single weighted curve number is NOT acceptable.

E. Peak Flow Rates:

1. Rational Method – This method may be used for design of conveyance facilities only. Extreme caution should be used by the design professional if the watershed has more then one main drainage channel, if the watershed is divided so that hydrologic properties are significantly different in one versus the other, if the time of concentration exceeds 60 minutes, or if stormwater runoff volume is an important factor. The combination of Rational Method hydrographs based on timing shall be prohibited.

2. NRCS Rainfall-Runoff Method – This method is recommended for design of stormwater management facilities and where stormwater runoff volume must be taken into consideration. The following provides guidance on the model applicability:

   a. NRCS's TR-55 – limited to 100 acres in size
   b. NRCS's TR-20 or HEC-HMS – no size limitations
   c. Other models as pre-approved by the Municipal Engineer

   The NRCS antecedent runoff condition II (ARC II, previously AMC II) must be used for all simulations. The use of continuous simulation models that vary the ARC are not permitted for stormwater management purposes.

3. For comparison of peak flow rates, flows shall be rounded to a tenth of a cubic foot per second (cfs).

F. Runoff Coefficients:

1. Rational Method – Use Table C-1 (Appendix C).

2. NRCS Rainfall-Runoff Method – Use Table C-2 (Appendix C). Curve Numbers (CN) should be rounded to tenths for use in hydrologic models as they are a design tool with statistical variability. For large sites, CN's should realistically be rounded to the nearest whole number.
3. For the purposes of pre-development peak flow rate and volume determination, existing non-forested pervious areas conditions shall be considered as meadow (good condition).
4. For the purposes of pre-development peak flow rate and volume determination, 20 percent of existing impervious area, when present, shall be considered meadow (good condition).

G. Design Storm:

1. All stormwater management facilities shall be verified by routing the proposed 1-year, 2-year, 10-year, 25-year, 50-year, and 100-year hydrographs through the facility using the storage indication method or modified puls method. The design storm hydrograph shall be computed using a calculation method that produces a full hydrograph.
2. The stormwater management and drainage system shall be designed to safely convey the post development 100-year storm event to stormwater detention facilities, for the purpose of meeting peak rate control.
3. All structures (culvert or bridges) proposed to convey runoff under a Municipal road shall be designed to pass the 50-year design storm with a minimum 1 foot of freeboard measured below the lowest point along the top of the roadway.

H. Time of Concentration:

1. The Time of Concentration is to represent the average condition that best reflects the hydrologic response of the area. The following Time of Concentration (T_c) computational methodologies shall be used unless another method is pre-approved by the Municipal Engineer:

   a. Pre-development – NRCS's Lag Equation:

      Time of Concentration = T_c = [(T_{lag}/.6) * 60] (minutes)

$$T_{lag} = L^{0.8}\frac{(S+1)^{0.7}}{1900\sqrt{Y}}$$

      Where:
      T_{lag} = Lag time (hours)
      L = Hydraulic length of watershed (feet)
      Y = Average overland slope of watershed (percent)
      S = Maximum retention in watershed as defined by: S = [(1000/CN) – 10]
      CN = NRCS Curve Number for watershed

   b. Post-development; commercial, industrial, or other areas with large impervious areas (>20% impervious area) – NRCS Segmental Method. The length of sheet flow shall be limited to 100 feet. T_c for channel and pipe flow shall be computed using Manning's equation.
   c. Post-development; residential, cluster, or other low impact designs less than or equal to 20% impervious area – NRCS Lag Equation or NRCS Segmental Method.

2. Additionally, the following provisions shall apply to calculations for Time of Concentration:

   a. The post-development T_c shall never be greater that the pre-development T_c for any watershed or sub-watershed. This includes when the designer has specifically used swales to reduce flow velocities. In the event that the designer believes that the post-development T_c is greater, it will still be set by default equal to the pre-development T_c for modeling purposes.
   b. The minimum T_c for any watershed shall be 5 minutes.
   c. The designer may choose to assume a 5 minute T_c for any post development watershed or subwatershed without providing any computations.
   d. The designer must provide computations for all pre-development T_c paths. A 5 minute T_c can not be assumed for pre-development.
   e. Undetained fringe areas (areas that are not tributary to a stormwater facility but where a reasonable effort has been made to convey runoff from all new impervious coverage to best management practices) may be assumed to represent the pre-development conditions for purpose of T_c calculation.

I. Drainage areas tributary to sinkholes or closed depressions in areas underlain by limestone or carbonate geologic features shall be excluded from the modeled point of analysis defining pre-development flows. If left undisturbed during construction activities, areas draining to closed depressions may also be used to reduce peak runoff rates in the post-development analysis. New, additional contributing runoff should not be directed to existing sinkholes or closed depressions.

J. Where uniform flow is anticipated, the Manning's equation shall be used for hydraulic computations and to determine the capacity of open channels, pipes, and storm sewers. The Manning's equation should not be used for analysis of pipes under pressure flow or for analysis of culverts. Manning's "n" values shall be obtained from PENNDOT's Drainage Manual, Publication 584. Inlet control shall be checked at all inlet boxes to ensure the headwater depth during the 10-year design event is contained below the top of grate for each inlet box.

K. The Municipality may approve the use of any generally accepted full hydrograph approximation technique that shall use a total runoff volume that is consistent with the volume from a method that produces a full hydrograph.

L. The Municipality has the authority to require that computed existing runoff rates be reconciled with field observations, conditions and site history. If the designer can substantiate, through actual physical calibration, that more appropriate runoff and time of concentration values should be utilized at a particular site, then appropriate variations may be made upon review and recommendation of the Municipality.

ARTICLE IX - EASEMENTS

Section 901. Easements

A. Easements shall be established to accommodate the existence of drainageways.

B. Where a tract is traversed by a watercourse, drainage-way, channel or stream, there shall be provided an easement paralleling the line of such watercourse, drainage-way, channel or stream with a width adequate to preserve the unimpeded flow of natural drainage in the 100-year floodplain.

C. Easements shall be established for all on-site stormwater management or drainage facilities, including but not limited to: detention facilitates (above or below ground), infiltration facilities, all stormwater BMPs, drainage swales, and drainage facilities (inlets, manholes, pipes, etc.).

D. Easements are required for all areas used for off-site stormwater control.

E. All easements shall be a minimum of 20 feet wide and shall encompass the 100-year surface elevation of the proposed stormwater facility.

F. Easements shall provide ingress to, and egress from, a public right-of-way. In lieu of providing an easement to the public right-of-way, a note may be added to the plan granting the Municipality or their designees access to all easements via the nearest public right-of-way able for vehicle ingress and egress on grades of less than 10% for carrying out inspection or maintenance activities.

G. Where possible, easements shall be centered on side and/or rear lot lines.

H. Nothing shall be planted or placed within the easement which would adversely affect the function of the easement, or conflict with any conditions associated with such easement.

I. All easement agreements shall be recorded with a reference to the recorded easement indicated on the site plan. The format and content of the easement agreement shall be reviewed and approved by the Municipal Engineer and Solicitor.

ARTICLE X - MAINTENANCE RESPONSIBILITIES

Section 1001. Financial Guarantee

A. The Applicant shall either construct the stormwater management controls to specifications prior to receiving a building permit, subdivision and/or land development approval or provide a Financial Guarantee in lieu of completion to the Municipality for the timely installation and proper construction of all stormwater management controls as required by the approved SWM Site Plan and this Ordinance, equal to 110% of the full construction cost of the required controls in accordance with the Municipalities Planning Code.

B. At the completion of the project and as a prerequisite for the release of the Financial Guarantee, the Applicant shall:

   1. Provide a certification of completion from an engineer, architect, surveyor or other qualified person, verifying that all permanent facilities have been constructed according to the SWM Site Plan & Report and approved revisions thereto.
   2. Provide a set of Record Drawings.
   3. Request a final inspection from the Municipality to certify compliance with this Ordinance, after receipt of the certification of completion and Record Drawings by the Municipality.

Section 1002. Maintenance Responsibilities

A. The SWM Site Plan & Report for the project site shall describe the future operation and maintenance responsibilities. The operation and maintenance description shall outline required routine maintenance actions and schedules necessary to ensure proper operation of the stormwater control facilities.

B. The SWM Site Plan & Report for the project site shall establish responsibilities for the continuing operating and maintenance of all proposed stormwater control facilities, consistent with the following principals:

   1. If a development consists of structures or lots that are to be separately owned and in which streets, sewers, and other public improvements are to be dedicated to the Municipality, stormwater control facilities/BMPs may also be dedicated to and maintained by the Municipality.
   2. If a development site is to be maintained in a single ownership or if sewers and other public improvements are to be privately owned and maintained, then the ownership and maintenance of stormwater control facilities/BMPs shall be the responsibility of the owner or private management entity.
   3. Facilities, areas, or structures used as stormwater BMPs shall be enumerated as permanent real estate appurtenances with a copy retained by the municipality.
   4. The Municipality may take enforcement actions against an Applicant for failure to satisfy any provision of this Ordinance.

C. The Municipality, upon recommendation of the Municipal Engineer, shall make the final determination on the continuing maintenance responsibilities prior to final approval of the SWM Site Plan & Report. The Municipality may require a dedication of such facilities as part of the requirements for approval of the SWM Site Plan. Such a requirement is not an indication that the Municipality will accept the facilities. The Municipality reserves the right to accept or reject the ownership and operating responsibility for any portion of the stormwater management controls.

D. If the Municipality accepts ownership of stormwater BMPs, the Municipality may, at its discretion, require a fee from the Applicant to the Municipality to offset the future cost of inspections, operations, and maintenance.

E. It shall be unlawful to alter or remove any permanent stormwater BMP required by an approved SWM Site Plan, or to allow the property to remain in a condition, which does not conform to an approved SWM Site Plan, unless the Municipality grants an exception in writing.

Section 1003. Maintenance Agreement for Privately Owned Stormwater Facilities

A. Prior to final approval of the SWM Site Plan & Report, the Applicant shall sign the Operation and Maintenance (O&M) Agreement (Appendix A) covering all stormwater control facilities that are to be privately owned. The Operation and Maintenance (O&M) Agreement shall be retained by the municipality.

B. Other items may be included in the Operation and Maintenance (O&M) Agreement where determined necessary to guarantee the satisfactory operation and maintenance of all BMP facilities. The Operation and Maintenance (O&M) Agreement shall be subject to the review and approval of the Municipality and the Municipal Solicitor.
   1. Where O&M Agreement requires Municipal Solicitor review, Developer shall reimburse the municipality for those costs.

C. The owner is responsible for operation and maintenance of the stormwater BMPs. If the owner fails to adhere to the Operation and Maintenance (O&M) Agreement, the Municipality may perform the services required and charge the owner appropriate fees. Non-payment of fees may result in a lien against the property.

ARTICLE XI - INSPECTIONS

Section 1101. Schedule of Inspections

A. PADEP or its designees normally ensure compliance with any permits issued, including those for stormwater management. In addition to PADEP compliance programs, the Municipality or their municipal assignee may inspect all phases of the installation of temporary or permanent stormwater management facilities.

B. During any stage of Earth Disturbance Activities, if the Municipality determines that the stormwater management facilities are not being installed in accordance with the approved SWM Site Plan, the Municipality shall revoke any existing permits or approvals until a revised SWM Site Plan is submitted and approved as specified in this Ordinance.

C. Stormwater BMPs shall be inspected by the landowner, or the landowner's designee according to the inspection schedule described on the SWM Site Plan for each BMP.

    1. The Municipality may require copies of the inspection reports, in a form as stipulated by the Municipality.
    2. If such inspections are not conducted or inspection reports not submitted as scheduled, the Municipality, or their designee, may conduct such inspections and charge the owner appropriate fees. Non-payment of fees may result in a lien against the property.
        a. Prior to conducting such inspections, the Municipality shall inform the owner of its intent to conduct such inspections. The owner shall be given thirty (30) days to conduct required inspections and submit the required inspection reports to the Municipality.

Section 1102. Right-of-Entry

A. Upon presentation of proper credentials, duly authorized representatives of the Municipality may enter at reasonable times, upon any property within the Municipality, to inspect the implementation, condition, or operations and maintenance of the stormwater BMPs in regard to any aspect governed by this Ordinance.

B. Stormwater BMP owners and operators shall allow persons working on behalf of the Municipality ready access to all parts of the premises for the purposes of determining compliance with this Ordinance.

C. Persons working on behalf of the Municipality shall have the right to temporarily locate on any stormwater BMP in the Municipality such devices, as are necessary, to conduct monitoring and/or sampling of the discharges from such stormwater BMP.

D. Unreasonable delay in allowing the Municipality access to a stormwater BMP is a violation of this Ordinance.

ARTICLE XII - FEES AND EXPENSES

Section 1201. General

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

Section 1202. Expenses Covered by Fees

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

   1. Administrative and Clerical Costs.
   2. Review of the SWM Site Plan & Report by the Municipality.
   3. Pre-construction meetings.
   4. Inspection of stormwater management facilities/BMPs and drainage improvements during construction.
   5. Final inspection upon completion of the stormwater management facilities/BMPs and drainage improvements presented in the SWM Site Plan.
   6. Any additional work required to enforce any permit provisions regulated by this Ordinance, correct violations, and assure proper completion of stipulated remedial actions.

Section 1203. Filing or Recording of Approved SWM Site Plan and Related Agreements

A. The owner of any land upon which permanent BMPs will be placed, constructed, or implemented, as described in the SWM Site Plan, shall provide the Municipality the following documents for official filing by the Municipality:

   1. The SWM Site Plan.
   2. Operations and Maintenance (O&M) Agreement (Appendix A).
   3. Signed and executed easements, as required for all on-site and off-site work.

B. The Municipality may elect to require the Developer to record the above documents in the Office of the Recorder of Deeds of McKean County, within 90 days of approval of the SWM Site Plan by the Municipality.

C. The Municipality may suspend or revoke any approvals granted for the project site upon discovery of the failure of the owner to comply with this Section.

ARTICLE XIII - PROHIBITIONS

Section 1301. Prohibited Discharges and Connections

A. Any drain (including indoor drains and sinks), or conveyance whether on the surface or underground, that allows any non-stormwater discharge including sewage, process wastewater, and wash water to enter the Municipality's separate storm sewer system or Waters of the Commonwealth is prohibited.

B. Any drain or conveyance connected from a commercial or industrial land use to the Municipality's separate storm sewer system, which has not been documented in plans, maps, or equivalent records, and approved by the Municipality is prohibited.

C. No person shall allow, or cause to allow, discharges into the Municipality's separate storm sewer system or into surface Waters of the Commonwealth, which are not composed entirely of stormwater, except: (1) as provided in subsection 1301.D below, and (2) discharges allowed under a state or federal permit.

D. The following discharges are authorized unless they are determined to be significant contributors to pollution to the Waters of the Commonwealth:

-Discharges from fire fighting activities
-Potable water sources including dechlorinated water and fire hydrant flushings
-Air conditioning condensate
-Springs
-Pavement wash waters where spills or leaks of toxic or hazardous materials have not occurred (unless all spill material has been removed) and where detergents are not used
-Water from crawl space pumps
-Flows from riparian habitats and wetlands
-Uncontaminated water from foundations or from footing drains
-Irrigation or Lawn watering
-Dechlorinated swimming pool discharges
-Water from individual residential car washing
-Routine external building washdown (which does not use detergents or other compounds)

E. In the event that the Municipality or PADEP determines that any of the discharges identified in subsection 1301.D is a significant contributor to pollution to the Waters of the Commonwealth, the responsible person(s) shall be notified to cease the discharge. Upon notice provided by the Municipality or PADEP, the discharger will have a reasonable time, as determined by the Municipality or PADEP, to cease the discharge, consistent with the degree of pollution caused by the discharge.

F. Nothing in this Section shall affect a discharger's responsibilities under Commonwealth Law.

Section 1302. Roof Drains

A. Roof drains and sump pumps shall discharge to infiltration areas, vegetative BMPs, or pervious areas to the maximum extent practicable.

Section 1303. Alteration of BMPs

A. No person shall modify, remove, fill, landscape, or alter any existing stormwater BMP, facilities, areas, or structures unless it is part of an approved maintenance program, without the written approval of the Municipality.

B. No person shall place any structure, fill, landscaping, or vegetation into a stormwater BMP, facilities, areas, structures, or within a drainage easement which would limit or alter the functioning of the BMP without the written approval of the Municipality.

ARTICLE XIV - ENFORCEMENT AND PENALTIES

Section 1401. Notification

A. In the event that a person fails to comply with the requirements of this Ordinance, an approved SWM Site Plan, or fails to conform to the requirements of any permit or approval issued hereunder, the Municipality shall provide written notification of the violation. Such notification shall set forth the nature of the violation(s) and establish a time limit for correction of these violation(s).

B. Failure to comply within the time specified shall subject such person to the Penalties Provisions of this Ordinance. All such penalties shall be deemed cumulative and shall not prevent the Municipality from pursuing any and all other remedies. It shall be the responsibility of the owner of the real property on which any Regulated Activity is proposed to occur, is occurring, or has occurred, to comply with the terms and conditions of this Ordinance.

Section 1402. Enforcement

A. The municipal governing body is hereby authorized and directed to enforce all of the provisions of this Ordinance. The approved SWM Site Plan shall be on file at the project site throughout the duration of the construction activity. The Municipality or their designee may make periodic inspections during construction.

B. Adherence to Approved SWM Site Plan

   1. It shall be unlawful for any person, firm, or corporation to undertake any Regulated Activity on any property except as provided for by an approved SWM Site Plan and pursuant to the requirements of this Ordinance.
   2. It shall be unlawful to alter or remove any control structure required by the SWM Site Plan pursuant to this Ordinance.
   3. It shall be unlawful to allow a property to remain in a condition that does not conform to an approved SWM Site Plan.

Section 1403. Public Nuisance

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

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

Section 1404. Suspension and Revocation

A. Any approval or permit issued by the Municipality may be suspended or revoked for:

   1. Non-compliance with or failure to implement any provision of the approved SWM Site Plan or Operation & Maintenance (O&M) Agreement.
   2. A violation of any provision of this Ordinance or any other applicable law, Ordinance, rule or regulation relating to the Regulated Activity.
   3. The creation of any condition or the commission of any act, during the Regulated Activity which constitutes or creates a hazard or nuisance, pollution, or which endangers the life or property of others.

B. A suspended approval or permit may be reinstated by the Municipality when:

1. The Municipality or their designee has inspected and approved the corrections to the violation(s) that caused the suspension.
2. The Municipality is satisfied that the violation(s) has been corrected.

C. An approval that has been revoked by the Municipality cannot be reinstated. The Applicant may apply for a new approval under the provisions of this Ordinance.

Section 1405. Penalties

[Municipalities should ask their solicitors to provide appropriate wording for this section.]

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

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

Section 1406. Appeals

A. Any person aggrieved by any action of the Municipality or its designee, relevant to the provisions of this Ordinance, may appeal to the Municipality within thirty (30) days of that action.

B. Any person aggrieved by any decision of the Municipality, relevant to the provisions of this Ordinance, may appeal to the McKean County Court of Common Pleas within thirty (30) days of the Municipality's decision.

(ORDINANCE NAME)

(ORDINANCE NUMBER)

ENACTED and ORDAINED at a regular meeting of the

____

on this _________ day of ______________________, 20________.

This Ordinance shall take effect immediately.

____
(Name) (Title)

____
(Name) (Title)

____
(Name) (Title)

ATTEST:

____
Secretary

I hereby certify that the foregoing Ordinance was advertised in the [name of newspaper] on [date], a newspaper of general circulation in the Municipality and was duly enacted and approved as set forth at a regular meeting of the [name of municipal governing body] held on [date].

____
Secretary

APPENDIX A - OPERATION AND MAINTENANCE AGREEMENT

OPERATION AND MAINTENANCE (O&M) AGREEMENT
STORMWATER MANAGEMENT BEST MANAGEMENT PRACTICES (SWM BMPs)

THIS AGREEMENT, made and entered into this ____________ day of _________, 20___, by and between ____________________________________, (hereinafter the "Landowner"), and ______________________________, McKean County, Pennsylvania, (hereinafter "Municipality");

WITNESSETH

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

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

WHEREAS, the SWM Site Plan approved by the Municipality (hereinafter referred to as the "Plan") for the property identified herein, which is attached hereto as Appendix A and made part hereof, as approved by the Municipality, provides for management of stormwater within the confines of the Property through the use of BMPs; and

WHEREAS, the Municipality, and the Landowner, his successors and assigns, agree that the health, safety, and welfare of the residents of the Municipality and the protection and maintenance of water quality require that on-site SWM BMPs be constructed and maintained on the Property; and

WHEREAS, the Municipality requires, through the implementation of the SWM Site Plan, that stormwater BMPs as required by said Plan and the Municipal Stormwater Management Ordinance be constructed and adequately operated and maintained by the Landowner, successors and assigns.

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

1. The Landowner shall construct the BMPs in accordance with the plans and specifications identified in the SWM Site Plan.
2. The Landowner shall operate and maintain the BMPs as shown on the Plan in good working order in accordance with the specific maintenance requirements noted on the approved SWM Site Plan.
3. The Landowner hereby grants permission to the Municipality, its authorized agents, and employees, to enter upon the property, at reasonable times and upon presentation of proper credentials, to inspect the BMPs whenever necessary. Whenever possible, the Municipality shall notify the Landowner prior to entering the property.
4. In the event the Landowner fails to operate and maintain the BMPs per paragraph 2, the Municipality or its representatives may enter upon the Property and take whatever action is deemed necessary to maintain said BMPs. It is expressly understood and agreed that the Municipality is under no obligation to maintain or repair said facilities, and in no event shall this Agreement be construed to impose any such obligation on the Municipality.
5. In the event the Municipality, pursuant to this Agreement, performs work of any nature, or expends any funds in performance of said work for labor, use of equipment, supplies, materials, and the like, the Landowner shall reimburse the Municipality for all expenses (direct and indirect) incurred within ten (10) days of receipt of invoice from the Municipality.
6. The intent and purpose of this Agreement is to ensure the proper maintenance of the onsite BMPs by the Landowner; provided, however, that this Agreement shall not be deemed to create or effect any additional liability of any party for damage alleged to result from or be caused by stormwater runoff.
7. The Landowner, its executors, administrators, assigns, and other successors in interests, shall release the Municipality from all damages, accidents, casualties, occurrences or claims which might arise

or be asserted against said employees and representatives from the construction, presence, existence, or maintenance of the BMPs by the Landowner or Municipality.

8. The Municipality may inspect the BMPs at a minimum of once every three years to ensure their continued functioning.

This Agreement shall be (a) Filed at the municipal office, or (b) upon direction by the municipality, recorded at the Office of the Recorder of Deeds of McKean County, Pennsylvania, and shall constitute a covenant running with the Property and/or equitable servitude, and shall be binding on the Landowner, his administrators, executors, assigns, heirs and any other successors in interests, in perpetuity.

ATTEST:

WITNESS the following signatures and seals:

(SEAL) For the Municipality:

____

For the Landowner:

____

ATTEST:

______________________________ (City, Borough, Township)

County of McKean, Pennsylvania

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

GIVEN UNDER MY HAND THIS _____________ day of _______________, 20_______.

________________________________ ____________________________________

NOTARY PUBLIC **(SEAL)**

APPENDIX B – LOW IMPACT DEVELOPMENT PRACTICES

LOW IMPACT DEVELOPMENT PRACTICES
ALTERNATIVE APPROACHES FOR MANAGING STORMWATER RUNOFF

Natural hydrologic conditions may be altered radically by poorly planned development practices, such as introducing unneeded impervious surfaces, destroying existing drainage swales, constructing unnecessary storm sewers, and changing local topography. A traditional drainage approach of development has been to remove runoff from a site as quickly as possible and capture it in a detention basin. This approach leads ultimately to the degradation of water quality, as well as expenditure of additional resources for detaining and managing concentrated runoff at some downstream location.

The recommended alternative approach is to promote practices that will minimize post-development runoff rates and volumes, which will minimize needs for artificial conveyance and storage facilities. To simulate pre-development hydrologic conditions, forced infiltration is often necessary to offset the loss of infiltration by creation of impervious surfaces. The ability of the ground to infiltrate runoff depends upon the soil types and its conditions.

Preserving natural hydrologic conditions requires careful alternative site design considerations. Site design practices include preserving natural drainage features, minimizing impervious surface area, reducing the hydraulic connectivity of impervious surfaces, and protecting natural depression storage. A well-designed site will contain a mix of all those features. The following describes various techniques to achieve the alternative approaches:

- **Preserving Natural Drainage Features**. Protecting natural drainage features, particularly vegetated drainage swales and channels, is desirable because of their ability to infiltrate and attenuate flows and to filter pollutants. However, this objective is often not accomplished in land development. In fact, commonly held drainage philosophy encourages just the opposite pattern - streets and adjacent storm sewers typically are located in the natural headwater valleys and swales, thereby replacing natural drainage functions with a completely impervious system. As a result, runoff and pollutants generated from impervious surfaces flow directly into storm sewers with no opportunity for attenuation, infiltration, or filtration. Developments designed to fit site topography also minimize the amount of grading on site.

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

- **Avoiding Introduction of Impervious Areas.** Careful site planning should consider reducing impervious coverage to the maximum extent possible. Building footprints, sidewalks, driveways, and other features producing impervious surfaces should be evaluated to minimize impacts on runoff.

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

Site grading should promote increasing travel time of stormwater runoff and should help reduce concentration of runoff to a single point in the development.

- **Routing Roof Runoff Over Lawns.** Roof runoff can be easily routed over lawns in most site designs. The practice discourages direct connections of downspouts to storm sewers or parking lots. The practice also discourages sloping driveways and parking lots to the street. The routing of roof drains and crowning the driveway to allow runoff to discharge to pervious areas is desirable as the pervious area essentially acts as a filter strip.

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

- **Reducing Street Widths.** Street widths can be reduced by either eliminating on-street parking or by reducing cartway widths. Municipal planners and traffic designers should encourage narrower neighborhood streets, which ultimately could lower maintenance and maintenance related costs.

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

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

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

- **Constructing Cluster Developments.** Cluster developments can also reduce the amount of impervious area for a given number of lots. The biggest savings is in street length, which also will reduce costs of the development. Cluster development "clusters" the construction activity onto less-sensitive areas without substantially affecting the gross density of development.

In summary, careful consideration of the existing topography and implementation of a combination of the above mentioned techniques may avoid construction of costly stormwater control measures. Other benefits include: reduced potential of downstream flooding, reduced water quality degradation of receiving streams and water bodies, enhancement of aesthetics, and reduction of development costs. Beneficial results include: more stable baseflows in receiving streams, improved groundwater recharge, reduced flood flows, reduced pollutant loads, and reduced costs for conveyance and storage.

APPENDIX C - STORMWATER MANAGEMENT DESIGN CRITERIA

TABLE C-1 - RATIONAL METHOD RUNOFF COEFFICIENTS

Hydraulic Soil Group	Storm	A			B			C			D		
Slope Range		0-2%	2-6%	+6%	0-2%	2-6%	+6%	0-2%	2-6%	+6%	0-2%	2-6%	+6%
Cultivated	<25yr	0.08	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
Land	≥25yr	0.14	0.08	0.22	0.16	0.21	0.28	0.2	0.25	0.34	0.24	0.29	0.41
Pasture	<25yr	0.12	0.2	0.3	0.18	0.28	0.37	0.24	0.34	0.44	0.3	0.4	0.5
	≥25yr	0.15	0.25	0.37	0.23	0.34	0.45	0.3	0.42	0.52	0.37	0.5	0.62
Meadow	<25yr	0.10	0.16	0.25	0.14	0.22	0.3	0.2	0.28	0.36	0.24	0.3	0.4
	≥25yr	0.14	0.22	0.3	0.2	0.28	0.37	0.26	0.35	0.44	0.3	0.4	0.5
Forest	<25yr	0.05	0.08	0.11	0.08	0.11	0.14	0.1	0.13	0.16	0.12	0.16	0.2
	≥25yr	0.08	0.11	0.14	0.1	0.14	0.18	0.12	0.16	0.2	0.15	0.2	0.25
Residential													
1/8 Acre	<25yr	0.25	0.28	0.31	0.27	0.3	0.35	0.3	0.33	0.38	0.33	0.36	0.42
	≥25yr	0.33	0.37	0.4	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
1/4 Acre	<25yr	0.22	0.26	0.29	0.24	0.29	0.33	0.27	0.31	0.36	0.3	0.34	0.4
	≥25yr	0.3	0.34	0.37	0.33	0.37	0.42	0.36	0.4	0.47	0.38	0.42	0.52
1/3 Acre	<25yr	0.19	0.23	0.26	0.22	0.26	0.3	0.25	0.29	0.34	0.28	0.32	0.39
	≥25yr	0.28	0.32	0.35	0.3	0.35	0.39	0.33	0.38	0.45	0.36	0.4	0.5
1/2 Acre	<25yr	0.16	0.2	0.24	0.19	0.23	0.28	0.22	0.27	0.32	0.26	0.3	0.37
	≥25yr	0.25	0.29	0.32	0.28	0.32	0.36	0.31	0.35	0.42	0.34	0.38	0.48
1 Acre	<25yr	0.14	0.19	0.22	0.17	0.21	0.26	0.2	0.25	0.31	0.24	0.29	0.35
	≥25yr	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.4	0.31	0.35	0.46
Industrial	<25yr	0.67	0.68	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.7
	≥25yr	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	<25yr	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
	≥25yr	0.88	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.9	0.89	0.89	0.9
Streets	<25yr	0.7	0.71	0.72	0.71	0.72	0.74	0.72	0.73	0.76	0.73	0.75	0.78
	≥25yr	0.76	0.77	0.79	0.8	0.82	0.84	0.84	0.85	0.89	0.89	0.91	0.95
Open Space	<25yr	0.05	0.1	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.16	0.21	0.28
	≥25yr	0.11	0.16	0.2	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Parking or	<25yr	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87
Impervious	≥25yr	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97

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

For simplification, a designer may use 0.3 for all pervious areas and 0.95 for all impervious areas.

TABLE C-2 - RUNOFF CURVE NUMBERS (FROM NRCS (SCS) TR-55)

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

Runoff Curve Numbers for Cultivated Agricultural Lands						
Cover Description			**Curve Numbers**			
Cover Type	***Treatment***	***Hydrologic Condition***	***A***	***B***	***C***	***D***
Fallow	Bare Soil	--	77	86	91	94
	Crop Residue Cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row Crops	Straight Row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & Terraced (C & T)	Poor	66	74	80	82
		Good	62	71	78	81
	C & T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small Grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C & T	Poor	61	72	79	82
		Good	59	70	78	81
	C & T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close Seeded or Broadcast Legumes Or Rotation Meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C & T	Poor	63	73	80	83
		Good	51	67	76	80
Runoff Curve Numbers for Other Agricultural Lands						
Pasture, Grassland, or Range – Continuous Forage for Grazing		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
Meadow – Continuous Grass, Protected from Grazing and Generally Mowed for Hay		--	30	58	71	78
Woods – Grass Combination (orchard or tree farm)		Poor	57	73	82	86
		Fair	43	65	76	82
		Good	32	58	72	79
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	30	55	70	77
Farmsteads – Buildings, Lanes, Driveways and Surrounding Lots.		--	59	74	82	86

APPENDIX D – REVIEW FEE REIMBERSEMENT AGREEMENT

THIS AGREEMENT MUST BE COMPLETED AND SIGNED BY THE DEVELOPER/APPLICANT PRIOR TO SUBMISSION OF THE SUBDIVISION/LAND DEVELOPMENT APPLICATION AND PLANS, SKETCH PLANS, CONDITIONAL USE APPLICATIONS OR ANY OTHER SUBMISSION WHICH REQUIRES MUNICPAL CONSULTANT REVIEW.

REVIEW FEE REIMBERSEMENT AGREEMENT

THIS AGREEMENT, made and entered into this ____________ day of _________, 20___, by and between ____________________________________, (hereinafter the "Landowner"), and ______________________________, McKean County, Pennsylvania, (hereinafter "Municipality");

WITNESSETH

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

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

WHEREAS, the Landowner has submitted a SWM Site Plan for review and approval by the Municipality (hereinafter referred to as the "Plan") for the property identified herein; and

WHEREAS, the Developer has requested and/or required the Municipality approval and/or review of its proposed plans, and the Municipality is willing to authorize its professional consultants to review said Plan and/or proposal upon execution of this agreement, and upon deposit of an escrow account according to the current Fee Schedule.

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

1. The Landowner and Municipality hereby authorize and direct the Municipality's professional consultants, as defined at Section 107 of the Pennsylvania Municipalities Planning Code to review Landowner's plans or proposals to use its property, and to make such recommendations and specifications as may be necessary with respect to such plans in accordance with all applicable Municipality ordinances, and State and Federal rules and regulations.
2. The Landowner and Municipality acknowledge that the Municipality will incur costs and fees relating to the review of Landowner's plans by its professional consultants, and Landowner agrees to pay and/or reimburse the Municipality for such costs in accordance with this agreement.
3. The Landowner shall pay the professional consultant's charges and fees for the following: (a) review of any and all Stormwater Management Plans, studies, or other correspondence relating to the Landowners submission; (b) attendance at any and all meetings relating to Landowner's plan; (c) preparation of any reports, legal documents, or other correspondence relating to Landowner's plan or proposal; and (d) administrative cost and incurred expenses relating to the administration of this agreement. It is understood by the execution of this agreement that the Landowner specifically accepts the Fee Schedule currently in effect in the Municipality.
4. The Landowner hereby agrees to deposit with the Municipality the sum of ______________ Dollars ($_____________), payable as cash in U.S. Dollars or check drawn on a Pennsylvania bank, as security for the payment of all costs and expenses, charges and fees as set forth in Paragraph 3 above, upon execution of this agreement, which shall be held in a noninterest- bearing account by the Municipality. In the event that the above deposited escrow fund shall fall below fifty percent (50%) of the original deposit, the Landowner shall immediately, upon receipt of written notice from the Municipality or its agent(s), deposit sums with the Municipality necessary to replenish the account to its original balance. In the event that this is insufficient to pay current Municipality incurred expenses, Landowner agrees to pay the total amount

currently due for Municipality incurred expenses without delay in addition to re-establishing the base escrow account balance. The Municipality will use its best efforts to advise the Landowner of the impending likelihood that its costs have exceeded the required escrow account sums as described above.

5. Landowner and Municipality agree that upon completion of the Municipality's review of Landowner's plan or proposal, all unused portions of the escrow account as described above shall be returned to the applicant upon written request to the Municipality.

6. Landowner and Municipality acknowledge that the Ordinance and appropriate fee schedules require Landowner to pay Municipality's professional consultant fees relating to this plan or project, and in the event that Landowner fails to provide sufficient funds in the above-described revolving escrow account upon fifteen (15) days written notice to the Landowner or make the initial deposit payment described above within five (5) days of the date of this agreement, Landowner shall be in default of this agreement and in violation of the above Sections of Ordinance. In the event of Landowner's default as described above, the Municipality may refuse to issue any permit or grant any approval necessary to further improve or develop the subject site until such time as the terms of this Agreement are strictly met by Landowner. Moreover, final approval or further review may be denied or delayed until such time as the terms of this agreement are strictly met by Landowner.

7. Landowner and the Municipality further agree that all fees or costs arising out of this Agreement shall be paid prior to the issuance of any permit, occupancy or otherwise, for the use, improvement or construction of the buildings as proposed on the Landowner's plan. The Landowner agrees and acknowledges that no permit, occupancy or otherwise, or recordable plans, shall be released by the Municipality until all outstanding professional consultant fees and costs are paid to the Municipality, and provided that the Landowner is not in default under this agreement.

8. The Landowner may at any time terminate all further obligations under this Agreement by giving fifteen (15) days written notice to the Municipality that it does not desire to proceed with the development as set forth on the plan and upon receipt of such written notice by the Landowner to the Municipality, the Landowner shall be liable to the Municipality for its costs and expenses incurred to the date and time of its receipt of the notice, plus the applicable administrative costs and expenses as outlined in Paragraph 3 above.

9. The Landowner and the Municipality further agree that the Municipality shall have the right and privilege to sue the Landowner or then property owner for reimbursement or to lien the property or both, in its sole discretion, for any expense in excess of the then current balance of funds on deposit with the Municipality in accordance with this agreement incurred by the Municipality by reason of any review, supervision and inspection of Landowner's project by its professionals including, but not limited to, the Municipality Engineer and Solicitor. The Municipality's election of its remedies under this paragraph shall not constitute a waiver of any other remedies the Municipality may have.

10. The Landowner and the Municipality acknowledge that this agreement represents their full understanding as to the Municipality's reimbursement for professional or consultant services.

11. This agreement shall be binding on and insure to the benefit of the successors and assigns of Landowner. The Municipality shall receive thirty (30) days advance written notice from Landowner of any proposed assignment of Landowner's rights and responsibilities under this Agreement.

ATTEST:

WITNESS the following signatures and seals:

(SEAL) For the Municipality:

____

For the Landowner:

____

ATTEST:

____________________________ (City, Borough, Township)

County of McKean, Pennsylvania

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

GIVEN UNDER MY HAND THIS _____________ day of _______________, 20_______.

______________________________ ___________________________________

NOTARY PUBLIC **(SEAL)**

APPENDIX E – SMALL PROJECTS SWM APPLICATION

McKean County
Small Project Stormwater Management Application

Per ***[Municipality]***'s Act 167 Stormwater Management Ordinance, an applicant is required to submit this Small Project Application whenever proposing Regulated Activities involving the creation of new impervious surfaces equal to, or greater, than 5,000 square feet. Impervious surfaces are areas that prevent the infiltration of water into the ground and shall include, but not be limited to, roofs, patios, garages, storage sheds and similar structures, and any new streets or sidewalks.

To Calculate Impervious Surfaces Please Complete This Table					
Surface Type	**Length**	**X**	**Width**	**=**	**Proposed Impervious Area**
Building (area per downspout)		x		=	
		x		=	
		x		=	
		x		=	
Driveway		x		=	
		x		=	
		x		=	
Parking Areas		x		=	
		x		=	
		x		=	
Patios/Walks		x		=	
		x		=	
		x		=	
		x		=	
Other		x		=	
		x		=	
		x		=	
Total Impervious Surface Area to be managed (sum of all areas)					

For all regulated activities that involve the creation of new impervious surface areas EQUAL to or GREATER than 5,000 square feet, the applicant must submit a Stormwater Management Site Plan & Report as defined in Article VII of the Ordinance and implement volume and rate controls.

If the Total Impervious Surface Area is LESS THAN 5,000 square feet, or the proposed development is a Single Family Residential activity implementing the minimum measures in Section 302.E. read, acknowledge, and sign below.

Based Upon the information you have provided a ***Stormwater Management Site Plan & Report IS NOT required*** for this regulated activity. ***[Municipality***] may request additional information and/or a SWM for any reason.

Applicant or Property Owner certifies that Sections 302.A, 302.B, and 302.C have been adequately addressed and acknowledges that a submission of inaccurate information may result in a stop work order or permit revocation. Acknowledgement of such is by signature below. I declare that I am the owner or the owner's legal representative. I further acknowledge that the information provided is accurate and employees of ***(Municipality***) are granted access to the above described property for review and inspection as they deem necessary.

______________________________ **Owner** **Date:** ______________

APPENDIX F – RELEASE RATE PLATE

APPENDIX G – OPTIONAL PROVISIONS

SECTION 304.B.3

The following criteria are recommended to provide an alternative method when infiltration-based BMP's are not possible or desirable to meet the Volume Control requirements.

3. **[OPTIONAL]** In cases where it is not possible or desirable to use infiltration-based best management practices to partially fulfill the requirements in either Section 304.B.1 or 304.B.2, the following procedure shall be used:

   a. At a minimum, the following documentation shall be provided to justify the decision to not use infiltration BMPs:
      i. Description of and justification for field infiltration /permeability testing with respect to the type of test and test locations).
      ii. An interpretive narrative describing existing site soils and their structure as these relate to the interaction between soils and water occurring on the site. In addition to providing soil and soil profile descriptions, this narrative shall identify depth to seasonal high water tables and depth to bedrock, and provide a description of all subsurface elements (fragipans and other restrictive layers, geology, etc.) that influence the direction and rate of subsurface water movement.
      iii. A qualitative assessment of the site's contribution to annual aquifer recharge shall be made, along with identification of any restrictions or limitations associated with the use of engineered infiltration facilities.
      iv. The provided documentation must be signed and sealed by a professional engineer or geologist.

   b. The following water quality pollutant load reductions will be required for all disturbed areas within the proposed development:

Pollutant Load	Units	Required reduction (%)
Total Suspended Solids (TSS)	Pounds	85
Total Phosphorous (TP)	Pounds	85
Total Nitrate (NO_3)	Pounds	50

   c. The performance criteria for water quality best management practices shall be determined from the Pennsylvania Stormwater Best Management Practices Manual, most current version.

SECTION 306

The following criteria are recommended to provide protection of Public Drinking Water supplies. Development within a Sensitive Area can endanger the public water supply and Stormwater Hotspots have a high pollutant risk. In these areas, infiltration based BMP's may not be appropriate to comply with Volume Control requirements.

Section 306. Sensitive Areas and Stormwater Hotspots Developments [OPTIONAL]

A. Sensitive areas, as defined below, and Stormwater Hotspots which require special consideration with regard to stormwater management.

   1. Sensitive areas are defined as those areas that, if developed, have the potential to endanger a water supply. These areas consist of the delineated 1-year zone of contribution and direct

upslope areas tributary to the water supply wells. Municipalities may update the sensitive area boundaries based on new research or studies as required.

2. Stormwater Hotspots are land development projects that have a high potential to endanger local water quality, and could potentially threaten ground water reservoirs. The Municipal Engineer will determine what constitutes these classifications on a case-by-case basis. The PADEP wellhead protection contaminant source list shall be used as a guide in these determinations. Industrial manufacturing site and hazardous material storage areas must provide NPDES SIC codes.

B. Performance Standards

1. The location of the boundaries of sensitive areas is set by drainage areas tributary to any public water supply. The exact location of these boundaries as they apply to a given development site, shall be determined using mapping at a scale which accurately defines the limits of the sensitive area. If the project site is within the sensitive area (in whole or in part), 2-foot contour interval mapping shall be provided to define the limits of the sensitive area. If the project site is adjacent to but within 500 linear feet of a defined Sensitive Area, a 5-foot contour interval map defining the limits of the Sensitive Area shall be included in the Stormwater Management Plan to document the site's location relative to the sensitive area.
2. Stormwater Hotspot developments may be required to prepare and implement a stormwater pollution prevention plan and file notice of intent as required under the provision of the EPA Industrial Stormwater NPDES Permit Requirements.
3. Stormwater Hotspot developments must use an acceptable pre-treatment BMP prior to volume control and/or rate control BMPs. Acceptable pre-treatment BMPs for these developments include those based on filtering, settling, or chemical reaction processes such as coagulation.
4. Stormwater Hotspot developments and development in sensitive areas must include Riparian Buffers as defined in Article VI.

ARTICLE V – PROTECTED WATERSHED STANDARDS [OPTIONAL]

Section 501. Protected Watershed Requirements

A. For any Regulated Activity within a protected watershed (High Quality or Exceptional Value), the applicant shall meet requirements as contained in 25 PA Code, Chapters 93 as required and applicable.

B. Existing Resources and Site Analysis Plan. Shall be prepared to provide the developer and the Municipality with a comprehensive analysis of existing conditions, both on the proposed development site and within 500 feet of the site. Conditions beyond the parcel boundaries may be described on the basis of existing published data available from governmental agencies and from aerial photographs. The Municipality shall review the plan to assess its accuracy, conformance with Municipal ordinances, and likely impact upon the natural and cultural resources on the property. The following information shall be required:

   1. Complete current perimeter boundary survey of the property to be subdivided or developed prepared by a registered surveyor, showing all courses, distances, and area and tie-ins to all adjacent intersections.

   2. A vertical aerial photograph enlarged to a scale not less detailed than one inch equals 400 feet, with the site boundaries clearly marked.

   3. Natural features, including:
      a. Contour lines at intervals of not more than two feet. (Ten-foot intervals are permissible beyond the parcel boundaries, interpolated from USGS published maps.) Contour lines shall be based on information derived from a topographic survey for the property, evidence of which shall be submitted, including the date and source of the contours. Datum to which contour elevations refer and references to known, established benchmarks and elevations shall be included on the plan.
      b. Steep slopes in the following ranges: 15% to 25%, 25% and greater. The location of these slopes shall be graphically depicted by category on the plan. Slope shall be measured over three or more two-foot contour intervals.
      c. Areas within the floodway, flood fringe, and approximated floodplain.
      d. Watercourses, either continuous or intermittent and named or unnamed, and lakes, ponds or other water features as depicted on the USGS Quadrangle Map, most current edition.
      e. Wetlands and wetland margins.
      f. Riparian buffers.
      g. Soil types and their boundaries, as mapped by the USDA Natural Resource Conservation Service, including a table listing the soil characteristics pertaining to suitability for construction and, in unsewered areas, for septic suitability. Alluvial and hydric soils shall specifically be depicted on the plan.
      h. Existing vegetation, denoted by type, including woodlands, hedgerows, tree masses, tree lines, individual freestanding trees over six inches DBH, wetland vegetation, pasture or croplands, orchards, permanent grass land, old fields, and any other notable vegetative features on the site. Vegetative types shall be described by plant community, relative age, and condition.
      i. Any identified Pennsylvania Natural Diversity Inventory (PNDI) site conflicts.
      j. Geologic formations on the tract, including rock outcroppings, cliffs, sinkholes, and fault lines, based on available published information or more detailed data obtained by the applicant.

   4. Existing man-made features, including:
      a. Location, dimensions, and use of existing buildings and driveways.
      b. Location, names, widths, center line courses, paving widths, identification numbers, and rights-of-way, of existing streets and alleys.

c. Location of trails that have been in public use (pedestrian, equestrian, bicycle, etc.).
d. Location and size of existing sanitary sewage facilities.
e. Location and size of drainage facilities.
f. Location of water supply facilities, including wellhead protection areas.
g. Any easements, deed restrictions, rights-of-way, or any other encumbrances upon the land, including location, size, and ownership.
h. Site features or conditions such as hazardous waste, dumps, underground tanks, active and abandoned wells, quarries, landfills, sandmounds, and artificial land conditions.

5. Total acreage of the tract, the adjusted tract area, where applicable, and the constrained land area with detailed supporting calculations.

C. Stormwater Management System Concept Plan. A written and graphic concept plan of the proposed post-development stormwater management system shall be prepared and include:
1. Preliminary selection and location of proposed structural stormwater controls;
2. Location of existing and proposed conveyance systems such as grass channels, swales, and storm drains;
3. Location of floodplain/floodway limits;
4. Relationship of site to upstream and downstream properties and drainages.
5. Preliminary location of proposed stream channel modifications, such as bridge or culvert crossings.

D. Consultation Meeting Prior to any stormwater management permit application submission, the land owner or developer shall meet with the Municipality and County Planning Commission for a consultation meeting on a concept plan for the post-development stormwater management system to be utilized in the proposed project. This consultation meeting shall take place at the time of the preliminary plan or other early step in the development process. The purpose of this meeting is to discuss the post-development stormwater management measures necessary for the proposed project, as well as to discuss and assess constraints, opportunities and potential ideas for stormwater management designs before the formal site design engineering is commenced.

E. All proposed Regulated Activities within a protected watershed shall utilize, to the maximum extent possible, Low Impact Development Practices as contained in Appendix B.

1. SWM Plan and Report shall address the following:
   a. Design using nonstructural BMPs
      i. Lot configuration and clustering.
         (a) Reduced individual lot impacts by concentrated/clustered uses and lots
         (b) Lots/development configured to avoid critical natural areas
         (c) Lots/development configured to take advantage of effective mitigative stormwater practices
         (d) Lots/development configured to fit natural topography

      ii. Minimum disturbance
         (a) Define disturbance zones (excavation/grading) for the site and individual lots to protect maximum total site area from disturbance
         (b) Barriers/flagging proposed to protect designated non-disturbance areas
         (c) Considered mitigative practices for minimal disturbance areas (e.g., Soil Restoration)
         (d) Considered re-forestation and re-vegetation opportunities

      iii. Reduce Impervious coverage
         (a) Reduced road width

(b) Reduced driveway lengths and widths
(c) Reduced parking ratios and sizes
(d) Utilized porous surfaces for applicable features

iv. Stormwater disconnected from impervious area
(a) Disconnected drives/walkways/small impervious areas to natural areas
(b) Use rain barrels and/or cisterns for lot irrigation

b. Apply structural BMP selection process that meets runoff quantity and quality needs.
(a) Manage close to source with collection with conveyance minimized
(b) Consistent with site factors (e.g., soils, slope, available space, amount of sensitive areas, pollutant removal needs)
(c) Minimize footprint and integrate into already disturbed areas/other building program components (e.g., recharge beneath parking areas, vegetated roofs)
(d) Consider other benefits such as aesthetic, habitat, recreational and educational benefits
(e) BMP's select based on maintenance needs that fit owner/users
(f) BMP's sustainable using a long-term maintenance plan

ARTICLE VI – RIPARIAN BUFFER STANDARDS [OPTIONAL]

Riparian Buffer Standards are recommended to reduce land use impact on water resource with effective control of non-point source pollutants such as sediment and nutrients. Riparian buffers also enhance the environment by mitigating temperature and light; increasing habitat diversity; stabilizing channel morphology; and protecting floodplains and its flow capacity.

Section 601. Riparian Buffer Requirements

Where a Riparian Buffer is required for a Regulated Activity, the Riparian Buffer shall be established as follows:

A. The buffer shall be measured perpendicularly from the top of the stream bank landward.
   1. High Quality or Exceptional Value Watersheds - a minimum of 150 feet;
   2. Impaired Watersheds – a minimum of 150 feet;
   3. All other watersheds - a minimum of 50 feet; or
   4. As determined by a stream corridor study approved by PADEP and the Municipality.

B. The riparian buffer shall be located on both sides of all perennial and intermittent streams. The perennial and intermittent streams and the riparian buffer boundaries shall be shown on all applications for Building Permits, subdivision, or land development. Existing uses within the buffer are permitted to continue but not be expanded. Placement of new structures or roadways within the riparian buffer shall be prohibited. Where a wetland exists within the buffer area, the buffer shall be extended landward to provide a minimum buffer of 25 feet, as measured perpendicularly from the wetland boundary.

C. Where wetlands are located partially or entirely within a buffer, the buffer shall be extended to encompass the wetland and shall be widened by a distance sufficient to provide a 25 foot forested buffer measured perpendicularly from the wetland boundary.

D. The following uses shall be permitted in the buffer:

   1. Footpaths, trails and bike paths provided that:
      a. Width is limited to 5 feet;
      b. Width may be increased provided a corresponding increase in the buffer is provided;
      c. Constructed with a non-eroding surface;
      d. Construction shall have minimal impact to the buffer.
   2. Stream crossings, provided the crossing is designed and constructed in such a manner as to minimize the impact to the buffer. The Riparian Buffer shall be restored to its original condition, to the maximum extent practical, upon completion of construction.
   3. Utility lines, provided that the crossing is designed and constructed in such a manner as to minimize the impact to the inner buffer and provided that there is no practical alternative to locating the utility line within the buffer. The Riparian Buffer shall be restored to its original condition, to the maximum extent practical, upon completion of construction.
   4. Maintenance and restoration of the Riparian Buffer.
   5. Projects conducted with the objective of improvement, stabilization, restoration, or enhancement of the stream bank, stream channel, floodplain, watershed hydrology, riparian buffers, or aquatic habitat and maintenance activities associated with such projects. These projects include, but are not limited to agricultural and stormwater management best management practices. Such projects must receive appropriate permits and approvals from PADEP prior to starting the project.
   6. Minor private recreational uses for the property owner. Such uses include benches, fire rings, and similar uses. Such uses do not include structures such as cabins, sheds, pavilions, garages, dwellings or similar structures.

E. Disturbance of the Riparian Buffer shall be limited to the area necessary to perform an allowable use.

F. Where possible and practical, disturbances shall be phased with each phase restored prior to beginning the next phase.

G. Allowable activities shall not cause stormwater flow to concentrate.

H. Any vegetation removed for an allowable activity shall be replaced immediately upon completion of the activity. Where mature trees are removed, such trees shall be replaced with the largest practical tree of acceptable native species.

I. Erosion and sediment pollution control shall be installed and maintained during construction. Evidence of an approved Erosion and Sediment Control Plan and/or NPDES Permit, if required, shall be submitted prior to issuance of local permits.

J. If a permit from PADEP is required for the activity, evidence of an approved permit shall be submitted prior to issuance of local permits.

K. Riparian buffers shall be maintained in a manner consistent with sound forest management practices. In the absence of a site specific management plan, the following maintenance guidelines apply:

    1. Buffers shall be inspected periodically for evidence of excessive sediment deposition, erosion or concentrated flow channels. Prompt action shall be taken to correct these problems and prevent future occurrence.
    2. Trees presenting an unusual hazard of creating downstream obstructions shall be removed. Such material shall be removed from the floodplain or the riparian buffer (whichever is widest); or cut into sections small enough so as to prevent the possibility of creating obstructions downstream. Wherever possible, large stable debris should be conserved.
    3. Vegetation should be inspected periodically to ensure diverse vegetative cover and vigorous plant growth consistent with buffering objectives.
        a. Invasive plant species that may threaten the integrity of the buffer shall be removed.
        b. Periodic cutting of trees may be necessary to promote vigorous growth and encourage regeneration.
    4. Excessive use of fertilizers, pesticides, herbicides, and other chemicals shall be avoided. These products should be used only when absolutely necessary to maintain buffer vegetation.

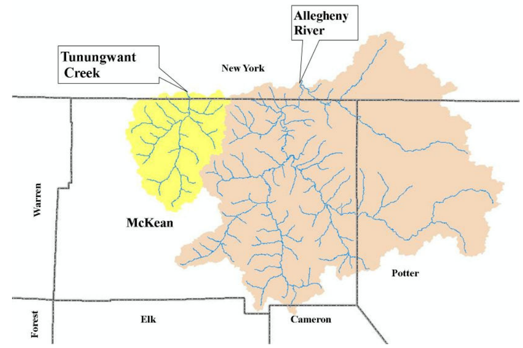
Section 602. Riparian Buffer Easement

A. Easements shall provided for all Riparian Buffers be in accordance with Section 901 and recorded in accordance with Section 1403 of this Ordinance.

Section 1203.A

1. Easements under Section 901. **[OPTIONAL]**
2. Riparian buffers under Section 602. **[OPTIONAL]**

Appendix A – Watershed Modeling Technical Data



An overview of the process that was used to complete the hydrologic modeling in preparation of this Plan is presented in *Section VI – Technical Analysis* of this report. The following technical data is included here to supplement the general information provided in that section.

DATA COLLECTION

The GIS data for the hydrologic models was compiled from a variety of sources by county, state, and federal agencies. The data was collected in and processed using GIS software. A description of GIS data collected, the source and its use is provided in *Table A.1*.

Data	Source	Use
10-m Digital Elevation Model (DEMs)	USGS (2008a)	Watershed delineation, length, basin slope, stream slope, average elevation
High Resolution Streamlines	USGS (2008b)	Watershed delineation, cartography, spatial orientation
National Land Cover Dataset – Land Use 2001	USGS (2008c)	Curve number generation for watershed subareas outside of McKean County for year 2010
Existing Land Use for McKean County for Year 2006	McKean County GIS	Existing curve number generation for watershed subareas inside of McKean County for year 2010
Future Land Use of McKean County	McKean County GIS	Future curve number generation for watershed subareas inside of McKean County for year 2020; Curve Numbers were adjusted to ensure there were not decrease in with future development
SURRGO Soils Data	NRCS (2008)	Curve number generation; analysis of infiltration limitations
Storage (percent of lakes, ponds, and wetlands)	USGS (2008d)	Calculation of parameters for USGS Regression Equations
Roadway Data	PennDOT (2009)	Cartography, spatial orientation

Table A.1. GIS Data Used in Act 167 Technical Analysis

HYDROLOGIC MODEL PARAMETER DATA

SOILS, LAND USE, AND CURVE NUMBERS

The determination of curve numbers is a function of soil type and land use. The hydrologic soil groups were defined by NRCS (2008). The 2001 NLCD was simplified to provide an estimate of curve numbers using the scheme shown in *Table A.2*.

GIS Value	NLCD (2001) and McKean County GIS Description	NRCS (1986) Description	A	B	C	D
11	Open Water	Water	98.0	98.0	98.0	98.0
21	Developed, Open Space	Open space - Good Condition	39.0	61.0	74.0	80.0
22	Developed, Low Intensity	Residential - 1 acre	51.0	68.0	79.0	84.0
23	Developed, Medium Intensity	Residential - 1/2 acre	54.0	70.0	80.0	85.0
24	Developed, High Intensity	Commercial and Business	89.0	92.0	94.0	95.0
31	Barren Land (Rock/Sand/Clay)	Newly graded areas	77.0	86.0	91.0	94.0
41	Deciduous Forest	Woods - Good Condition	30.0	55.0	70.0	77.0
42	Evergreen Forest	Woods - Good Condition	30.0	55.0	70.0	77.0
43	Mixed Forest	Woods - Good Condition	30.0	55.0	70.0	77.0
52	Shrub/Scrub	Brush - Good Condition	30.0	48.0	65.0	73.0
71	Grassland/Herbaceous	Meadow - Good Condition	30.0	58.0	71.0	78.0
81	Pasture/Hay	Pasture - Good Condition	39.0	61.0	74.0	80.0
82	Cultivated Crops	Contoured Row Crops - Good Condition	65.0	75.0	82.0	86.0
90	Woody Wetlands	Woods - Good Condition	30.0	55.0	70.0	77.0
95	Emergent Herbaceous Wetlands	Water	98.0	98.0	98.0	98.0
110	Residential	Residential - 1/2 acre	54.0	70.0	80.0	85.0
111	Residential (High Density or Multiple Dwelling)	Residential - 1/8 acre	77.0	85.0	90.0	92.0
114	Residential (Rural, Single Unit)	Residential - 1 acre	51.0	68.0	79.0	84.0
120	Commercial and Services	Commercial and Business	89.0	92.0	94.0	95.0
123	Other Commercial	Commercial and Business	89.0	92.0	94.0	95.0
130	Industrial	Industrial	81.0	88.0	91.0	93.0
180	Recreation Land	Woods - Good Condition	30.0	55.0	70.0	77.0
190	Recreation Open Use	Open space - Good Condition	39.0	61.0	74.0	80.0
210	Cropland/Pasture	Pasture - Good Condition	39.0	61.0	74.0	80.0
213	Idle Fields	Pasture - Good Condition	39.0	61.0	74.0	80.0
220	Orchard/Nursuries/Horticulture	Contoured Row Crops - Good Condition	65.0	75.0	82.0	86.0
240	Other Agriculture	Contoured Row Crops - Good Condition	30.0	55.0	70.0	77.0
320	Upland Shrubs	Woods - Good Condition	30.0	55.0	70.0	77.0
330	Mixed Range Land	Pasture - Good Condition	39.0	61.0	74.0	80.0
410	Deciduous Forest	Woods - Good Condition	30.0	55.0	70.0	77.0
413	Aspen-Birch Forests	Woods - Good Condition	30.0	55.0	70.0	77.0
420	Confierous Forest	Woods - Good Condition	30.0	55.0	70.0	77.0
440	Brushland/Shrubland	Woods - Good Condition	30.0	55.0	70.0	77.0
510	Waterways/Streams/Canals	Water	98.0	98.0	98.0	98.0
530	Artificial Lakes	Water	98.0	98.0	98.0	98.0
2011	Countryside	Pasture - Good Condition	39.0	61.0	74.0	80.0
2012	Industrial	Industrial	81.0	88.0	91.0	93.0
2013	Resource Production	Woods - Good Condition	30.0	55.0	70.0	77.0
2014	Town Center	Commercial and Business	89.0	92.0	94.0	95.0
2015	Town Neighborhood	Residential - 1/2 acre	54.0	70.0	80.0	85.0
2016	Urban Downtown	Commercial and Business	89.0	92.0	94.0	95.0
2017	Urban Neighborhood	Residential - 1/8 acre	77.0	85.0	90.0	92.0
2018	Village	Residential - 1/8 acre	77.0	85.0	90.0	92.0

Table A.2 (Continued). Curve Number Determination for McKean County for Each Hydrologic Soil Group

The curve numbers presented in the above tables represent "average" antecedent runoff condition (i.e. ARC = 2). In a significant hydrologic event, runoff is often influenced by external factors such as extremely dry antecedent runoff conditions (ARC=1) or wet antecedent runoff conditions (ARC=3). The antecedent runoff conditions of the above curve numbers were altered during the calibration process so that model results are within a reasonable range of other hydrologic estimates.

HYDROLOGIC MODEL PREPARATION

Two watersheds within the county were selected for hydrologic modeling: Tunungwant Creek and the Allegheny River. These watersheds were delineated into subwatersheds based on problem areas, significant obstructions, and natural subwatershed divides. The delineation of these subwatershed areas created points of interest at junctions where the subwatersheds were hydraulically connected in the HEC-HMS model.

TUNUNGWANT CREEK MODEL

The Tunungwant Creek watershed has a drainage area of 141.6 square miles and was divided into 73 subbasins for the HEC-HMS model. *Figure A.1* illustrates the Tunungwant Creek subwatershed and cumulative discharge points.

This watershed contains three dams that were considered to have a significant enough impact on the hydrology of the watershed. For this study dams with small storage volumes (less than 100 acre-feet) and dams that would be completely filled during minor runoff events (0.3 inches of runoff) were generally considered "run-of-the-river dams" that would only affect the immediate area near the dam. Their impacts to the overall watershed hydrology within McKean County were considered negligible and were not included in this study.

Dams No. 2, No. 3 and No. 5 are located in Bradford Township, McKean County. The tributary drainage area to the dams is relatively small (4.5 mi^2 to 6.9 mi^2, respectively) compared to the total drainage area of located within McKean County. Outflow data for the dams was provided by DEP in the form of archived design files. This information was used to model the flows from the dam within the HEC-HMS model. The following table summarizes the impoundments within the watershed.

Impoundment	Stream	Location	Owner	Storage (acre-ft)
No. 2 Dam	Gilbert Run	Bradford Twp.	Bradford City Water Authority	632
No. 3 Dam	Marilla Brook	Bradford Twp.	Bradford City Water Authority	368
No. 5 Dam	West Branch Tunungwant Creek	Bradford Twp.	Bradford City Water Authority	3,390

Table A.3. Impoundments within the Tunungwant Creek Watershed

ALLEGHENY RIVER MODEL

The Allegheny River watershed within McKean County has a drainage area of approximately 422 square miles. There is an additional 438 square miles of the Allegheny River watershed which lies outside of McKean County that was included in the model. The entire scope of the Allegheny River model is 860 square miles composed of 259 subbasins for the HEC-HMS model. For data management purposes, the Allegheny River was modeled with five interconnected HEC-HMS models. *Diagram A.1* outlines how these models are interconnected. The five subwatersheds are listed in *Table A.4*. *Figures A.2* through *Figure A.6* illustrates the Allegheny River subwatersheds and cumulative discharge points.

Subwatershed	Downstream Boundary	Individual Drainage Area (mi²)	Cumulative Drainage Area (mi²)
Allegheny "C"	Above Confluence w/ Sartwell Creek	170	170
Potato Creek	Above Confluence w/ Allegheny River	223	223
Oswayo Creek	Above Confluence w/ Little Genessee Creek	182	182
Allegheny "B"	Above Confluence w/ Potato Creek below Sartwell Creek	135	305
Allegheny "A"	Below Confluence w/ Potato Creek	150	860

Table A.4. Allegheny River Subwatersheds

The same "run-of-the-river" dam criteria for deciding whether or not a dam would be included was used for the Allegheny River Watershed. This watershed does not have any dams that were considered to have a significant enough impact on the hydrology of the watershed.

Diagram A.1 depicts an interconnected flow diagram of how the HEC-HMS Model was divided in order to efficiently model the Allegheny River Watershed within McKean County.

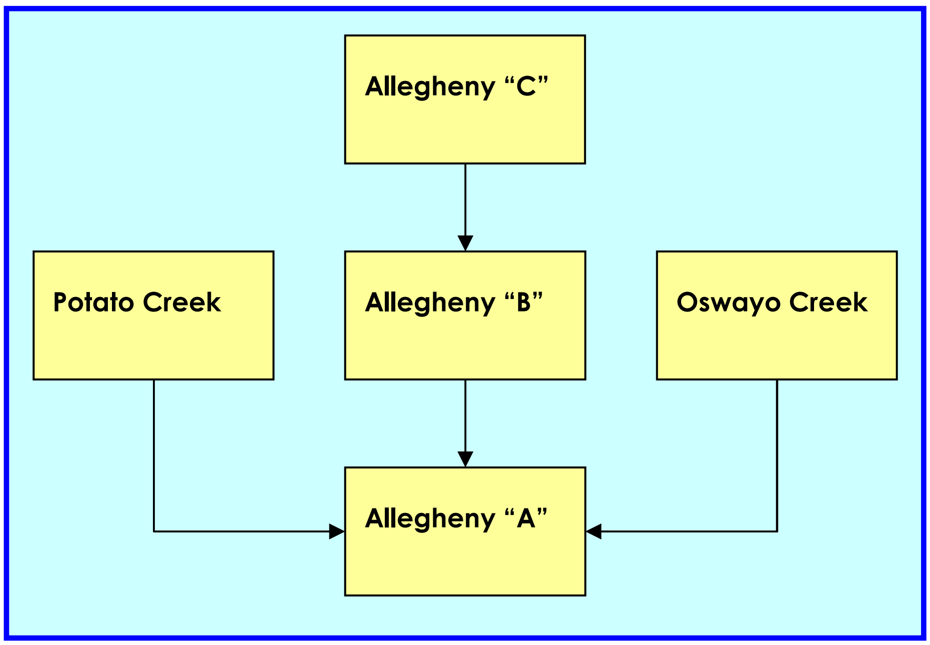


Diagram A.1. Interconnected HEC-HMS Model for the Allegheny River

FIGURE A.1

FIGURE A.2

FIGURE A.3

FIGURE A.4

FIGURE A.5

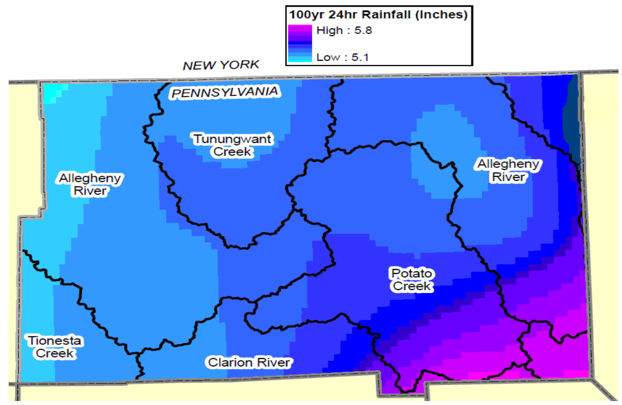
FIGURE A.6

HYDROLOGIC MODEL PARAMETERS

The various parameters entered into the hydrologic models include subwatershed area, soil-type, land cover, lag time, reach lengths and slopes, reach cross sectional dimensions, and design rainfall depths. A brief description of these components follows.

RAINFALL DATA

Rainfall data used in this modeling effort incorporates rainfall runoff data from the NOAA Atlas 14. NOAA Atlas 14 provides the most up to date precipitation frequency estimates, with associated confidence limits, for the United States and is accompanied by additional information such as temporal distributions and seasonality. The following table provides the rainfall estimates used for various design storm frequencies for McKean County (NOAA, 2008):



NOAA Atlas 14 100-year, 24-hour Rainfall

Design Storm (years)	Design Depth (in)
2	2.48
10	3.48
25	4.13
50	4.66
100	5.22

Table A.5. Rainfall Values for McKean County

It was assumed in all of the following analyses that these single rainfall quantities could be applied uniformly over the entire subwatershed area. Additionally, the rainfall quantities were applied to the NRCS Type II storm distribution. Although this combination of Atlas 14 data with the NRCS Type II storm distribution results in a relatively conservative rainfall pattern, this approach is consistent with the guidelines in *PA Stormwater BMP Manual* (2006).

SUBWATERSHED AREA

Generally, the subwatershed area for the modeled watersheds was 3-5 mi^2. The drainage areas may be slightly larger or smaller depending on hydrologic characteristics and location of problem areas. Subwatersheds with an area less than one square mile were included in the model if they formed a junction between two larger basins or were tributary to a defined problem area.

Basins with drainage area outside of McKean County and New York (the Act 167 Designated Watersheds of Tunungwant Creek and Allegheny River) were beyond the scope of study so they were not studied at the same level of detail as portions of the watershed within the scope of this Plan. Generally, they were delineated into areas between 10 and 25 mi^2 and were assumed to have only negligible changes in hydrology due to future land use. This generalized approach includes the Act 167 designated watersheds of Oswayo Creek and a portion of the Allegheny River (Allegheny River "C") watershed located outside of McKean County.

SOILS

Soil properties, specifically infiltration rate and subsurface permeability, are an important factor in runoff estimates. Runoff potential of different soils can vary considerably. Soils are classified into four Hydrologic Soil Groups (A, B, C, and D) according to their minimum infiltration rate (SCS 1986). HSG A refers to soils with relatively high permeability and favorable drainage characteristics; HSG D soils have relatively low permeability and poor drainage characteristics. The runoff potential increases dramatically in order of group A (lowest), B, C, and D (highest). Soil cover data was used in conjunction with land use cover data within GIS to develop composite curve numbers for each subwatershed in the models.

In Section III, Table 3.7 shows the relative percentage of hydrologic soil groups in McKean County. Generally, the runoff potential of soils in the northwestern portion of the county is very high; the location of these soil types corresponds to the location of many of the counties' identified problem areas.

LAND USE

Existing land use was derived from the McKean County Planning Department. This data was converted to land uses that correspond to NRCS curve number tables (SCS, 1986). The land use categories that were used are listed in *Table A.2*.

LAG TIME

Lag time is the transform routine when using the NRCS Curve Number Runoff Method. Lag can be related to time of concentration using the empirical relation:

$$T_{Lag} = 0.6 * T_C$$

Lag time values for the subwatersheds were based on NRCS Lag Equation and altered as depicted in the tables at the end of this section:

$$T_{Lag} = L^{0.8} \frac{(S+1)^{0.7}}{1900\sqrt{Y}}$$

Where: T_{lag} = Lag time (hours)

L = Hydraulic length of watershed (feet)

Y = Average overland slope of watershed (percent)

S = Maximum retention in watershed as defined by: S = [(1000/CN) – 10]

CN = Curve Number (as defined by the NRCS Rainfall-Runoff Method)

For comparison purposes, a lag time was also calculated for each subwatershed using the TR-55 segmental method. Given the rural landscape of McKean County, the best estimate for time of concentration calculation was provided by the NRCS lag equation.

REACH LENGTHS, SLOPES, AND CROSS SECTION DIMENSIONS

Reach lengths and slopes were determined within GIS. Channel baseflow widths and depths for each river reach were estimated based on drainage area and percent carbonate using the methodology outlined in *Development of Regional Curves Relating Bankfull-Channel Geometry and Discharge to Drainage Area for Streams in Pennsylvania and Selected Areas of Maryland*

(USGS, 2005). Dimensions for the overbank area were visually determined from FEMA floodplains or visual inspection of topographic data. *Figure A.7* shows the dimensions as they are approximated.

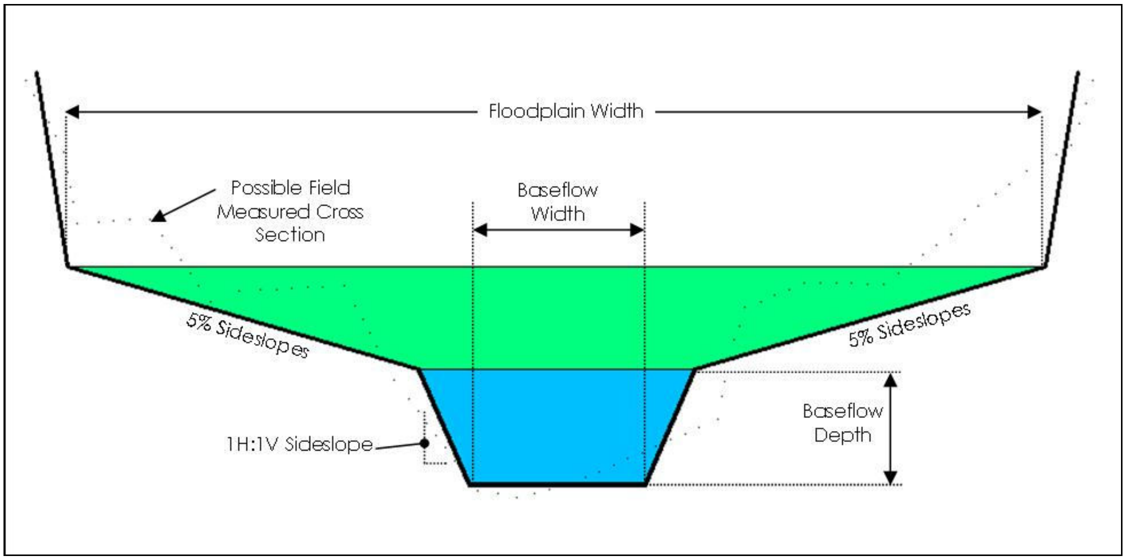


Figure A.7. Cross Sections Used for Reaches in HEC-HMS Model

The reaches were modeled using the Muskingum-Cunge routing procedure. This procedure is based on the continuity equation and the diffusion form of the momentum equation. Manning's Roughness Coefficient *n* values were assumed to be 0.055 in channel; overbank channel values were assumed to be 0.08. When necessary for calibration, Manning's *n* values and the overbank sideslopes were altered so that realistic discharge values could be obtained. The data used for each specific reach is available within the HEC-HMS Model.

INFILTRATION AND HYDROLOGIC LOSS ESTIMATES

Infiltration and all other hydrologic loss estimates (e.g., evapotranspiration, percolation, depression storage, etc.) taken into account within the HEC-HMS model was consistent with the recharge volume criteria contained in Control Guidance 1 and 2 (CG-1 and CG-2). These losses were modeled in existing conditions as the standard initial abstraction in the NRCS Curve Number Runoff method (i.e., $I_a = 0.2S$). CG1 was simulated by modifying the standard initial abstraction using the following procedure.

The runoff volume is computed by HEC-HMS using the following equation:

$$Q_{volume} = \frac{(P - I_a)^2}{(P - I_a) + S}$$

Where P = rainfall for a specific storm event (in),
I_a = initial abstraction (in), and
S = maximum retention (in).

S is defined by the following equation which relates runoff volume to curve number:

$$S = \frac{1000}{CN} - 10$$

The standard initial abstraction I_a used in Pennsylvania is typically $0.2S$. HEC-HMS calculates this automatically if no value is entered by the user. This was the approach used for the existing and future conditions modeling scenarios.

In future conditions with implementation of CG-1, the following equation is applicable. The goal of CG-1 is to ensure there is no discharge volume increase for the 2-year storm event, so

$$Q_{CG1} = Q_{Existing} = \frac{(P - I_a)^2}{(P - I_a) + S_{Proposed}}$$

Where P = rainfall for a specific storm event(in),
I_a = initial abstraction (in), and
$S_{Proposed}$ = maximum retention in proposed conditions as a function of the proposed conditions curve number (in).

Assuming $I_a = 0.2S$ as the Initial abstraction is no longer applicable with CG-1 since BMPs are to be installed to control or remove the increase in runoff volume for the 2-year storm. Using the HEC-HMS modeling output for $Q_{Existing}$, the initial abstraction for CG-1 may be calculated using the following equation:

$$I_a = P_{2-year} - \frac{1}{2}\left(Q_{Existing} \pm \sqrt{Q_{Existing}^2 + 4Q_{Existing}S_{Proposed}}\right) \text{ for the 2-year event}$$

Thus, the volume control required by CG-1 is implicitly modeled by overriding the HEC-HMS default for initial abstraction with the above value. The qualitative effect of this will be to eliminate the increase in runoff volume for the 2-year storm and to reduce the increase in runoff volume of the more extreme events. Increases in the peak flow values are reduced for all storms, but not eliminated, since the time of concentrations for proposed condition are decreased. Figure A.10 shows the effects of implementing a CG-1 policy on an example watershed. In the first figure representing a 2-year storm event, the hydrograph volumes are exactly the same and the peaks are similar. In the second figure representing a 100-year storm event, the hydrograph volumes are not the same since only the 2-year volume is abstracted; consequently there is still a substantial increase in peak flows, although the CG-1 implementation does reduce the peak flow.

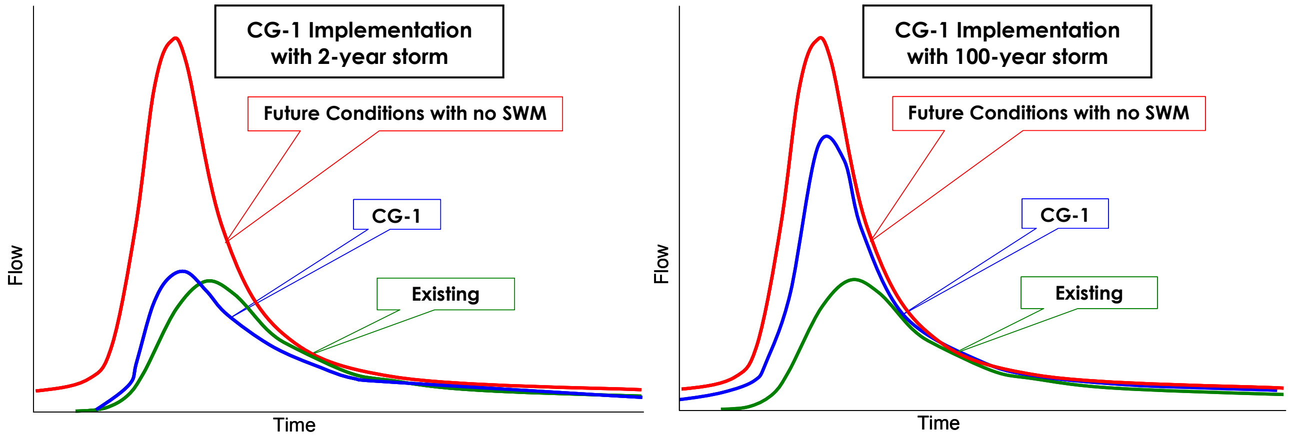


Figure A.8. Typical On-Site Runoff Control Strategy

In the case of this particular sample, release rates might be necessary to prevent increases in peak flow. In situations where there is only a small increase in impervious coverage, however, CG-1 may reduce the proposed conditions peak flow to existing conditions levels without the use of release rates.

For the 2-year event, modeling CG-1 with the above equations results in an increased approximation in initial abstraction represented by D:

$$D = I_a^{CG-1} - 0.2S$$

For every event of greater magnitude (e.g., 10, 25, 50, and 100-year events), the initial abstraction is calculated using the sum of the traditional method and the increase in initial abstraction for the 2-year event.

$I_a = 0.2S + D$ for all events greater than the 2-year event.

MODEL CALIBRATION

Three parameters were modified to develop a calibrated hydrologic model: the curve number, the time of concentration, and the Manning's coefficient used in the Muskingum-Cunge routing method.

The antecedent runoff condition was altered for each storm event so that each subbasin and calibration point was within an acceptable range of a target flow. The equation used to modify antecedent runoff condition (Maryland Hydrology Panel, 2006):

For ARC≤2:

$$CN_x = \frac{[10 + 5.8(x - 2)]CN_2}{10 + 0.058(x - 2)CN_2}$$

For ARC>2:

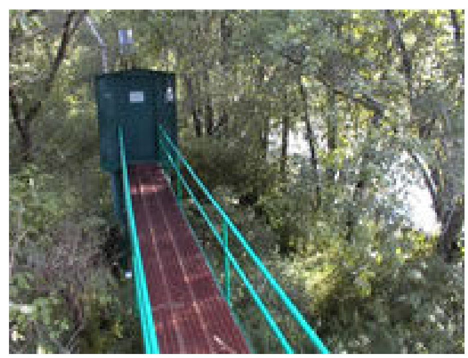
$$CN_x = \frac{[10 + 13(x - 2)]CN_2}{10 + 0.013(x - 2)CN_2}$$

Thus a unique ARC and resulting curve number was calculated for each subbasin for each storm event. The same ARC was applied in both existing and proposed conditions. The calibrated and future condition curve numbers for the two watersheds are presented in the Tables at the end of this appendix.

Additionally, lag times were calculated using both TR-55 and the NRCS lag equation. The initial model runs used the results from the NRCS lag equation. A factor between 0 and 2 was applied to the initial value to obtain a calibrated time of concentration value. The same time of concentration was applied to all existing condition storms. The future land use time of concentration was calculated using the NRCS lag equation with future land use curve numbers and it was subsequently adjusted by the same factor used in existing conditions.

Finally the Manning's n value for channels and overbank areas was modified to obtain realistic flow values. The respective ranges for the channel and overbank areas were 0.02-0.07 and 0.03-0.2.

The accuracy of the model remains unknown unless it is calibrated to another source of runoff information. Possible sources of information include stream gage data, high water marks (where detailed survey is available to facilitate hydraulic analysis), and other hydrologic models. The most desirable source of calibration information is stream gage data as this provides an actual measure of the runoff response of the watershed during real rain events.



USGS Gage 03007800 Allegheny River at Port Alleghany, PA

There are six USGS stream gages with adequate record associated with Tunungwant Creek and the Allegheny River within McKean County. The following table lists these gages and their respective statistics.

USGS Stream Gage No.	Site Name	Drainage Area mi^2	Number of Gage Years at Gage	Used in HEC-HMS Model
03007800	Allegheny River at Port Alleghany, PA	248	34	Used
03008000	Newell Creek near Port Alleghany, PA	7.8	19	Used
03009680	Potato Creek at Smethport, PA	160	24	Used
03010500	Allegheny River at Eldred, PA	550	94	Used
03011800	Kinzua Creek near Guffery, PA	38.8	43	Not Used
03026500	Sevenmile Run near Rasselas, PA	7.8	57	Not Used

Table A.6. USGS Stream Gages Associated with Tunungwant Creek and Allegheny River within McKean County

Flow estimates were derived at this gage using the Bulletin 17B methodology outlined in USGS (1982). This method produces estimates for storms of all of the frequencies desired in this study (between the 1 and 100 year storm events) for any gage that has more than 10 years of data.

When no stream gage data is available, the next most desirable source of data for purposes of comparison is other hydrologic studies prepared by local, state, or federal agencies. FEMA Flood Insurance Studies (FIS) often provide discharge estimates at specific locations within FEMA floodplains. The estimates provided in FEMA FISs are valid sources for comparison but should be carefully considered when used for calibration since they are sometimes dependent on outdated methodology, or focus exclusively on the 100-year event for flood insurance purposes.

The third available source of information that may be used for calibration is regression equation estimates. The regression equations were developed on the basis of peak flow data collected at numerous stream gages throughout Pennsylvania. This procedure is the most up-to-date method and takes into account watershed average elevation, carbonate (limestone) area, and minor surface water storage features such as small ponds and wetlands. The methodology for developing regression equation estimates within Pennsylvania is outlined in *USGS Scientific Investigations Report 2008-5102* (USGS, 2008e). Mean Elevation, Percent Carbonate Rock, and Percent Storage, the applicable parameters within McKean County, were calculated using GIS from layers supplied from USGS Digital Elevation Model (DEM) data, Environmental Resources Research Institute (1996), and USGS (2008c).

The target flow rates were determined from one of these three sources. The HEC-HMS models were then calibrated to the target flow rates at the overall watershed level, at subwatersheds where significant hydrologic features were identified (e.g., confluences, dams, USGS Gages), and at each individual subbasin. This approach was used so that a flow value anywhere in the model would compare favorably to the best available data source. The parameters of calibration for the entire overall watershed were the antecedent runoff condition, lag time, and reach routing coefficients. Detailed calibration results are provided in the form of tables at the end of this section.

The following figures (*Figures A.9-A.19*) show the overall watershed calibration results for Tunungwant Creek and the Allegheny River in McKean County. As can be shown, the calibration results are in general agreement with the range of values for other hydrologic studies. with the exception of USGS Gage 03007800, USGS Gage 03008000, and USGS Gage 03010500. There are two calibration points where USGS Gage data provided anonymous results. The period of record for USGS Gage 03010500 contains a rare extreme rainfall event that occurred in 1942 which produced 30.8 inches of rain in 4.5 hours (Tomilson et al., 2009). This 1942 storm, when included or excluded in the runoff analysis can alter the runoff value by 10,000 cubic feet per second as depicted in Figures A.18-A.19. Therefore, the comparison of flows can differ depending if the 1942 rainfall event is included in the runoff analysis. For the purposes of this study, it was determined that calibrating to the Bulletin 17B results without the 1942 storm was most appropriate. This storm was clearly an extraordinary event and is not reflective of the level of storm designers should consider in the vast majority of stormwater management facilities.

The second anonymous set of gage data is at Gage 03088000 at Newell Creek, near Port Alleghany, PA. This gage has a relatively short set of data (19 years, 1960-1978) and a small drainage area (7.8 mi^2). This data reflects an extraordinary high runoff response and is therefore considered but not the sole target values used in this analysis.

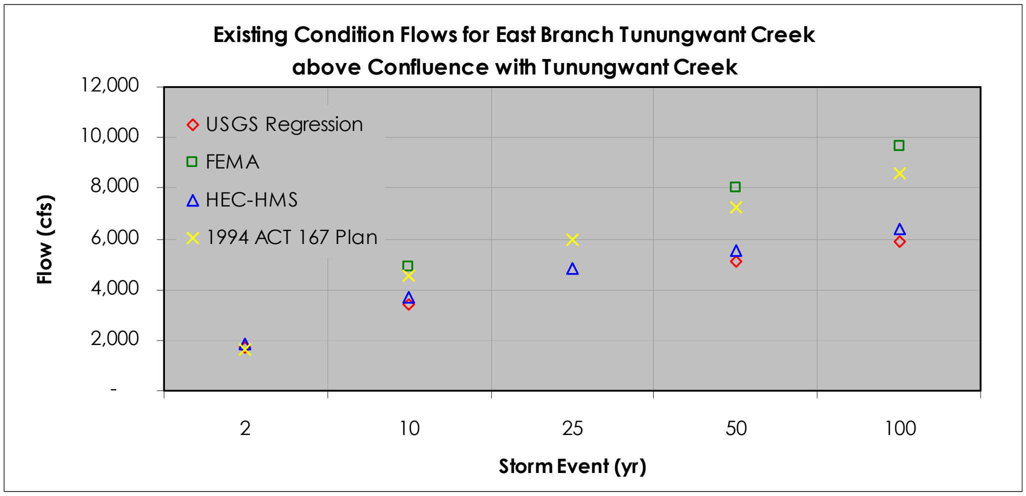


Figure A.9.

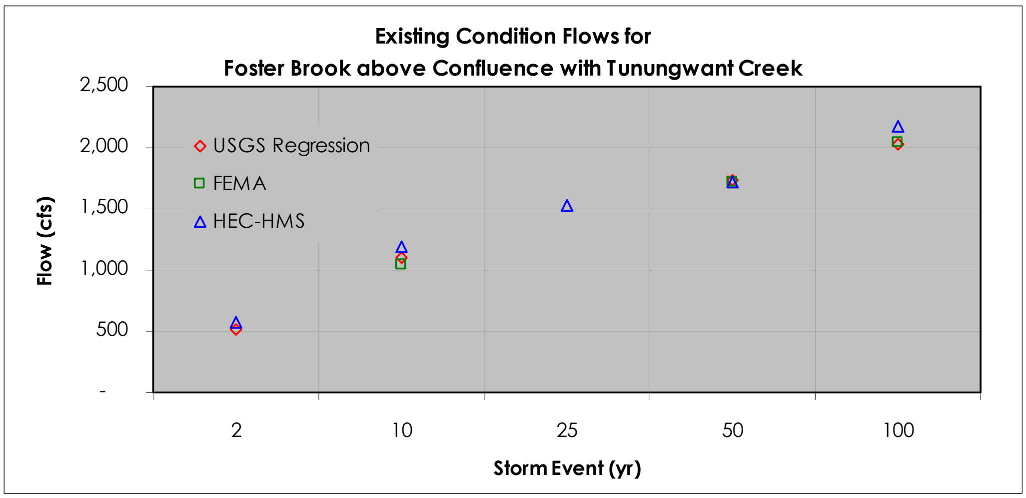


Figure A.10.

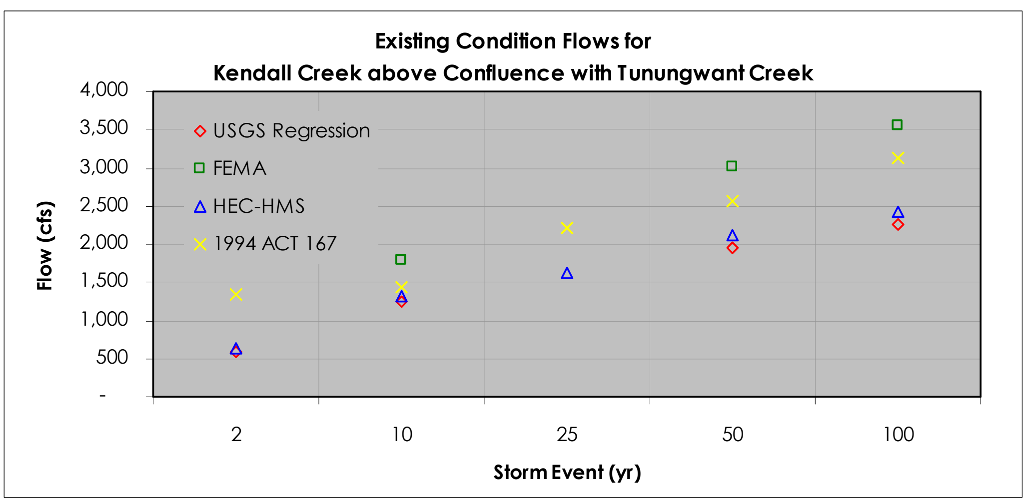


Figure A.11.

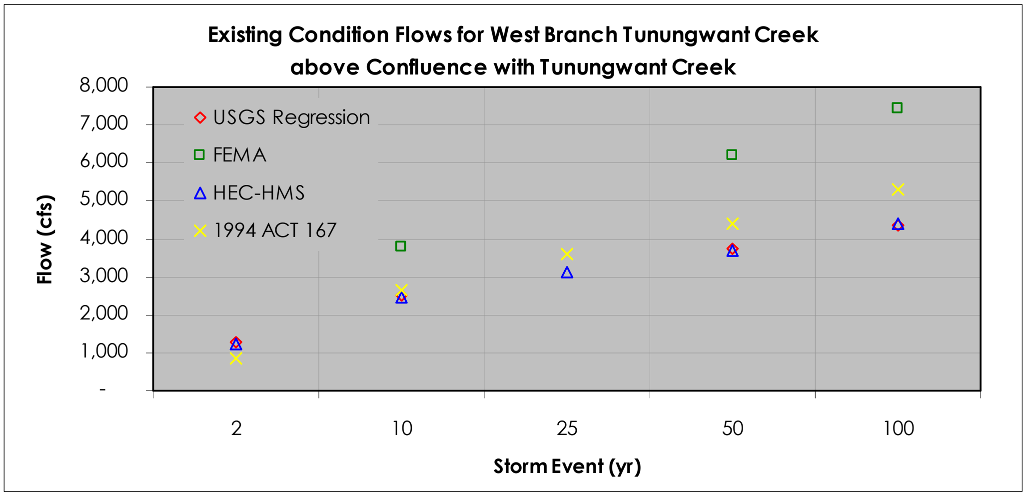


Figure A.12.

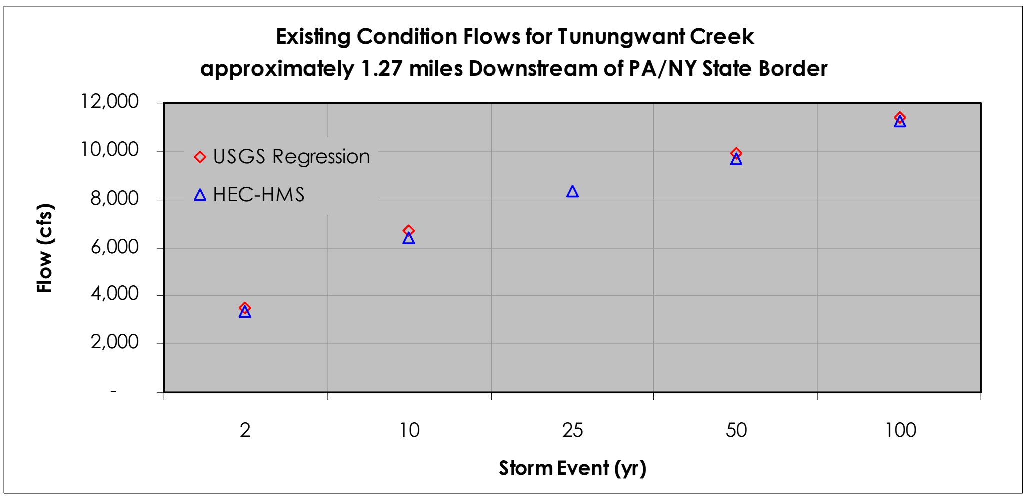


Figure A.13.

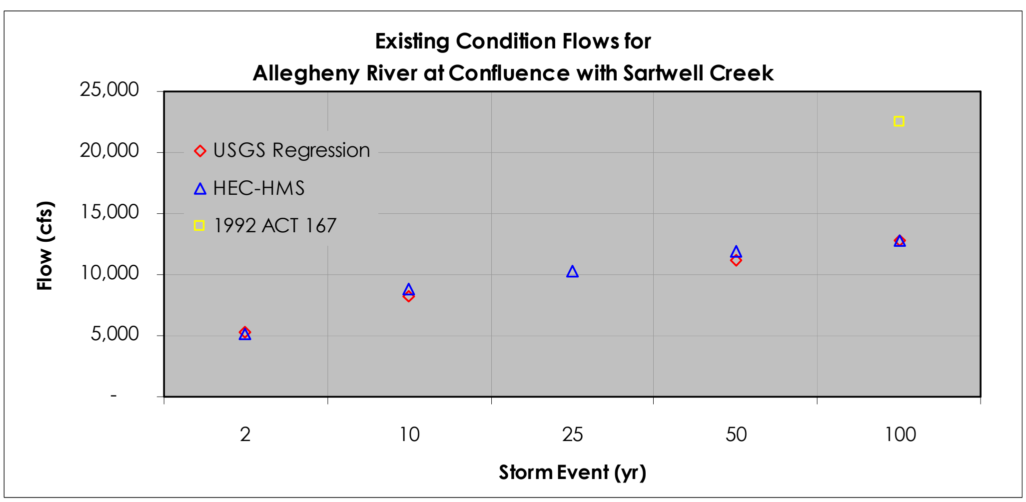


Figure A.14.

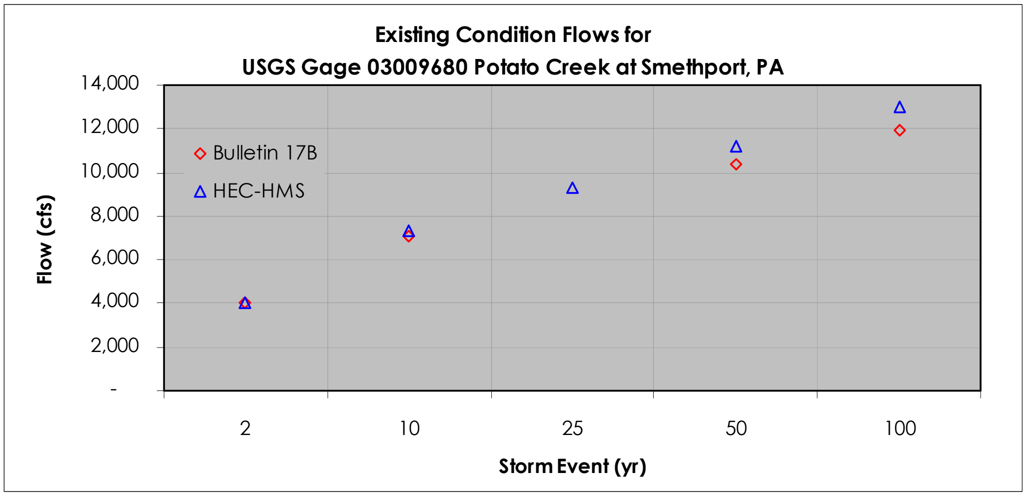


Figure A.15.

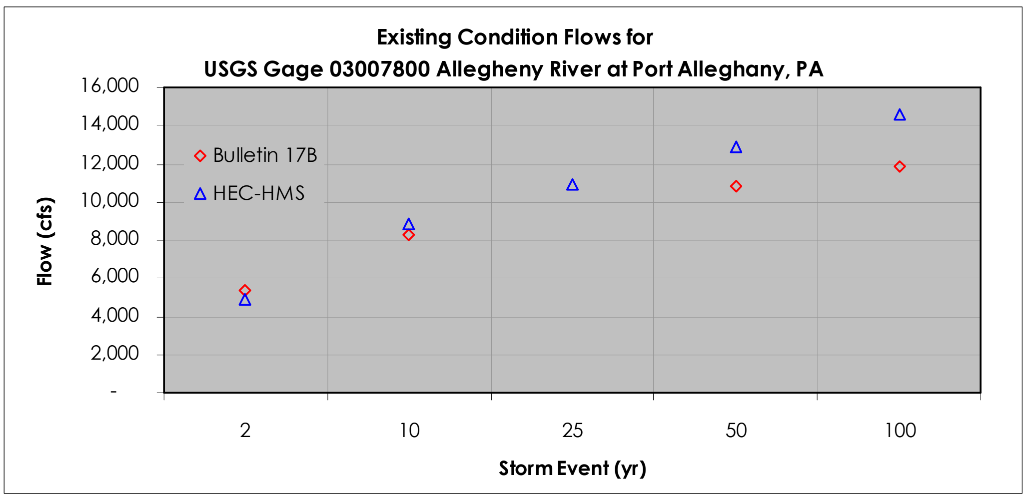


Figure A.16.

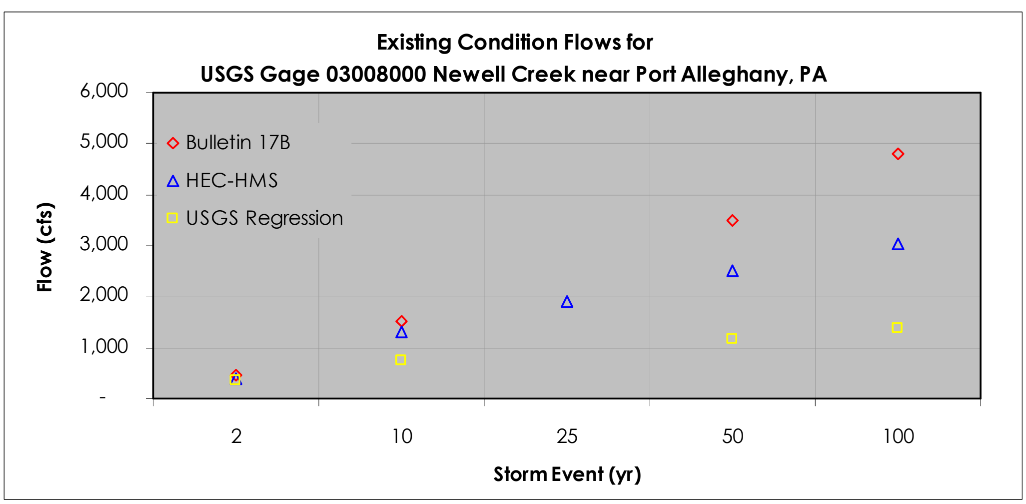


Figure A.17.

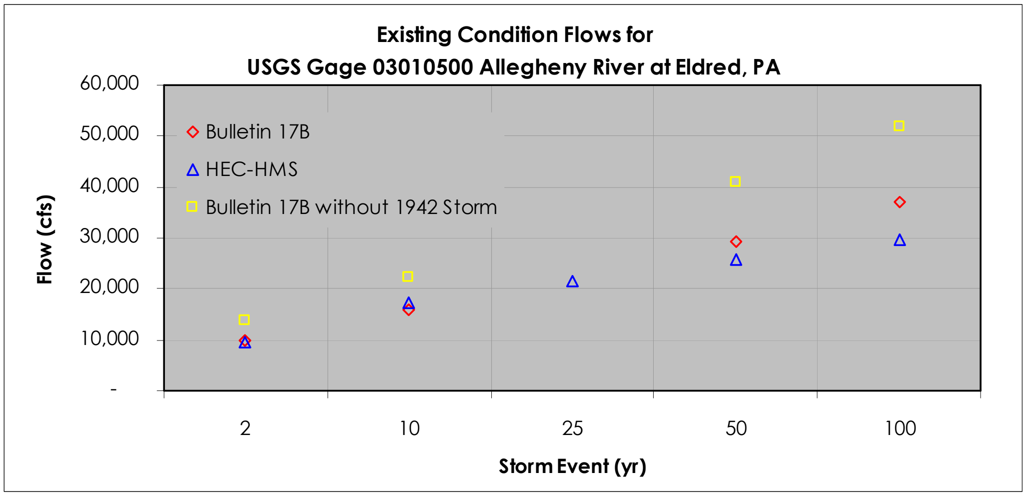


Figure A.18.

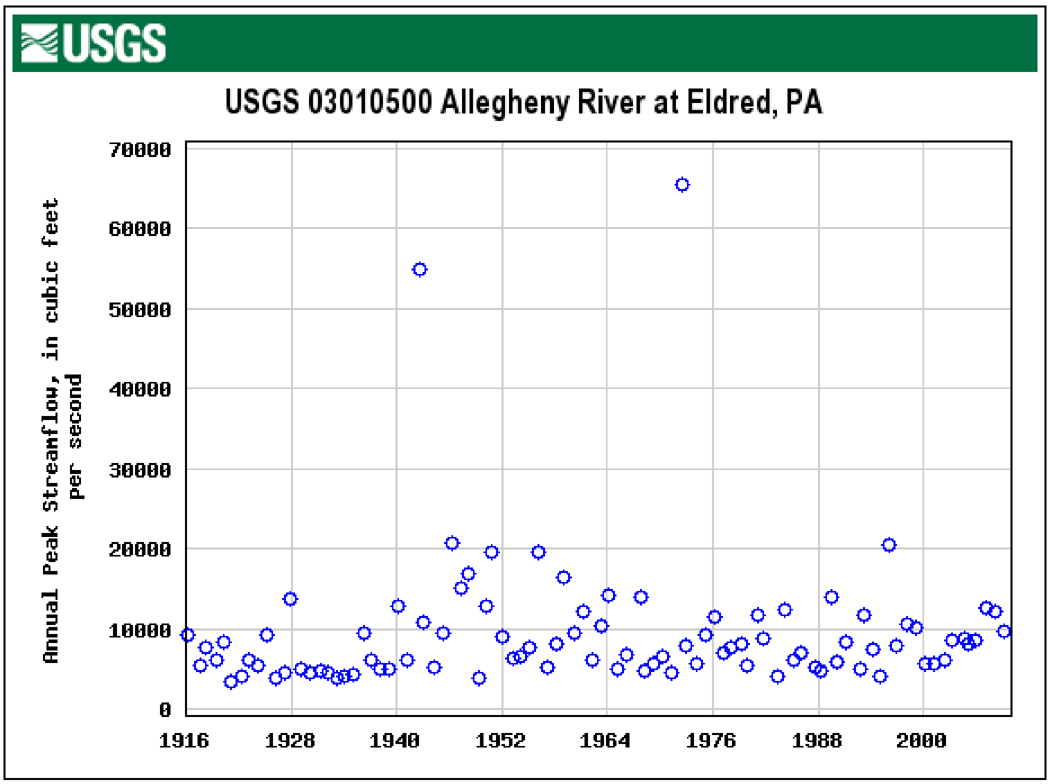


Figure A.19. (Source: USGS, 2010)

MODELING RESULTS

Once the existing conditions model was calibrated and the existing conditions peak flows were established, additional models were developed to assist in determining appropriate stormwater management controls for the watersheds. Based on a comparison of existing and future land use, most subbasins will experience varying degrees of development through the full build-out future condition.

The following simulations were performed with HEC-HMS (2, 10, 25, 50 and 100-year) for Tunungwant Creek and the Allegheny River:

Existing Conditions (Ex)

An existing conditions model was developed and analyzed using the using the calibration procedures described above. Results from the existing conditions model reflect the estimated land uses from 2010. The existing condition flows are provided in the form of tables at the end of this section.

Future Conditions with No Stormwater Controls (F-1)

A future conditions model was developed and analyzed using the projected future land use coverage for the year 2020 provided by the McKean County. The revised land use resulted in an increased curve number and a decreased time of concentration for several subbasins. It was assumed that there was no required detention or any other stormwater controls in this simulation.

Future Conditions with Design Storm Method and Release Rates (CG-1R)

A future conditions model with Stormwater Controls was developed by modifying the future conditions model to include the effects of peak rate controls and the volume removal requirements of the Design Storm Method.

The effects of peak rate controls, through detention of post development flows, was estimated by routing the post development flow for each subbasin through a simulated reservoir. The reservoirs were designed so that they could release no more than the pre-development flow estimate. This approach was assumed to simulate the additive effect of all of the individual detention facilities within a sub-basin. The volume removal requirements of the Design Storm Method were simulated using modified initial abstraction values as described above and illustrated in the form of tables at the end of this section.

The approach in this Act 167 Plan was to 1) estimate the effects of detention of post development flows and 2) apply release rates to subwatershed wherever there is a significant increases in peak flow at the points of interest. The results for each watershed are presented below; detailed results of the modeling are provided at the end of this section.

TUNUNGWANT CREEK

For the Tunungwant Creek watershed, the projected future increases are located mostly around city of Bradford and the southern portion of the watershed. This development pattern indicates the potential need for peak rate controls more stringent than the traditional 100% release rates. The increases within Tunungwant Creek are depicted in *Figure 6.1* and *Table A.7*.

Storm Event (year)	Effects of Future Condition on Discharges		
	Maximum % Increase in Future Conditions	Average % Increase in Future Conditions[1]	Portion of subbasins with Increase (%)
2	265.4	18.8	60.3
10	209.6	15.3	60.3
25	202.4	14.5	60.3
50	187.2	14.0	60.3
100	179.3	13.6	60.3

Notes: [1] Area weighted averages

Table A.7. Future Condition Flows with No Stormwater Management Controls for Tunungwant Creek

Table A.8 shows the reduction in peak flows that would occur if only the Design Storm Method were implemented without any peak rate controls. The flows for the lower magnitude events are substantially reduced compared to future conditions with no stormwater management controls with the implementation of the Design Storm Method. The flows for the higher magnitude events are moderately reduced with implementation of the Design Storm Method, but significant increases still occur.

Storm Event (year)	Effects of CG-1 on Discharges		
	Maximum % Increase with CG1	Average % Increase with CG1[1]	Portion of subbasins with Increase (%)
2	3.0	0.3	20.5
10	45.4	3.7	57.5
25	69.4	5.2	52.1
50	79.6	6.1	53.4
100	89.2	6.7	54.8

Notes: [1]Area weighted averages

Table A.8 Future Subbasin Flows with Design Storm Method Only – No peak control for Tunungwant Creek

ALLEGHENY RIVER

For the Allegheny River watershed, the projected future increases are located in numerous areas throughout the county. The increases within the Allegheny River Watershed within McKean County are depicted in *Figure 6.2.*

Storm Event (year)	Effects of Future Condition on Discharges		
	Maximum % Increase in Future Conditions	Average % Increase in Future Conditions[1]	Portion of subbasins with Increase (%)
2	318.8	4.5	34.2
10	187.6	3.5	32.8
25	175.3	3.3	32.8
50	165.6	3.1	32.2
100	156.2	3.0	32.2

Notes: [1]Area weighted averages

Table A.9. Future Condition Flows with No Stormwater Management Controls for the Allegheny River within McKean County

Table A.10 shows the reduction in peak flows that would occur if only the Design Storm Method were implemented without any peak rate controls. The lower magnitude events are substantially reduced with the implementation of the Design Storm Method; the higher magnitude events are helped with implementation of the Design Storm Method, but some increases still occur.

Storm Event (year)	Effects of CG1 on Discharges		
	Maximum % Increase with CG1	Average % Increase with CG1[1]	Portion of subbasins with Increase (%)
2	1.5	0.2	16.4
10	30.2	0.8	29.4
25	44.8	1.1	29.1
50	55.7	1.3	29.7
100	63.2	1.5	29.1

Notes: [1] Area weighted averages

Table A.10. Future Subbasin Flows with Design Storm Method Only – no peak control for the Allegheny River within McKean County

STORMWATER MANAGEMENT DISTRICTS

The regional philosophy used in Act 167 planning introduces a different stormwater management approach than is found in the traditional on-site approach. The difference between the on-site stormwater control philosophy and the Act 167 watershed-level philosophy is the consideration of downstream impacts throughout an individual watershed. The objective of typical on-site design is to control post-development peak flow rates from the site itself; however, a watershed-level design is focused on maintaining existing peak flow rates in the entire drainage basin. The watershed approach requires knowledge of how the site relates to the entire watershed in terms of the timing of peak flows, contribution to peak flows at various downstream locations, and the impact of the additional runoff volume generated by the development of the site. The proposed watershed-level stormwater runoff control philosophy is based on the assumption that runoff volumes will increase with development and the philosophy seeks to manage the increase in volumes such that peak rates of flow throughout the watershed are not increased. The controls implemented in this Plan are aimed at minimizing the increase in runoff volumes and their impacts, especially for the 2-year storm event.

The basic goal of both on-site and watershed-level philosophies is the same, i.e. no increase in the peak rate of stream flow. The end products, however, can be very different as illustrated in the following simplified example.

Presented in *Figure A.19* is a typical on-site runoff control strategy for dealing with the increase in the peak rate of runoff with development. The Existing Condition curve represents the pre-development runoff hydrograph. The Developed Condition hydrograph illustrates three important changes in the site runoff response with development:

1. A higher peak rate,

2. A faster occurring peak (shorter time for the peak rate to occur), and

3. An increase in total runoff volume.

The "Controlled" Developed Condition hydrograph is based on limiting the post-development runoff peak rate to the pre-development level through use of detention facilities; but the volume is still increased. The impact of "squashing" the post-development runoff to the pre-development peak without reducing the volume is that the peak rate occurs over a much longer period of time. The instantaneous pre-development peak has become an extended peak (approximately two (2) hours long in this example) under the "Controlled" Developed Condition.

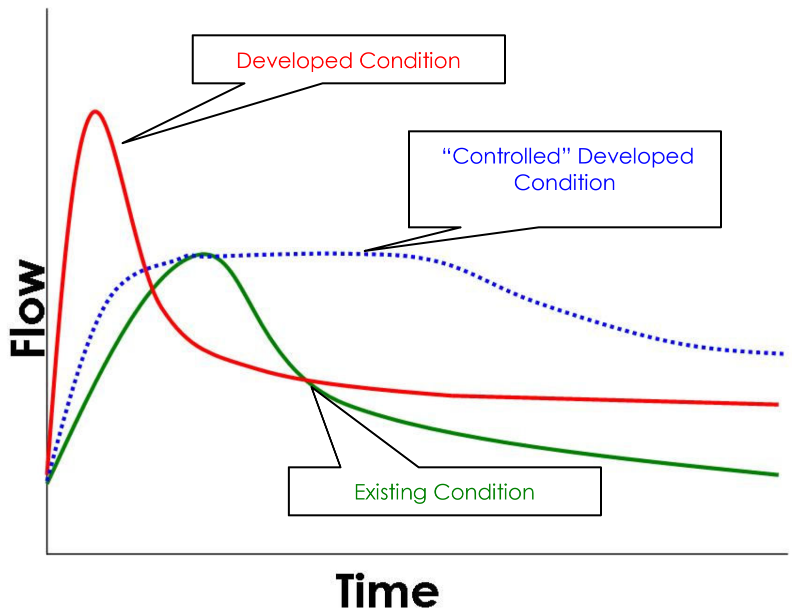


Figure A.20. Typical On-Site Runoff Control Strategy

Considering the outflow from the site only, the maintenance of the pre-development peak rate of runoff is an effective management approach. However, *Figures A.21* and *A.22* illustrate the potential detrimental impact of this approach. *Figure A.21* represents the existing hydrograph at the point of confluence of Watershed A and Watershed B. The timing relationship of the watersheds is that Watershed A peaks more quickly (at time T_{pA}) than the Total Hydrograph, while Watershed B peaks later (at time T_{pB}), than the Total Hydrograph, resulting in a combined time to peak approximately in the middle (at time T_p). Watershed A is an area of significant development pressure, and all new development proposals are met with the on-site runoff control philosophy as depicted in *Figure A.20*. The eventual end product of the Watershed A development under the "Controlled" Development Condition is an extended peak rate of runoff as shown in *Figure A.22*. The extended Watershed A peak occurs long enough so that it coincides with the peak of Watershed B. Since the Total Hydrograph at the confluence is the summation of Watershed A and Watershed B, the Total Hydrograph peak is increased under these conditions to the "Controlled" Total Hydrograph. The conclusion from the example is that simply controlling peak rates of runoff on-site does not guarantee an effective watershed level of control because of the increase in total runoff volume. The net result is that downstream peaks can increase and extend for longer durations.

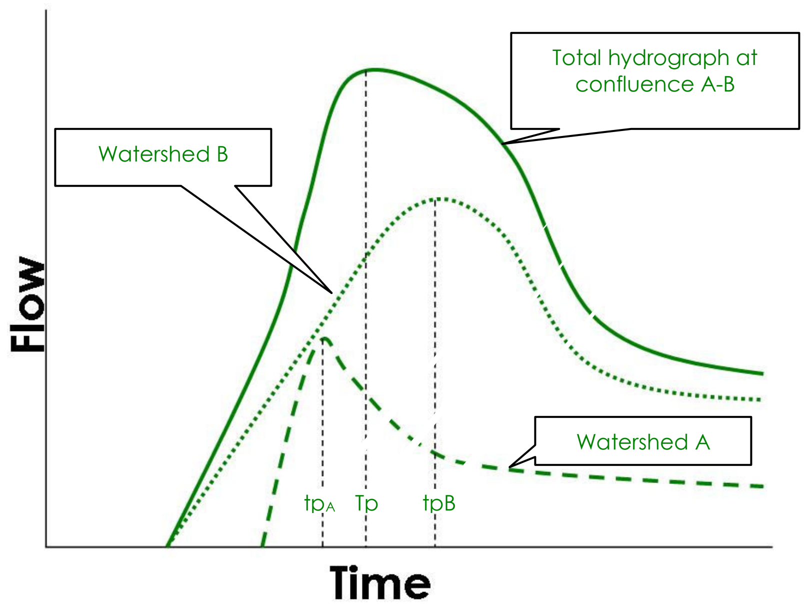


Figure A.21. Existing Hydrograph (Pre-Development)

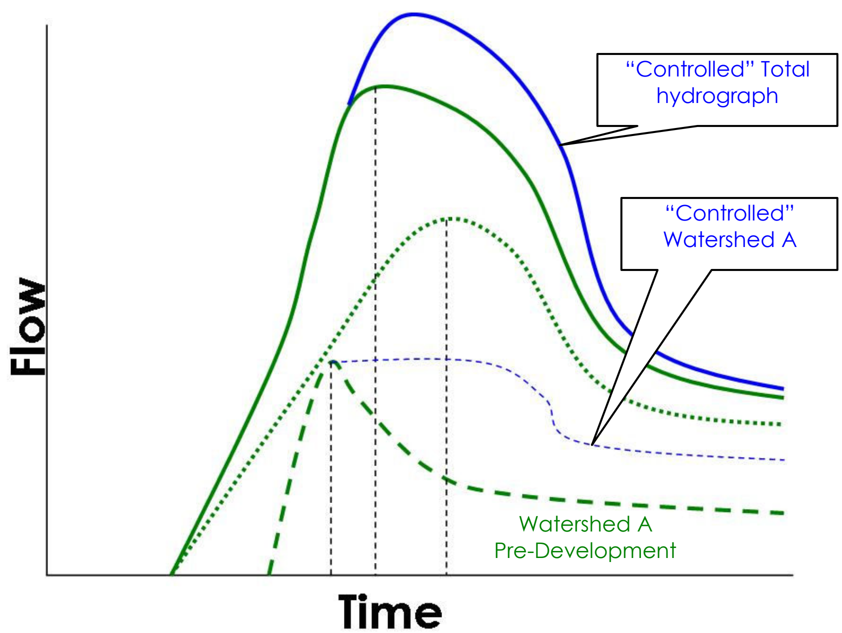


Figure A.22 Controlled Runoff Condition (Post-Development)

RELEASE RATE CONCEPT

The previous example indicated that, in certain circumstances, it is not enough to control post-development runoff peaks to pre-development levels if the overall goal is no increase in peak runoff at any point in the watershed. The reasons for this potential increase are how the various parts of the watershed interact, in time, with one another and the increased rate and volume of runoff associated with development and increases in impervious surfaces. The critical runoff criteria for a given site or watershed area is not necessarily its own pre-development peak rate of runoff but rather the pre-development contribution of the site or watershed area to the peak flow at a given point of interest.

To account for increases of volume and peak flow resulting from the combination of these post-development hydrographs, stormwater management districts have been assigned to various areas within the county boundary that have more restrictive release rates than the conventional 100% release rate. As shown in Plate 10, some areas within specific watersheds have reduced release rates where CG-1 may be difficult to completely implement.

The specification of a 100% release rate as a performance standard would represent the conventional approach to runoff control philosophy, namely controlling the post-development peak runoff to pre-development levels. This is a well-established and technically feasible control that is effective at-site and, where appropriate, would be an effective watershed-level control.

It is important to acknowledge that there are several problems with the release rate concept. One of the problems is that some areas can reach unreasonably low release rates. This can be seen in the release rate equation, which dictates that sub-watersheds which peak farther away from the entire watershed will have a lower release rate. Indeed, sub-watersheds whose runoff drains almost completely before or after the watershed peak will approach a release rate of zero (because the numerator approaches zero).

Another problem is that release rates are highly dependent on, and sensitive to, the timing of hydrographs. Since natural storms follow a different timing than design storms, it is still possible that watershed wide controls designed with release rates only, will encounter increased runoff problems. This is because the runoff rates are still much higher in the developed condition, and increased volumes over an extended time can combine to increase peak flow rates. Similar to the traditional on-site detention pond, release rates are purely a peak "rate" type of control.

Patterns of development may also determine how effective designs are that use only release rates, or any control based on timing. This is because rates based on timing assume a certain development and rainfall patterns, and the model uses uniform parameters across a sub-watershed. In reality, the actual development and rainfall patterns can be highly variable across a sub-watershed and can be quite different than the "Future Full Build Out" land use scenario used in the planning study. This uncertainty can affect any type of control, but controls based on timing alone are especially sensitive to these parameters. Some controls, such as volume controls, are less sensitive since they remove a certain amount of runoff from the storm event wherever development occurs. In a sense, volume controls tend to more closely simulate what occurs in a natural system.

Combining volume controls with peak rate controls, as proposed in this plan, will be more effective than having only peak rate controls. Volume controls have several advantages such as:

1. Increased runoff volume may infiltrate and provide recharge to existing groundwater supplies. This may not happen with rate controls since all of the runoff excess is discharged in a relatively short time frame.

2. Volume controls tend to mimic natural systems (i.e., excess runoff volume is infiltrated) and thus are more effective in controlling natural storms since they are not highly sensitive to timing issues.

3. Volume controls often have enhanced water quality benefits.

4. The Design Storm Method and The Simplified Method as implemented in this Plan, provide the benefits described above.

SUMMARY MODEL OUTPUT

Hydrologic Parameters for Tunungwant Creek HEC-HMS Model

Hydrologic Results for Tunungwant Creek HEC-HMS Model

Hydrologic Parameters for Allegheny River HEC-HMS Model

Hydrologic Results for Allegheny River HEC-HMS Model

Hydrologic Parameters for Tunungwant Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Bennett Brook	W310	4.44	64.1	100.4	64.5	86.3
	W320	0.15	68.2	29.6	75.6	21.0
	W330	0.05	65.8	47.6	71.6	37.4
Bolivar Run	W530	2.48	66.8	67.7	66.8	52.3
	W540	2.09	65.3	57.1	65.4	48.2
	W550	0.66	64.5	36.3	67.7	29.3
	W560	0.07	71.3	18.7	78.4	13.2
	W570	0.05	77.8	29.5	87.1	17.2
East Branch Tunungwant Creek	W050	3.56	62.6	101.1	63.2	85.4
	W610	4.39	69.6	139.0	74.6	78.5
	W620	1.90	61.5	73.6	61.5	64.2
	W630	3.21	61.6	99.6	62.0	86.6
	W640	2.71	63.9	63.3	64.4	53.3
	W650	0.01	73.8	19.4	88.7	6.4
	W660	2.20	64.8	69.9	66.1	57.7
	W670	2.08	65.2	62.1	65.1	55.0
	W680	0.22	68.0	39.3	68.7	23.4
	W690	2.38	68.3	51.7	71.0	42.9
	W700	1.42	65.3	45.2	70.0	36.0
	W710	0.92	68.1	43.5	76.8	31.4
Foster Brook	W590	3.34	61.9	76.8	62.2	68.5
	W600	2.58	66.6	62.8	69.2	52.6
Fuller Brook	W210	3.51	65.3	67.5	65.3	56.1
	W220	1.02	85.4	32.3	85.4	23.0
Gilbert Run	W080	4.55	62.8	88.1	62.8	73.8
	W090	0.49	63.3	30.9	63.4	27.6
Harrisburg Run	W370	4.03	67.5	91.7	67.4	72.2
Kendall Creek	W340	2.84	62.2	70.8	62.6	62.8
	W470	3.77	62.8	73.4	62.9	63.4
	W480	1.48	65.3	65.5	65.9	56.0
	W490	3.35	62.6	73.8	62.7	66.1
	W500	1.74	62.7	49.7	66.1	41.7
	W510	0.92	66.1	45.8	78.8	28.9
	W520	0.02	83.1	22.0	87.5	13.4
Lafferty Run	W350	1.43	60.5	63.1	70.8	43.7
	W360	0.00	67.3	13.1	86.6	4.9
Langmade Brook	W230	2.06	63.4	68.2	63.4	57.4
Lewis Run	W040	4.60	63.2	113.3	66.0	89.5
	W100	2.18	72.2	64.0	72.3	53.6
	W110	2.07	65.6	75.3	66.7	59.3
	W120	2.08	63.8	78.3	65.1	63.0
	W130	2.98	65.4	95.5	66.8	77.1
Marilla Brook	W240	4.93	61.9	99.8	61.9	84.3
	W250	0.82	61.3	48.0	61.3	41.9

Hydrologic Parameters for Tunungwant Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Marilla Brook	W260	0.73	64.7	45.4	64.7	38.7
	W270	0.17	65.2	21.1	65.2	18.6
	W280	3.02	65.9	83.3	66.8	71.6
Minard Run	W150	3.32	65.6	78.6	65.8	61.1
	W160	4.19	66.2	78.2	66.2	65.6
	W170	1.30	64.1	42.6	64.1	38.8
	W180	0.71	65.0	46.0	66.2	39.2
Pennbrook Run	W580	3.22	61.7	84.7	61.7	74.1
Railroad Run	W060	2.74	63.0	105.3	63.3	86.5
	W070	2.56	64.0	94.4	65.5	75.8
Rutherford Run	W190	1.72	62.9	62.4	63.5	54.9
Sheppard Run	W140	2.60	62.2	86.9	62.3	73.7
Tunungwant Creek	W720	1.08	70.1	52.5	74.2	35.7
	W730	0.39	72.1	35.7	82.1	24.2
	W740	0.42	70.4	30.3	75.3	23.0
	W750	1.88	66.3	65.9	68.8	50.0
	W760	3.64	65.2	91.4	66.1	74.7
West Branch Tunungwant Creek	W200	2.43	63.7	92.4	63.7	75.4
	W290	0.58	67.2	32.4	69.8	25.8
	W300	0.26	64.4	29.4	68.4	24.2
	W380	2.29	66.2	69.2	66.3	53.6
	W390	2.00	65.5	73.6	65.5	59.5
	W400	0.13	72.0	22.1	72.0	17.0
	W410	3.08	64.3	77.4	64.3	64.5
	W420	1.56	65.3	49.7	65.3	42.8
	W430	2.26	64.1	65.8	64.3	57.4
	W440	0.82	62.3	38.0	66.9	30.7
	W450	0.22	64.6	26.8	67.9	22.1
	W460	0.53	72.2	36.5	79.1	26.7

Hydrologic Parameters for Tunungwant Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Bennett Brook	W310	64.1	68.8	64.5	61.1	57.9	56.0
	W320	68.2	70.7	66.3	62.9	61.2	59.2
	W330	65.8	70.3	65.9	62.4	60.7	58.7
Bolivar Run	W530	66.8	65.6	61.6	58.5	55.9	54.2
	W540	65.3	66.5	61.5	58.3	56.3	54.1
	W550	64.5	67.6	63.0	59.4	57.7	55.6
	W560	71.3	73.4	69.2	65.9	64.3	62.3
	W570	77.8	82.1	78.9	76.3	75.0	73.3
East Branch Tunungwant Creek	W050	62.6	67.1	63.3	60.7	57.8	55.3
	W610	69.6	69.8	65.8	63.4	60.6	58.6
	W620	61.5	66.0	63.1	60.1	56.7	54.7
	W630	61.6	68.2	64.4	61.6	58.4	56.4
	W640	63.9	65.5	61.5	58.0	56.1	53.2
	W650	73.8	79.0	75.4	72.6	71.1	69.3
	W660	64.8	66.3	62.9	59.9	57.6	55.1
	W670	65.2	67.3	62.7	59.6	57.5	54.6
	W680	68.0	72.0	67.8	64.4	62.8	60.8
	W690	68.3	65.4	61.2	58.6	55.6	52.5
	W700	65.3	67.7	61.3	58.9	56.1	53.1
	W710	68.1	72.5	68.2	64.9	63.3	61.3
Foster Brook	W590	61.9	66.5	62.7	59.7	57.0	55.6
	W600	66.6	67.7	62.7	60.2	57.5	55.5
Fuller Brook	W210	65.3	66.8	61.8	57.8	55.5	52.5
	W220	85.4	71.1	71.1	71.1	71.1	71.1
Gilbert Run	W080	62.8	66.6	60.9	57.5	54.7	52.0
	W090	63.3	67.2	62.5	59.0	57.2	55.1
Harrisburg Run	W370	67.5	67.5	63.4	60.2	57.4	56.2
Kendall Creek	W340	62.2	65.7	61.4	57.7	56.6	54.1
	W470	62.8	65.0	60.9	57.0	55.8	53.1
	W480	65.3	67.6	62.7	59.4	58.3	55.6
	W490	62.6	66.0	61.3	57.8	56.7	53.8
	W500	62.7	65.9	60.5	57.5	55.8	52.8
	W510	66.1	69.9	65.4	61.9	60.3	58.2
	W520	83.1	87.4	85.0	83.0	82.0	80.7
Lafferty Run	W350	60.5	65.5	62.4	58.9	56.6	55.0
	W360	67.3	74.5	70.5	67.3	65.7	63.8
Langmade Brook	W230	63.4	67.5	63.2	59.9	56.4	54.6
Lewis Run	W040	63.2	67.7	63.7	61.2	58.3	55.7
	W100	72.2	66.0	61.3	58.9	56.2	52.7
	W110	65.6	67.0	62.5	59.7	57.0	55.4
	W120	63.8	67.2	63.1	60.5	57.5	55.4
	W130	65.4	68.0	63.0	60.6	58.2	56.6
Marilla Brook	W240	61.9	67.9	63.2	59.8	55.9	53.8
	W250	61.3	64.3	64.3	64.3	64.3	64.3

Hydrologic Parameters for Tunungwant Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Marilla Brook	W260	64.7	66.7	66.7	66.7	66.7	66.7
	W270	65.2	68.2	68.2	68.2	68.2	68.2
	W280	65.9	69.0	64.6	60.8	58.7	55.9
Minard Run	W150	65.6	65.7	61.3	58.5	55.6	53.8
	W160	66.2	66.7	61.1	58.4	56.4	53.4
	W170	64.1	65.5	60.1	57.9	55.4	52.4
	W180	65.0	68.1	63.5	60.0	58.2	56.2
Pennbrook Run	W580	61.7	66.3	63.2	60.1	56.4	55.6
Railroad Run	W060	63.0	67.2	64.1	61.8	59.1	55.6
	W070	64.0	67.5	63.6	61.0	58.1	55.7
Rutherford Run	W190	62.9	67.2	61.6	58.9	57.3	54.7
Sheppard Run	W140	62.2	67.4	63.2	60.6	57.6	55.1
Tunungwant Creek	W720	70.1	68.4	64.0	61.6	58.8	57.2
	W730	72.1	75.9	72.0	68.9	67.3	65.4
	W740	70.4	72.6	68.4	65.1	63.4	61.4
	W750	66.3	66.8	63.1	60.0	57.4	56.2
	W760	65.2	68.5	62.7	59.6	57.2	55.3
West Branch Tunungwant Creek	W200	63.7	67.4	63.4	60.0	56.0	54.0
	W290	67.2	69.0	64.5	61.0	59.3	57.3
	W300	64.4	68.8	64.2	60.7	59.0	56.9
	W380	66.2	67.1	62.8	59.4	55.9	54.0
	W390	65.5	66.0	60.7	56.5	53.8	50.5
	W400	72.0	76.0	72.1	69.0	67.4	65.5
	W410	64.3	67.9	63.2	59.8	56.6	54.6
	W420	65.3	67.5	62.1	58.5	56.0	53.0
	W430	64.1	68.0	63.6	60.1	57.6	54.9
	W440	62.3	66.9	62.2	58.6	56.9	54.8
	W450	64.6	68.4	63.9	60.3	58.6	56.6
	W460	72.2	75.1	71.1	68.0	66.4	64.5

Hydrologic Parameters for Tunungwant Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Bennett Brook	W310	64.5	69.2	65.0	61.6	58.4	56.5
	W320	75.6	77.8	74.1	71.1	69.6	67.8
	W330	71.6	75.6	71.6	68.5	66.9	65.0
Bolivar Run	W530	66.8	65.7	61.6	58.5	55.9	54.2
	W540	65.4	66.6	61.6	58.4	56.4	54.2
	W550	67.7	70.6	66.2	62.8	61.1	59.1
	W560	78.4	80.1	76.7	73.9	72.5	70.8
	W570	87.1	89.8	87.8	86.1	85.3	84.2
East Branch Tunungwant Creek	W050	63.2	67.7	63.9	61.3	58.4	56.0
	W610	74.6	74.8	71.1	68.9	66.3	64.5
	W620	61.5	66.0	63.1	60.2	56.7	54.8
	W630	62.0	68.6	64.8	62.1	58.8	56.8
	W640	64.4	66.0	62.0	58.5	56.6	53.7
	W650	88.7	91.3	89.5	88.0	87.3	86.3
	W660	66.1	67.6	64.2	61.3	59.1	56.6
	W670	65.1	67.2	62.6	59.4	57.4	54.5
	W680	68.7	72.7	68.5	65.1	63.5	61.5
	W690	71.0	68.2	64.2	61.7	58.7	55.7
	W700	70.0	72.2	66.2	63.9	61.3	58.4
	W710	76.8	80.4	76.9	74.2	72.8	71.1
Foster Brook	W590	62.2	66.8	63.0	60.0	57.3	55.9
	W600	69.2	70.3	65.5	63.1	60.4	58.5
Fuller Brook	W210	65.3	66.8	61.8	57.8	55.5	52.5
	W220	85.4	71.0	71.0	71.0	71.0	71.0
Gilbert Run	W080	62.8	66.6	60.9	57.5	54.7	52.0
	W090	63.4	67.2	62.6	59.0	57.3	55.2
Harrisburg Run	W370	67.4	67.4	63.3	60.1	57.3	56.1
Kendall Creek	W340	62.6	66.1	61.8	58.2	57.1	54.5
	W470	62.9	65.0	61.0	57.1	55.9	53.2
	W480	65.9	68.1	63.2	59.9	58.9	56.2
	W490	62.7	66.1	61.3	57.9	56.8	53.9
	W500	66.1	69.2	64.1	61.1	59.5	56.6
	W510	78.8	81.5	78.3	75.6	74.3	72.6
	W520	87.5	90.9	89.0	87.5	86.7	85.7
Lafferty Run	W350	70.8	75.0	72.4	69.3	67.3	65.9
	W360	86.6	90.2	88.2	86.6	85.7	84.6
Langmade Brook	W230	63.4	67.5	63.2	59.9	56.4	54.6
Lewis Run	W040	66.0	70.2	66.4	63.9	61.1	58.6
	W100	72.3	66.1	61.4	59.0	56.3	52.9
	W110	66.7	68.1	63.6	60.9	58.2	56.6
	W120	65.1	68.5	64.4	61.9	58.9	56.8
	W130	66.8	69.4	64.5	62.1	59.8	58.2
Marilla Brook	W240	61.9	67.9	63.2	59.8	55.9	53.8
	W250	61.3	64.3	64.3	64.3	64.3	64.3

Hydrologic Parameters for Tunungwant Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Marilla Brook	W260	64.7	66.7	66.7	66.7	66.7	66.7
	W270	65.2	68.2	68.2	68.2	68.2	68.2
	W280	66.8	69.9	65.5	61.8	59.7	57.0
Minard Run	W150	65.8	65.9	61.5	58.7	55.9	54.1
	W160	66.2	66.7	61.1	58.4	56.5	53.4
	W170	64.1	65.5	60.1	57.9	55.4	52.4
	W180	66.2	69.2	64.7	61.3	59.6	57.5
Pennbrook Run	W580	61.7	66.3	63.2	60.1	56.4	55.5
Railroad Run	W060	63.3	67.5	64.4	62.1	59.5	55.9
	W070	65.5	68.8	65.0	62.5	59.6	57.2
Rutherford Run	W190	63.5	67.7	62.2	59.4	57.8	55.3
Sheppard Run	W140	62.3	67.4	63.3	60.7	57.7	55.1
Tunungwant Creek	W720	74.2	72.8	68.6	66.4	63.7	62.2
	W730	82.1	84.9	82.1	79.8	78.6	77.1
	W740	75.3	77.2	73.4	70.4	68.9	67.0
	W750	68.8	69.2	65.6	62.7	60.0	58.9
	W760	66.1	69.4	63.7	60.6	58.2	56.4
West Branch Tunungwant Creek	W200	63.7	67.4	63.4	60.0	56.0	54.0
	W290	69.8	71.6	67.2	63.9	62.2	60.2
	W300	68.4	72.4	68.2	64.9	63.2	61.2
	W380	66.3	67.2	62.9	59.5	55.9	54.1
	W390	65.5	66.0	60.7	56.5	53.8	50.5
	W400	72.0	76.0	72.1	69.0	67.4	65.5
	W410	64.3	67.9	63.2	59.8	56.6	54.6
	W420	65.3	67.5	62.1	58.5	56.0	53.0
	W430	64.3	68.1	63.8	60.3	57.8	55.1
	W440	66.9	71.2	66.9	63.5	61.8	59.8
	W450	67.9	71.5	67.1	63.8	62.1	60.1
	W460	79.1	81.5	78.2	75.5	74.2	72.5

Hydrologic Results for Tunungwant Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	J1008	1702640.6	614681.1	2.18	107	217	305	352	371	109	220	308	356	376
2	J1053	1700575.2	639665.0	3.51	185	355	425	512	561	185	355	424	512	561
3	J_No. 2 Reservoir	1704039.7	655388.2	4.55	97	187	248	293	340	97	187	248	293	340
4	J_No. 3 Reservoir	1699109.5	652856.5	4.93	179	351	456	474	572	179	351	456	474	572
5	J_No. 1 Reservoir	1702107.6	652523.4	5.75	194	388	510	542	659	194	388	510	542	659
6	J1119	1705505.4	652656.7	11.52	306	610	810	904	1,084	306	610	810	905	1,084
7	P42	1706504.7	651324.2	11.69	309	616	819	915	1,096	309	616	819	915	1,097
8	P43	1716769.3	653440.9	0.58	66	128	159	199	235	93	171	211	259	303
9	P66	1720229.2	654655.4	4.44	227	436	542	596	718	240	457	568	625	752
10	O5	1720962.1	653722.6	4.59	232	444	552	608	732	246	468	581	640	769
11	J1027	1700442.0	625873.9	2.29	123	252	317	339	414	125	254	320	342	418
12	J1033	1703706.6	630804.1	6.72	323	644	798	860	1,011	324	646	801	863	1,014
13	J_No. 5 Reservoir	1704172.9	632069.9	6.85	-	64	102	123	165	-	65	102	123	166
14	J1048	1707037.7	638265.9	14.46	405	790	991	1,156	1,337	405	790	990	1,155	1,337
15	J1056	1710035.8	642063.5	18.07	588	1,151	1,451	1,670	1,950	587	1,151	1,450	1,670	1,949
16	J1083	1717164.5	647993.0	35.05	997	2,085	2,705	3,254	3,864	1,016	2,122	2,752	3,310	3,929
17	J1078	1719829.5	651524.1	36.70	1,046	2,177	2,825	3,401	4,037	1,076	2,230	2,891	3,480	4,125
18	J1094	1721561.7	652656.7	41.55	1,197	2,411	3,093	3,655	4,348	1,239	2,488	3,193	3,772	4,482
19	J_W.Branch Tunungwant	1725383.9	654162.9	42.08	1,215	2,442	3,132	3,702	4,402	1,261	2,524	3,237	3,824	4,542
20	J997	1711434.9	612149.4	8.84	380	766	1,041	1,188	1,350	476	926	1,243	1,416	1,609
21	J1011	1729423.3	616213.5	2.74	113	251	341	392	414	118	260	352	404	428
22	J1016	1718163.9	619211.6	10.92	465	934	1,264	1,439	1,645	574	1,113	1,489	1,693	1,935
23	J1030	1735752.6	630071.2	3.32	136	286	386	439	538	141	294	397	452	552
24	J1038	1732021.6	634002.0	7.51	330	634	858	1,022	1,176	336	643	870	1,036	1,191
25	P41	1728690.4	635467.7	8.80	370	706	956	1,138	1,303	376	715	968	1,152	1,319
26	J101	1722827.6	601622.9	4.39	200	378	501	567	671	349	616	795	898	1,050
27	J1000	1725359.3	608551.8	9.84	382	768	1,017	1,139	1,335	561	1,053	1,375	1,544	1,802
28	J1003	1724826.3	617479.3	18.35	727	1,521	2,018	2,257	2,599	938	1,833	2,411	2,704	3,117
29	P84	1721628.3	623075.7	21.06	795	1,659	2,194	2,468	2,834	1,011	1,974	2,586	2,914	3,351
30	J1019	1721428.5	623408.9	34.97	1,361	2,785	3,721	4,223	4,869	1,694	3,287	4,351	4,934	5,685
31	P40	1722061.4	627839.3	37.17	1,424	2,911	3,882	4,414	5,087	1,763	3,422	4,520	5,134	5,913
32	J1024	1724426.5	636200.6	41.84	1,521	3,067	4,068	4,624	5,320	1,852	3,564	4,688	5,323	6,120
33	J1043	1723960.2	637466.5	51.58	1,788	3,541	4,699	5,373	6,188	2,122	4,039	5,321	6,075	6,991
34	J1064	1724026.8	645328.1	55.68	1,845	3,631	4,807	5,499	6,324	2,182	4,129	5,427	6,198	7,124

Hydrologic Results for Tunungwant Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	Year	2-Year	10-Year	25-Year	50-Year	100-Year
35	P69	1724293.3	649202.2	57.10	1,859	3,644	4,821	5,513	6,336	2,198	4,145	5,442	6,214	7,138
36	J_E.Branch Tunungwant	1725771.7	653495.8	58.02	1,878	3,673	4,855	5,553	6,382	2,223	4,181	5,485	6,264	7,194
37	J1200	1735785.3	653555.5	1.43	66	162	203	243	300	231	439	537	627	742
38	J1059	1745279.8	642729.7	3.77	146	328	398	533	602	149	332	403	538	608
39	J1067	1742614.8	644861.7	8.09	351	744	918	1,225	1,389	367	771	950	1,264	1,433
40	J1201	1738217.6	650391.5	11.44	495	1,028	1,277	1,701	1,918	513	1,059	1,314	1,747	1,970
41	J1070	1735419.4	653389.5	14.61	607	1,251	1,560	2,047	2,320	696	1,377	1,708	2,216	2,507
42	P67	1730997.8	657078.3	15.53	640	1,306	1,626	2,124	2,410	749	1,455	1,801	2,320	2,625
43	J_Kendall Creek	1730611.0	657520.5	15.55	642	1,307	1,628	2,126	2,412	750	1,457	1,803	2,323	2,627
44	J1153	1719363.1	665381.8	2.48	111	244	319	373	461	112	245	320	375	463
45	J1202	1725092.8	660318.4	4.56	210	438	568	679	822	212	441	571	683	827
46	P65	1728623.8	659652.2	5.22	237	490	630	756	911	245	500	643	770	927
47	O3	1729396.1	659785.4	5.29	224	457	589	706	850	233	471	605	725	871
48	J1150	1746545.6	658852.7	3.22	137	317	409	434	568	137	316	408	433	568
49	J1126	1740349.6	659252.4	10.58	472	1,015	1,308	1,462	1,865	474	1,019	1,314	1,468	1,874
50	J_Foster Brook	1731029.3	662913.1	13.16	570	1,186	1,535	1,722	2,174	593	1,219	1,572	1,765	2,222
51	J1113	1726025.5	653922.5	100.10	2,851	5,495	7,165	8,215	9,513	3,212	6,013	7,806	8,935	10,336
52	J1073	1730422.7	657720.1	116.73	3,123	5,997	7,815	9,085	10,528	3,508	6,530	8,478	9,820	11,364
53	J1116	1730822.4	659985.3	122.45	3,221	6,178	8,042	9,364	10,857	3,610	6,712	8,705	10,095	11,688
54	J1129	1730489.3	663316.5	136.04	3,422	6,574	8,531	9,954	11,605	3,804	7,096	9,181	10,677	12,424
55	J1158	1730689.2	666714.3	137.92	3,356	6,445	8,330	9,703	11,299	3,734	6,983	9,001	10,462	12,165
56	Outlet-Tunungwant	1728024.2	675075.5	141.55	3,369	6,444	8,311	9,684	11,276	3,742	6,980	8,978	10,442	12,141

Hydrologic Parameters for Allegheny C HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Allegheny River	W193	10.43	65.5	105.5	N/A	N/A
	W194	16.25	63.1	115.9	N/A	N/A
	W195	21.31	64.0	129.3	N/A	N/A
	W196	16.34	65.5	143.4	N/A	N/A
	W197	17.39	65.2	111.8	N/A	N/A
	W198	10.66	62.3	96.6	N/A	N/A
	W199	6.66	62.1	88.4	N/A	N/A
East Branch Fishing Creek	W187	9.90	61.9	118.0	N/A	N/A
Fishing Creek	W188	12.47	63.1	95.4	N/A	N/A
	W189	1.70	62.8	51.2	N/A	N/A
Mill Creek	W191	15.30	62.7	90.3	N/A	N/A
	W192	15.92	61.0	152.6	N/A	N/A
Startwell Creek	W190	15.50	63.2	112.0	N/A	N/A

Hydrologic Parameters for Allegheny C HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Allegheny River	W193	65.5	67.9	62.2	57.9	54.8	50.9
	W194	63.1	67.7	62.0	57.8	54.9	51.2
	W195	64.0	68.2	62.6	58.4	55.3	51.8
	W196	65.5	69.4	64.5	60.6	57.8	54.4
	W197	65.2	68.0	62.1	57.7	54.6	50.9
	W198	62.3	67.8	62.0	58.3	55.7	52.3
	W199	62.1	67.8	62.4	58.8	56.4	53.1
East Branch Fishing Creek	W187	61.9	68.5	63.1	59.5	57.5	54.4
Fishing Creek	W188	63.1	67.4	61.7	57.5	54.4	50.9
	W189	62.8	67.6	62.4	58.9	56.5	53.3
Mill Creek	W191	62.7	66.5	60.4	55.9	52.7	51.2
	W192	61.0	68.9	63.8	59.9	58.3	55.1
Startwell Creek	W190	63.2	67.9	62.5	58.4	55.5	51.9

Hydrologic Parameters for Allegheny C HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Allegheny River	W193	N/A	N/A	N/A	N/A	N/A	N/A
	W194	N/A	N/A	N/A	N/A	N/A	N/A
	W195	N/A	N/A	N/A	N/A	N/A	N/A
	W196	N/A	N/A	N/A	N/A	N/A	N/A
	W197	N/A	N/A	N/A	N/A	N/A	N/A
	W198	N/A	N/A	N/A	N/A	N/A	N/A
	W199	N/A	N/A	N/A	N/A	N/A	N/A
East Branch Fishing Creek	W187	N/A	N/A	N/A	N/A	N/A	N/A
Fishing Creek	W188	N/A	N/A	N/A	N/A	N/A	N/A
	W189	N/A	N/A	N/A	N/A	N/A	N/A
Mill Creek	W191	N/A	N/A	N/A	N/A	N/A	N/A
	W192	N/A	N/A	N/A	N/A	N/A	N/A
Startwell Creek	W190	N/A	N/A	N/A	N/A	N/A	N/A

Hydrologic Results for Allegheny C HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y	Area (mi^2)	2-Year	10-Year	25-Year	50-Year	Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	J3361	1912646.7	579342.0	15.30	643	1,097	1,261	1,394	1,769	N/A	N/A	N/A	N/A	N/A
2	J3225	1860738.6	595837.6	22.37	986	1,720	2,067	2,410	2,577	N/A	N/A	N/A	N/A	N/A
3	J3367	1925434.6	606355.4	10.43	468	801	936	1,047	1,062	N/A	N/A	N/A	N/A	N/A
4	J3308	1911137.8	603560.2	26.68	1,126	1,947	2,288	2,570	2,635	N/A	N/A	N/A	N/A	N/A
5	J3364	1895167.5	585471.1	79.20	3,081	5,343	6,273	7,190	7,800	N/A	N/A	N/A	N/A	N/A
6	J3131	1876099.2	573969.6	95.54	3,656	6,372	7,496	8,572	9,294	N/A	N/A	N/A	N/A	N/A
7	J3154	1864219.3	585319.7	112.93	4,023	6,966	8,192	9,346	10,113	N/A	N/A	N/A	N/A	N/A
8	J3180	1855063.5	588270.8	147.66	4,774	8,208	9,685	11,071	11,995	N/A	N/A	N/A	N/A	N/A
9	Outlet-Sartwell Ck Conf	1843562.0	590919.2	169.83	5,118	8,776	10,367	11,854	12,836	N/A	N/A	N/A	N/A	N/A

Hydrologic Parameters for Allegheny B HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Allegheny Portage Creek	W442	6.93	64.2	53.8	64.2	53.8
	W451	3.89	61.3	85.3	61.3	85.3
	W452	0.16	59.9	19.5	59.9	19.5
	W453	0.13	65.8	15.8	65.8	15.8
	W454	2.17	61.2	47.6	61.2	47.6
	W455	1.44	61.2	59.1	61.2	59.1
	W456	4.43	60.8	59.3	61.0	59.0
	W457	2.61	63.4	80.1	63.7	79.4
Allegheny River	W437	1.99	60.0	61.3	60.2	61.0
	W438	0.13	63.6	20.4	64.8	19.9
	W441	2.39	60.7	68.3	61.8	66.5
	W485	3.74	62.5	73.7	63.1	72.7
	W486	0.91	61.0	39.4	62.1	38.3
	W487	0.97	63.8	51.2	64.9	49.7
	W488	0.04	63.3	10.8	66.1	10.0
	W489	0.05	74.8	25.5	75.7	24.9
	W490	1.45	67.7	32.6	68.8	31.6
	W491	1.50	63.8	49.2	64.7	48.2
	W492	1.36	64.5	42.1	65.4	41.2
	W493	0.26	68.1	34.1	70.1	32.3
	W494	3.21	64.9	45.0	66.6	43.0
	W495	1.96	70.8	57.0	72.1	55.0
	W496	0.51	67.5	66.4	67.5	66.4
	W497	0.06	98.0	9.3	98.0	9.3
	W498	1.42	81.3	65.0	81.5	64.5
Annin Creek	W470	3.67	60.3	52.3	60.3	52.3
	W471	3.97	60.7	80.6	61.9	78.2
	W472	1.45	64.9	53.0	66.0	51.6
	W473	0.19	67.7	32.7	68.1	32.3
Coleman Creek	W449	2.21	58.7	84.4	59.3	83.2
Combs Creek	W439	2.26	60.7	57.9	60.7	57.9
	W448	1.44	58.8	49.1	58.9	49.1
	W450	4.08	60.4	80.6	60.4	80.6
Fair Run	W443	3.27	59.1	66.5	59.1	66.5
Hamilton Run	W447	4.01	59.1	62.4	59.2	62.3
Lillibridge Creek	W458	2.10	59.8	48.7	59.8	48.7
	W459	4.22	61.5	58.4	61.7	58.1
	W460	2.16	62.9	51.6	64.9	49.0
	W461	0.27	67.3	27.1	68.8	26.0
Long Branch	W469	2.62	62.4	70.9	62.8	70.0
Newell Creek	W479	0.88	61.6	40.8	62.5	44.3
	W480	4.16	61.0	52.1	61.0	69.4
	W481	2.38	61.9	38.0	62.3	47.0
	W482	0.33	65.6	17.3	66.3	21.2

Hydrologic Parameters for Allegheny B HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Newell Creek	W483	0.28	62.2	13.0	63.5	12.6
	W484	0.91	72.2	40.0	72.2	40.0
Open Brook	W477	3.06	60.7	49.1	61.3	48.3
	W478	2.58	64.1	72.1	64.9	70.6
Potato Creek	W499	0.39	84.6	18.4	84.6	18.4
Rock Run	W444	3.14	64.5	109.8	64.5	109.8
	W474	5.00	60.1	94.7	60.1	94.7
	W475	0.85	63.3	44.1	65.0	42.2
	W476	0.16	70.5	34.5	70.8	34.2
Scaffold Lick Run	W445	4.27	69.2	111.3	69.2	111.3
	W446	3.57	65.0	110.3	65.0	110.3
Skinner Creek	W440	2.79	61.0	70.8	61.0	70.8
	W462	3.91	62.7	72.4	62.7	72.4
	W463	4.02	61.9	92.2	61.9	92.2
	W464	3.14	61.7	101.9	61.8	101.8
Twomile Creek	W465	1.87	63.4	39.6	63.4	39.6
	W466	1.72	61.2	43.7	61.2	43.6
	W467	2.44	62.8	60.1	63.2	59.5
	W468	1.81	63.0	58.3	63.0	58.2

Hydrologic Parameters for Allegheny B HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Allegheny Portage Creek	W442	64.2	65.4	59.5	57.5	56.2	54.3
	W451	61.3	69.5	63.3	61.1	60.3	58.5
	W452	59.9	66.4	59.3	57.9	57.0	55.2
	W453	65.8	71.7	65.1	63.8	62.9	61.3
	W454	61.2	63.2	60.5	58.5	57.2	55.3
	W455	61.2	68.0	62.6	60.5	59.6	57.7
	W456	60.8	64.9	61.1	58.9	57.7	55.8
	W457	63.4	69.8	65.1	63.1	62.4	60.8
Allegheny River	W437	60.0	66.9	66.1	60.7	58.5	58.8
	W438	63.6	67.7	65.1	61.2	59.1	59.9
	W441	60.7	67.4	66.0	62.7	60.5	59.5
	W485	62.5	67.3	65.6	60.5	58.1	58.8
	W486	61.0	65.0	63.9	58.8	56.4	57.1
	W487	63.8	67.7	66.6	61.7	59.3	60.1
	W488	63.3	67.2	66.1	61.2	58.8	59.5
	W489	74.8	77.9	77.0	73.0	71.0	71.7
	W490	67.7	65.4	62.5	58.8	56.1	55.7
	W491	63.8	67.1	65.6	61.9	60.0	57.4
	W492	64.5	67.0	64.4	61.7	59.8	57.3
	W493	68.1	71.7	69.5	66.7	65.4	62.9
	W494	64.9	66.3	62.5	59.9	58.1	55.3
	W495	70.8	64.8	57.9	56.0	52.5	50.5
	W496	67.5	71.2	68.9	65.2	63.2	62.2
	W497	98.0	98.3	98.1	97.8	97.6	97.5
	W498	81.3	83.8	82.3	79.7	78.2	77.5
Annin Creek	W470	60.3	65.7	62.9	58.8	57.0	54.2
	W471	60.7	67.6	67.2	63.1	60.5	59.5
	W472	64.9	67.9	66.6	63.1	61.3	60.6
	W473	67.7	71.3	69.1	66.3	64.9	64.1
Coleman Creek	W449	58.7	68.0	68.0	63.9	60.8	63.2
Combs Creek	W439	60.7	67.6	61.9	59.8	58.8	56.9
	W448	58.8	67.1	61.7	59.4	58.4	56.6
	W450	60.4	69.5	63.5	61.4	60.2	58.5
Fair Run	W443	59.1	68.3	62.0	59.7	58.7	56.7
Hamilton Run	W447	59.1	67.0	61.2	58.7	57.8	55.8
Lillibridge Creek	W458	59.8	65.7	63.7	58.3	56.0	56.5
	W459	61.5	67.3	62.1	58.4	56.0	54.9
	W460	62.9	66.7	65.2	60.2	57.5	56.4
	W461	67.3	71.0	69.9	65.3	63.0	62.1
Long Branch	W469	62.4	67.6	66.2	62.4	60.6	59.7
Newell Creek	W479	61.6	70.0	69.0	68.1	67.6	66.9
	W480	61.0	66.8	68.3	67.8	67.4	66.3
	W481	61.9	66.5	67.6	67.3	67.2	66.0
	W482	65.6	71.6	72.6	71.8	71.2	70.6

Hydrologic Parameters for Allegheny B HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Newell Creek	W483	62.2	66.2	66.3	61.2	59.2	58.3
	W484	72.2	75.5	75.6	71.4	69.7	68.9
Open Brook	W477	60.7	65.8	63.5	59.2	57.4	54.6
	W478	64.1	67.3	63.8	61.8	59.4	56.5
Potato Creek	W499	84.6	86.8	85.5	83.3	82.0	81.4
Rock Run	W444	64.5	71.6	66.2	64.3	63.7	62.1
	W474	60.1	67.7	67.5	64.2	61.9	59.8
	W475	63.3	67.2	67.3	62.3	60.4	59.5
	W476	70.5	74.0	71.8	69.2	67.9	65.5
Scaffold Lick Run	W445	69.2	70.1	65.7	64.3	63.4	61.7
	W446	65.0	70.5	65.8	63.9	63.0	61.3
Skinner Creek	W440	61.0	67.3	61.6	59.6	58.5	54.8
	W462	62.7	67.2	60.9	58.9	57.6	54.6
	W463	61.9	68.2	61.7	60.4	59.6	57.1
	W464	61.7	69.1	63.2	62.5	62.0	59.4
Twomile Creek	W465	63.4	65.7	62.4	59.3	57.1	54.3
	W466	61.2	66.0	63.8	59.7	57.9	55.1
	W467	62.8	67.3	65.3	61.5	59.9	58.9
	W468	63.0	67.5	66.6	62.3	60.7	59.8

Hydrologic Parameters for Allegheny B HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Allegheny Portage Creek	W442	64.2	65.4	59.5	57.5	56.2	54.3
	W451	61.3	69.5	63.3	61.1	60.3	58.5
	W452	59.9	66.4	59.3	57.9	57.0	55.2
	W453	65.8	71.7	65.1	63.8	62.9	61.3
	W454	61.2	63.2	60.5	58.5	57.2	55.3
	W455	61.2	68.0	62.7	60.5	59.6	57.7
	W456	61.0	65.1	61.3	59.2	57.9	56.0
	W457	63.7	70.2	65.4	63.4	62.8	61.1
Allegheny River	W437	60.2	67.1	66.2	60.9	58.7	59.0
	W438	64.8	68.7	66.2	62.4	60.3	61.1
	W441	61.8	68.4	67.1	63.8	61.6	60.6
	W485	63.1	67.8	66.1	61.1	58.7	59.4
	W486	62.1	66.1	64.9	59.9	57.5	58.2
	W487	64.9	68.8	67.7	62.9	60.5	61.2
	W488	66.1	69.9	68.8	64.1	61.8	62.5
	W489	75.7	78.7	77.8	74.0	72.0	72.6
	W490	68.8	66.5	63.7	60.0	57.4	57.0
	W491	64.7	67.9	66.4	62.7	60.9	58.3
	W492	65.4	67.8	65.2	62.6	60.8	58.2
	W493	70.1	73.6	71.4	68.8	67.5	65.0
	W494	66.6	68.0	64.3	61.7	60.0	57.2
	W495	72.1	66.2	59.4	57.6	54.1	52.1
	W496	67.5	71.2	68.9	65.2	63.2	62.2
	W497	98.0	98.3	98.1	97.8	97.6	97.5
	W498	81.5	84.0	82.5	80.0	78.5	77.8
Annin Creek	W470	60.3	65.7	62.9	58.8	57.0	54.2
	W471	61.9	68.7	68.3	64.3	61.7	60.7
	W472	66.0	68.9	67.7	64.2	62.4	61.8
	W473	68.1	71.8	69.6	66.8	65.4	64.6
Coleman Creek	W449	59.3	68.5	68.5	64.4	61.4	63.8
Combs Creek	W439	60.7	67.6	61.9	59.8	58.8	56.9
	W448	58.9	67.2	61.8	59.4	58.4	56.6
	W450	60.4	69.5	63.5	61.4	60.2	58.5
Fair Run	W443	59.1	68.3	62.0	59.7	58.7	56.7
Hamilton Run	W447	59.2	67.1	61.3	58.8	57.9	55.9
Lillibridge Creek	W458	59.8	65.7	63.7	58.3	56.0	56.5
	W459	61.7	67.5	62.4	58.6	56.3	55.2
	W460	64.9	68.6	67.1	62.2	59.6	58.5
	W461	68.8	72.4	71.3	66.8	64.5	63.6
Long Branch	W469	62.8	68.1	66.7	62.8	61.1	60.2
Newell Creek	W479	62.5	70.8	69.8	68.9	68.4	67.7
	W480	61.0	66.8	68.3	67.8	67.5	66.3
	W481	62.3	66.9	68.0	67.7	67.6	66.4
	W482	66.3	72.3	73.3	72.4	71.9	71.3

Hydrologic Parameters for Allegheny B HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Newell Creek	W483	63.5	67.4	67.5	62.6	60.6	59.7
	W484	72.2	75.5	75.6	71.4	69.7	68.9
Open Brook	W477	61.3	66.4	64.2	59.9	58.0	55.3
	W478	64.9	68.1	64.6	62.6	60.2	57.3
Potato Creek	W499	84.6	86.8	85.5	83.3	82.0	81.4
Rock Run	W444	64.5	71.6	66.2	64.3	63.7	62.1
	W474	60.1	67.7	67.5	64.2	61.9	59.9
	W475	65.0	68.9	69.0	64.1	62.2	61.3
	W476	70.8	74.2	72.1	69.5	68.2	65.8
Scaffold Lick Run	W445	69.2	70.1	65.7	64.3	63.4	61.7
	W446	65.0	70.5	65.8	63.9	63.0	61.3
Skinner Creek	W440	61.0	67.3	61.6	59.6	58.5	54.8
	W462	62.7	67.2	60.9	58.9	57.6	54.6
	W463	61.9	68.2	61.7	60.4	59.6	57.1
	W464	61.8	69.2	63.2	62.5	62.1	59.4
Twomile Creek	W465	63.4	65.7	62.4	59.3	57.1	54.3
	W466	61.2	66.1	63.8	59.8	58.0	55.2
	W467	63.2	67.8	65.8	62.0	60.3	59.4
	W468	63.0	67.6	66.6	62.3	60.7	59.8

Hydrologic Results for Allegheny B HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	P93	1830547.1	594475.6	1.99	113	319	336	403	567	116	325	343	411	577
2	J2908	1829185.1	561408.7	4.27	232	427	612	782	932	232	427	612	782	932
3	J3112	1819196.9	574499.2	3.70	241	434	616	821	987	242	435	617	822	988
4	J2913	1846891.4	560879.0	6.93	347	640	959	1,268	1,542	347	640	959	1,268	1,543
5	J2837	1840005.6	562241.0	14.09	786	1,346	1,938	2,565	3,092	787	1,346	1,938	2,566	3,092
6	J2954	1838643.6	563981.4	17.39	966	1,634	2,325	3,063	3,680	966	1,634	2,325	3,064	3,680
7	J2803	1838416.6	565419.1	25.36	1,348	2,313	3,264	4,249	5,084	1,348	2,313	3,264	4,250	5,084
8	J3070	1834179.2	572607.5	27.53	1,359	2,351	3,310	4,301	5,143	1,359	2,351	3,310	4,302	5,143
9	J3040	1832211.8	575785.6	32.98	1,362	2,339	3,263	4,222	5,037	1,363	2,339	3,263	4,223	5,038
10	J3139	1826915.0	586454.8	45.19	1,593	2,721	3,788	4,896	5,849	1,595	2,723	3,790	4,899	5,851
11	J_Allegheny_Portage_Ck	1823847.2	597187.9	47.79	1,620	2,757	3,827	4,939	5,896	1,622	2,760	3,830	4,943	5,900
12	J3297	1838340.9	614376.2	2.10	117	323	336	403	597	117	323	336	403	597
13	J3247	1830774.1	606658.1	6.31	340	713	817	981	1,361	347	721	827	993	1,376
14	P29	1825174.7	600377.7	8.48	417	882	1,008	1,201	1,639	434	904	1,037	1,233	1,676
15	J110	1809662.8	591448.8	3.91	206	345	500	649	715	206	345	501	649	715
16	J3174	1816775.5	590313.8	10.71	548	911	1,343	1,764	1,940	549	911	1,344	1,765	1,941
17	J_Skinner_Ck	1822205.4	597857.8	13.85	699	1,156	1,722	2,269	2,510	700	1,157	1,724	2,272	2,513
18	P55	1835314.2	621186.3	1.87	119	293	381	461	518	119	293	381	461	518
19	J3335	1830547.1	617856.9	3.59	218	549	685	842	947	219	550	687	843	949
20	J3300	1823358.6	611500.8	6.03	343	844	1,043	1,291	1,520	349	853	1,054	1,304	1,535
21	J3396	1828655.4	632158.2	3.67	195	496	586	733	823	195	496	587	734	824
22	J3330	1817607.9	625348.1	10.26	515	1,324	1,567	1,898	2,297	549	1,380	1,636	1,976	2,389
23	P58	1809587.1	621867.3	11.71	556	1,406	1,665	2,015	2,447	592	1,467	1,740	2,098	2,545
24	J3257	1800961.0	609760.5	3.06	173	460	533	663	744	191	495	574	710	797
25	J3289	1802171.6	622245.7	294.33	5,245	9,503	11,725	13,883	15,697	5,271	9,542	11,774	13,941	15,760
26	P61	1811781.5	626558.7	5.00	235	652	806	942	1,100	235	652	807	943	1,101
27	P60	1805349.7	624364.4	5.85	256	701	862	1,009	1,183	259	704	866	1,013	1,187
28	J2831	1810646.4	639497.9	4.16	259	901	1,337	1,730	2,086	259	901	1,337	1,730	2,087
29	J2826	1806560.4	632233.8	7.41	392	1,269	1,894	2,465	2,993	397	1,276	1,902	2,474	3,002
30	USGS 03008000	1805349.7	630115.1	7.74	402	1,290	1,922	2,500	3,036	408	1,298	1,931	2,510	3,045
31	P28	1804517.3	628223.4	8.03	408	1,303	1,937	2,518	3,057	414	1,311	1,947	2,528	3,068
32	J3183	1834027.8	590692.2	175.77	5,152	8,872	10,480	11,985	13,023	5,154	8,875	10,483	11,988	13,026
33	J3177	1830471.4	593264.9	178.80	4,435	7,937	9,439	10,843	11,818	4,438	7,943	9,445	10,851	11,825
34	J3198	1824039.7	597502.3	227.56	4,635	8,472	10,423	12,294	13,754	4,643	8,486	10,441	12,314	13,776

Hydrologic Results for Allegheny B HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y	Area (mi^2)	2-Year	10-Year	25-Year	50-Year	Year	2-Year	10-Year	25-Year	50-Year	100-Year
35	J3207	1823207.3	598183.3	236.34	4,689	8,537	10,496	12,386	13,919	4,701	8,555	10,519	12,415	13,948
36	J3193	1822148.0	598107.6	250.24	4,867	8,840	10,912	12,915	14,532	4,879	8,859	10,936	12,945	14,563
37	USGS 03007800	1820407.6	602345.0	251.69	4,875	8,849	10,922	12,927	14,551	4,888	8,869	10,948	12,959	14,583
38	J3236	1818969.9	606431.1	261.02	4,970	9,039	11,155	13,206	14,879	4,984	9,062	11,183	13,241	14,915
39	J3260	1815716.2	610668.5	264.77	4,990	9,047	11,164	13,215	14,896	5,006	9,072	11,195	13,253	14,936
40	J3242	1814581.2	613089.9	265.03	4,986	9,025	11,135	13,180	14,856	5,002	9,050	11,166	13,218	14,896
41	J109	1810268.1	614376.2	268.24	5,012	9,074	11,199	13,257	14,946	5,030	9,102	11,234	13,301	14,992
42	J3272	1806182.0	620732.3	282.10	5,130	9,270	11,435	13,535	15,288	5,153	9,305	11,479	13,588	15,345
43	J2840	1803079.7	623229.4	288.63	5,197	9,413	11,613	13,749	15,543	5,221	9,450	11,658	13,803	15,601
44	Outlet-Ab Potato Ck Conf	1798766.6	630493.5	304.69	5,355	9,730	12,027	14,254	16,141	5,382	9,771	12,078	14,315	16,207
45	J3325	1797707.2	628526.1	305.08	5,352	9,713	12,004	14,227	16,113	5,379	9,754	12,055	14,288	16,179

Hydrologic Parameters for Potato Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Blacksmith Run	W301	2.26	63.4	74.2	63.4	49.5
	W348	4.48	66.5	95.1	67.0	93.9
	W350	1.73	69.2	48.9	69.5	48.5
Boyer Brook	W339	3.78	60.2	100.0	60.3	124.9
Brewer Run	W292	0.01	85.2	11.2	85.2	11.2
	W323	3.56	63.6	79.3	63.6	79.3
	W324	3.36	62.5	78.9	62.5	78.9
Cole Creek	W372	2.78	68.5	61.5	68.5	61.5
Colegrove Brook	W328	3.24	60.9	54.2	60.9	54.2
	W329	0.98	58.3	33.7	58.3	33.7
	W330	3.08	61.8	87.1	63.4	104.4
Daly Brook	W340	2.87	63.4	79.5	63.4	99.4
Donley Fork	W331	1.66	60.8	61.8	60.8	77.3
East Branch Potato Creek	W313	4.45	63.1	103.1	63.1	103.1
	W314	2.27	60.2	65.3	60.2	65.3
	W315	2.03	61.2	51.3	61.2	51.3
Hamlin Run	W311	3.34	66.0	106.6	66.0	106.6
Havens Run	W316	3.87	59.9	84.7	59.9	84.7
	W317	1.74	61.2	69.4	61.2	69.4
Indian Run	W318	4.49	60.9	94.7	60.9	94.7
Jet Brook	W344	1.14	63.8	53.5	63.8	53.5
Kane Creek	W341	2.14	66.6	69.9	67.2	68.8
Marvin Creek	W296	3.50	61.5	52.2	61.5	52.2
	W297	1.26	62.9	42.0	63.2	41.7
	W298	3.09	65.2	52.2	65.5	51.9
	W299	0.01	73.9	5.1	73.9	5.1
	W300	2.84	62.1	59.1	62.1	59.1
	W351	3.65	67.3	84.3	67.7	69.6
	W352	2.41	64.0	60.0	64.1	59.7
	W353	0.04	78.5	7.0	86.6	5.4
	W354	2.43	64.8	65.7	66.1	52.9
	W355	1.34	63.7	43.0	64.1	42.6
	W356	0.11	60.1	11.5	62.4	10.9
	W357	2.00	64.9	64.3	65.7	62.9
	W358	3.28	63.4	75.8	63.4	75.8
	W359	4.56	63.1	86.9	63.9	85.3
	W360	1.13	67.3	24.8	72.3	21.7
	W361	0.08	72.0	17.8	81.2	13.6
North Branch Cole Creek	W306	2.52	62.2	55.1	62.3	55.1
	W365	2.99	63.2	65.0	63.5	64.6
	W366	3.34	63.6	75.5	63.6	75.6
Panther Run	W312	1.83	63.2	67.5	63.2	67.5
	W363	3.32	69.1	85.9	70.8	82.0
	W364	1.99	66.8	85.3	67.2	84.5

Hydrologic Parameters for Potato Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Pierce Brook	W373	3.52	63.8	82.4	63.8	82.4
Potato Creek	W294	2.57	61.2	57.1	61.2	63.4
	W302	1.60	66.2	60.7	66.4	60.4
	W303	1.95	65.6	29.3	65.9	14.6
	W305	0.01	84.5	3.6	84.5	3.6
	W307	0.77	61.8	31.9	61.8	31.9
	W308	0.70	64.9	33.8	64.9	33.8
	W309	0.14	79.5	33.0	79.5	33.0
	W310	0.88	65.1	56.3	65.1	56.3
	W376	0.17	65.1	20.2	65.1	20.2
	W377	0.21	65.9	17.7	65.9	17.7
	W378	3.57	61.7	75.7	61.8	75.6
	W379	1.55	65.6	48.6	65.6	48.6
	W380	2.21	64.1	54.6	65.0	53.4
	W381	0.72	59.6	37.8	66.4	37.3
	W382	1.25	67.5	33.8	74.4	28.0
	W383	0.68	66.9	50.8	75.5	40.1
	W384	0.18	65.5	15.4	80.5	10.1
	W385	0.22	65.5	23.3	76.5	17.2
	W386	1.02	63.1	38.7	69.9	36.0
	W387	1.11	63.9	38.0	64.3	41.7
	W388	2.60	64.3	48.3	64.3	53.7
	W389	2.86	63.7	60.0	64.6	65.2
	W390	0.05	65.3	11.6	70.8	11.1
	W392	0.01	70.1	9.0	89.2	4.9
	W393	0.47	68.2	16.4	70.8	15.3
	W394	1.10	71.4	72.2	71.5	45.1
	W395	2.72	71.9	84.2	71.5	53.3
	W396	4.67	70.4	124.5	70.4	77.8
	W397	0.51	80.3	28.6	80.3	28.6
	W398	0.32	77.4	15.6	77.4	7.8
	W399	0.60	81.7	35.1	81.7	35.1
Red Mill Brook	W325	3.46	65.1	74.7	65.8	81.5
	W326	3.00	62.8	77.7	62.8	86.4
	W327	2.98	65.6	74.2	67.8	77.9
Rices Creek	W374	2.88	61.3	65.3	61.3	65.3
	W375	3.61	63.7	91.0	63.7	75.8
Robbins Brook	W332	2.98	63.9	112.5	63.9	75.0
	W333	3.17	63.1	73.7	65.3	86.9
South Branch Cole Creek	W304	4.12	62.0	86.6	62.2	86.2
	W367	2.44	65.5	68.0	65.5	68.0
	W368	1.00	61.8	36.0	61.8	36.0
	W369	3.43	64.1	83.3	64.1	83.3
	W370	1.49	63.2	56.9	63.2	56.9

Hydrologic Parameters for Potato Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
South Branch Cole Creek	W371	3.74	63.9	76.8	63.9	76.8
South Branch Potato Creek	W320	2.16	66.3	77.8	66.3	77.8
	W321	2.64	61.0	69.1	61.0	69.1
Stanton Brook	W343	2.66	65.9	71.3	65.9	71.2
	W345	0.02	69.1	13.4	69.1	13.4
Walcott Brook	W293	1.90	66.0	49.5	66.0	49.5
	W295	2.17	65.1	66.7	68.1	61.6
	W334	1.04	64.5	47.6	65.6	46.2
	W335	0.80	60.4	33.0	61.1	46.3
	W336	2.47	62.7	77.7	71.4	61.8
	W337	0.18	70.8	23.0	87.1	13.8
	W338	0.02	66.3	26.9	84.9	14.1
Warner Brook	W346	3.70	64.1	88.9	64.2	88.5
	W347	2.38	64.8	77.7	64.8	77.7
	W349	0.03	49.5	26.8	51.5	25.5
West Branch Potato Creek	W319	4.00	62.7	102.2	62.7	102.2
	W322	4.16	60.6	89.4	60.6	89.2
Wildcat Run	W342	2.72	64.4	73.5	64.4	73.4
Wolf Run	W362	3.62	66.2	69.0	67.5	66.6

Hydrologic Parameters for Potato Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Blacksmith Run	W301	63.4	68.8	61.3	58.5	56.6	54.6
	W348	66.5	69.9	64.2	61.5	59.7	57.9
	W350	69.2	66.8	62.6	60.0	58.3	56.7
Boyer Brook	W339	60.2	68.6	66.7	62.8	60.1	59.9
Brewer Run	W292	85.2	84.9	84.2	82.4	81.2	78.5
	W323	63.6	65.1	62.4	58.4	55.6	52.4
	W324	62.5	67.5	62.1	58.4	55.8	52.5
Cole Creek	W372	68.5	63.4	56.6	53.7	51.8	47.7
Colegrove Brook	W328	60.9	66.7	60.7	57.7	55.7	52.5
	W329	58.3	57.8	56.4	53.8	52.1	49.6
	W330	61.8	69.2	66.1	62.1	60.7	58.8
Daly Brook	W340	63.4	67.9	65.4	61.6	59.7	57.8
Donley Fork	W331	60.8	68.2	64.7	60.4	59.0	57.1
East Branch Potato Creek	W313	63.1	67.4	63.4	60.0	57.7	54.7
	W314	60.2	67.1	61.1	57.3	55.2	51.9
	W315	61.2	65.4	60.8	57.0	54.3	51.0
Hamlin Run	W311	66.0	68.4	65.2	61.6	59.1	56.1
Havens Run	W316	59.9	67.3	62.0	58.1	56.2	53.0
	W317	61.2	66.8	62.7	59.2	57.5	54.4
Indian Run	W318	60.9	67.8	62.7	58.8	56.9	53.9
Jet Brook	W344	63.8	67.5	62.9	60.3	58.6	56.7
Kane Creek	W341	66.6	67.7	63.1	60.3	58.4	56.5
Marvin Creek	W296	61.5	66.1	60.3	57.3	55.3	53.3
	W297	62.9	66.5	61.6	58.9	57.1	55.2
	W298	65.2	66.4	61.1	58.3	56.3	54.1
	W299	73.9	73.5	72.4	70.2	68.7	67.1
	W300	62.1	66.6	61.8	59.0	57.1	55.1
	W351	67.3	68.7	62.3	59.5	57.5	55.7
	W352	64.0	67.0	62.2	59.4	57.5	55.6
	W353	78.5	78.2	77.2	75.3	74.0	72.5
	W354	64.8	64.8	59.3	56.1	53.9	51.5
	W355	63.7	66.8	61.8	59.1	57.3	55.5
	W356	60.1	59.7	58.3	55.7	54.0	52.1
	W357	64.9	67.8	63.5	60.9	59.2	57.5
	W358	63.4	69.0	63.7	61.1	59.4	57.5
	W359	63.1	69.4	64.3	61.3	59.7	57.9
	W360	67.3	64.2	58.8	55.8	53.8	51.9
	W361	72.0	71.6	70.5	68.2	66.7	65.0
North Branch Cole Creek	W306	62.2	65.1	60.5	57.0	54.5	51.1
	W365	63.2	66.0	61.7	58.3	56.0	52.6
	W366	63.6	66.7	62.7	59.3	57.0	53.7
Panther Run	W312	63.2	66.5	62.5	58.6	55.9	52.6
	W363	69.1	67.3	63.4	60.0	57.6	54.3
	W364	66.8	67.9	64.6	61.6	59.6	56.5

Hydrologic Parameters for Potato Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Pierce Brook	W373	63.8	69.6	64.4	61.7	60.1	58.2
Potato Creek	W294	61.2	68.0	62.7	59.5	57.9	56.0
	W302	66.2	69.4	63.9	61.4	59.7	58.0
	W303	65.6	63.9	57.2	54.3	52.4	50.6
	W305	84.5	84.2	83.5	81.9	80.9	79.7
	W307	61.8	64.6	60.0	57.4	55.7	53.8
	W308	64.9	67.6	63.1	60.6	58.9	57.1
	W309	79.5	81.4	78.2	76.3	75.1	73.6
	W310	65.1	67.8	63.3	60.8	59.2	57.3
	W376	65.1	64.7	62.6	58.9	56.3	53.1
	W377	65.9	65.5	63.5	59.8	57.2	53.9
	W378	61.7	66.1	61.6	58.0	55.5	52.3
	W379	65.6	64.2	57.1	52.0	48.3	47.1
	W380	64.1	64.0	58.2	53.3	49.7	48.7
	W381	59.6	59.1	57.7	55.1	53.4	51.5
	W382	67.5	62.7	56.9	53.4	51.0	48.9
	W383	66.9	66.5	65.2	62.7	61.1	58.7
	W384	65.5	65.1	63.8	61.3	59.6	57.2
	W385	65.5	67.5	63.8	61.3	59.6	57.2
	W386	63.1	67.1	62.5	58.9	56.4	54.6
	W387	63.9	66.9	61.9	58.2	55.7	53.6
	W388	64.3	66.8	61.4	57.3	54.4	52.4
	W389	63.7	64.0	61.5	57.4	54.5	52.3
	W390	65.3	64.8	63.5	61.0	59.3	56.9
	W392	70.1	69.7	68.5	66.2	64.6	62.3
	W393	68.2	67.7	66.5	64.1	62.5	60.7
	W394	71.4	62.2	58.3	54.2	51.2	51.2
	W395	71.9	61.7	57.9	54.3	51.8	51.8
	W396	70.4	62.3	58.1	53.4	50.0	50.0
	W397	80.3	80.0	79.0	77.2	76.0	74.6
	W398	77.4	77.1	76.1	74.1	72.7	71.2
	W399	81.7	81.4	80.5	78.8	77.6	76.3
Red Mill Brook	W325	65.1	64.7	63.7	60.0	57.4	56.4
	W326	62.8	68.4	64.5	61.6	60.3	57.3
	W327	65.6	68.8	64.6	62.0	60.4	57.8
Rices Creek	W374	61.3	67.9	62.2	59.2	57.5	55.6
	W375	63.7	67.2	59.8	56.5	54.2	52.0
Robbins Brook	W332	63.9	71.1	63.2	60.5	58.7	56.8
	W333	63.1	68.7	65.1	61.1	59.2	57.3
South Branch Cole Creek	W304	62.0	66.8	62.3	59.4	57.6	54.5
	W367	65.5	66.4	62.2	58.9	56.6	53.3
	W368	61.8	63.8	60.2	56.8	54.4	51.3
	W369	64.1	67.1	63.3	59.9	57.6	54.6
	W370	63.2	66.5	62.6	59.5	57.4	54.5

Hydrologic Parameters for Potato Creek HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
South Branch Cole Creek	W371	63.9	66.5	62.6	59.1	56.7	53.6
South Branch Potato Creek	W320	66.3	68.5	63.4	59.6	56.9	53.4
	W321	61.0	67.0	61.0	57.6	55.2	51.8
Stanton Brook	W343	65.9	67.8	63.2	60.6	58.8	56.8
	W345	69.1	68.7	67.5	65.1	63.5	61.7
Walcott Brook	W293	66.0	66.3	61.6	58.8	56.9	55.2
	W295	65.1	69.2	63.5	61.0	59.2	57.5
	W334	64.5	65.9	62.4	59.7	57.9	56.1
	W335	60.4	62.4	58.5	55.9	54.2	52.3
	W336	62.7	69.5	64.5	61.6	60.3	58.3
	W337	70.8	70.4	69.1	66.8	65.3	63.0
	W338	66.3	68.2	64.5	62.1	60.4	58.6
Warner Brook	W346	64.1	68.0	63.4	60.6	58.7	56.8
	W347	64.8	68.5	64.2	61.7	60.0	58.2
	W349	49.5	49.0	47.6	44.9	43.2	41.4
West Branch Potato Creek	W319	62.7	68.6	63.3	60.0	58.0	54.8
	W322	60.6	67.7	62.3	58.6	56.8	53.5
Wildcat Run	W342	64.4	67.9	63.3	60.6	58.9	57.0
Wolf Run	W362	66.2	65.9	61.5	57.9	55.4	52.0

Hydrologic Parameters for Potato Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Blacksmith Run	W301	63.4	68.8	61.3	58.5	56.6	54.6
	W348	67.0	70.3	64.7	62.0	60.2	58.4
	W350	69.5	67.1	62.9	60.4	58.7	57.0
Boyer Brook	W339	60.3	68.6	66.8	62.8	60.1	60.0
Brewer Run	W292	85.2	84.9	84.2	82.4	81.2	78.5
	W323	63.6	65.1	62.4	58.4	55.6	52.4
	W324	62.5	67.5	62.1	58.4	55.8	52.5
Cole Creek	W372	68.5	63.4	56.6	53.7	51.8	47.7
Colegrove Brook	W328	60.9	66.7	60.7	57.7	55.7	52.5
	W329	58.3	57.8	56.4	53.8	52.1	49.6
	W330	63.4	70.7	67.7	63.7	62.3	60.5
Daly Brook	W340	63.4	67.9	65.4	61.6	59.7	57.8
Donley Fork	W331	60.8	68.2	64.7	60.4	59.0	57.1
East Branch Potato Creek	W313	63.1	67.4	63.4	60.0	57.7	54.7
	W314	60.2	67.1	61.1	57.3	55.2	51.9
	W315	61.2	65.4	60.8	57.0	54.3	51.0
Hamlin Run	W311	66.0	68.4	65.2	61.6	59.1	56.1
Havens Run	W316	59.9	67.3	62.0	58.1	56.2	53.0
	W317	61.2	66.8	62.7	59.2	57.5	54.4
Indian Run	W318	60.9	67.8	62.7	58.8	56.9	53.9
Jet Brook	W344	63.8	67.5	62.9	60.3	58.6	56.7
Kane Creek	W341	67.2	68.3	63.7	60.9	59.1	57.2
Marvin Creek	W296	61.5	66.1	60.3	57.3	55.3	53.3
	W297	63.2	66.7	61.9	59.2	57.4	55.5
	W298	65.5	66.6	61.4	58.5	56.6	54.4
	W299	73.9	73.5	72.4	70.2	68.7	67.1
	W300	62.1	66.6	61.8	59.0	57.1	55.1
	W351	67.7	69.0	62.7	59.8	57.9	56.1
	W352	64.1	67.2	62.3	59.6	57.7	55.8
	W353	86.6	86.4	85.7	84.4	83.4	82.4
	W354	66.1	66.1	60.6	57.4	55.3	52.9
	W355	64.1	67.1	62.1	59.4	57.6	55.9
	W356	62.4	61.9	60.6	58.0	56.3	54.5
	W357	65.7	68.7	64.4	61.8	60.1	58.4
	W358	63.4	69.0	63.7	61.1	59.4	57.5
	W359	63.9	70.1	65.0	62.0	60.5	58.7
	W360	72.3	69.5	64.4	61.6	59.6	57.8
	W361	81.2	80.9	80.0	78.3	77.1	75.7
North Branch Cole Creek	W306	62.3	65.1	60.6	57.0	54.6	51.2
	W365	63.5	66.3	61.9	58.6	56.2	52.9
	W366	63.6	66.6	62.6	59.3	56.9	53.7
Panther Run	W312	63.2	66.5	62.5	58.6	55.9	52.6
	W363	70.8	69.1	65.3	61.9	59.5	56.3
	W364	67.2	68.3	65.0	62.0	60.0	56.9

Hydrologic Parameters for Potato Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Pierce Brook	W373	63.8	69.6	64.4	61.7	60.1	58.2
Potato Creek	W294	61.2	68.0	62.7	59.5	57.9	56.0
	W302	66.4	69.6	64.0	61.6	59.9	58.2
	W303	65.9	64.1	57.4	54.6	52.7	50.9
	W305	84.5	84.2	83.5	81.9	80.9	79.7
	W307	61.8	64.6	60.0	57.4	55.7	53.8
	W308	64.9	67.6	63.1	60.6	58.9	57.1
	W309	79.5	81.4	78.2	76.4	75.1	73.7
	W310	65.1	67.8	63.3	60.8	59.2	57.3
	W376	65.1	64.7	62.6	58.9	56.3	53.1
	W377	65.9	65.5	63.5	59.8	57.2	53.9
	W378	61.8	66.1	61.6	58.0	55.5	52.4
	W379	65.6	64.2	57.1	52.0	48.3	47.1
	W380	65.0	64.9	59.1	54.2	50.7	49.6
	W381	66.4	66.0	64.7	62.3	60.6	58.8
	W382	74.4	70.2	64.8	61.6	59.3	57.2
	W383	75.5	75.2	74.1	72.0	70.6	68.5
	W384	80.5	80.2	79.3	77.5	76.3	74.5
	W385	76.5	78.0	75.1	73.0	71.6	69.6
	W386	69.9	73.5	69.4	66.1	63.7	62.0
	W387	64.3	67.3	62.3	58.7	56.1	54.0
	W388	64.3	66.8	61.4	57.4	54.5	52.4
	W389	64.6	64.9	62.3	58.3	55.4	53.2
	W390	70.8	70.4	69.2	66.9	65.4	63.1
	W392	89.2	89.0	88.4	87.3	86.5	85.3
	W393	70.8	70.4	69.2	66.9	65.3	63.6
	W394	71.5	62.3	58.4	54.3	51.3	51.3
	W395	71.5	61.2	57.3	53.7	51.3	51.3
	W396	70.4	62.3	58.1	53.4	50.0	50.0
	W397	80.3	80.0	79.0	77.2	76.0	74.6
	W398	77.4	77.1	76.1	74.1	72.7	71.2
	W399	81.7	81.4	80.5	78.8	77.6	76.3
Red Mill Brook	W325	65.8	65.4	64.4	60.7	58.1	57.1
	W326	62.8	68.4	64.5	61.6	60.3	57.3
	W327	67.8	70.9	66.7	64.3	62.6	60.1
Rices Creek	W374	61.3	67.9	62.2	59.2	57.5	55.6
	W375	63.7	67.2	59.8	56.5	54.2	52.0
Robbins Brook	W332	63.9	71.1	63.2	60.5	58.7	56.8
	W333	65.3	70.8	67.3	63.4	61.5	59.7
South Branch Cole Creek	W304	62.2	67.0	62.5	59.6	57.8	54.7
	W367	65.5	66.4	62.2	58.9	56.6	53.3
	W368	61.8	63.8	60.2	56.8	54.4	51.3
	W369	64.1	67.1	63.3	59.9	57.6	54.6
	W370	63.2	66.5	62.6	59.5	57.4	54.5

Hydrologic Parameters for Potato Creek HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
South Branch Cole Creek	W371	63.9	66.5	62.6	59.1	56.7	53.6
South Branch Potato Creek	W320	66.3	68.5	63.4	59.6	56.9	53.4
	W321	61.0	67.0	61.0	57.6	55.2	51.8
Stanton Brook	W343	65.9	67.8	63.2	60.6	58.8	56.8
	W345	69.1	68.7	67.4	65.1	63.5	61.7
Walcott Brook	W293	66.0	66.3	61.6	58.8	56.9	55.2
	W295	68.1	72.1	66.7	64.2	62.5	60.8
	W334	65.6	67.0	63.5	60.9	59.1	57.3
	W335	61.1	63.1	59.2	56.7	54.9	53.1
	W336	71.4	77.1	72.9	70.4	69.2	67.5
	W337	87.1	86.9	86.3	84.9	84.0	82.7
	W338	84.9	86.0	83.9	82.4	81.4	80.2
Warner Brook	W346	64.2	68.2	63.5	60.7	58.8	57.0
	W347	64.8	68.5	64.2	61.7	60.0	58.2
	W349	51.5	51.0	49.6	46.9	45.2	43.3
West Branch Potato Creek	W319	62.7	68.6	63.3	60.0	58.0	54.8
	W322	60.6	67.8	62.4	58.7	56.8	53.6
Wildcat Run	W342	64.4	67.9	63.3	60.7	58.9	57.0
Wolf Run	W362	67.5	67.3	62.9	59.4	56.9	53.5

Hydrologic Results for Potato Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi²)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	J2855	1802398.6	534773.6	3.87	186	338	411	512	554	186	338	411	512	554
2	J2872	1811705.8	543097.1	7.80	349	723	895	1,054	1,157	349	723	895	1,054	1,157
3	J2885	1807468.4	542340.4	11.90	502	1,004	1,238	1,465	1,603	502	1,004	1,239	1,465	1,603
4	J2858	1779849.6	535606.0	2.16	127	229	278	321	340	127	229	278	321	340
5	J2877	1781590.0	541205.4	8.79	443	780	975	1,160	1,249	443	780	975	1,160	1,249
6	J106	1780606.3	552555.6	3.56	135	341	410	468	506	135	341	409	468	506
7	O10	1792259.2	554901.3	6.92	278	597	723	834	901	277	597	723	833	900
8	J2849	1773569.2	562316.7	3.47	128	392	478	553	713	143	423	516	596	766
9	J104	1783179.0	563905.7	6.47	283	699	877	1,061	1,278	303	735	920	1,110	1,338
10	J2846	1803458.0	562392.4	3.24	193	341	455	562	606	193	340	455	562	606
11	J3059	1800204.3	566705.4	4.22	206	388	522	648	705	206	388	522	648	705
12	J2929	1779546.9	571321.2	4.64	252	404	504	628	753	251	403	504	628	753
13	J3107	1801415.0	582368.7	1.90	115	234	317	394	483	115	234	317	394	483
14	J3100	1806106.4	572834.5	1.84	91	224	310	392	480	107	254	349	438	534
15	J3045	1796193.9	576769.3	8.38	516	995	1,338	1,681	2,038	793	1,402	1,841	2,274	2,723
16	O12	1793621.2	576315.3	8.55	520	1,002	1,345	1,688	2,045	800	1,412	1,851	2,283	2,738
17	J2918	1754954.9	564813.8	3.70	188	358	473	578	694	192	363	480	586	704
18	J3048	1752609.2	570715.8	7.21	354	673	894	1,099	1,320	358	680	902	1,108	1,332
19	O7	1751398.5	572304.9	2.66	153	297	399	493	586	153	297	399	494	587
20	J3119	1761916.3	575255.9	3.50	198	362	484	598	727	198	362	484	598	727
21	J3222	1771753.2	601058.7	6.74	403	637	846	1,040	1,249	419	662	877	1,076	1,291
22	J2969	1731270.8	559290.0	3.65	208	332	441	542	656	217	346	459	563	681
23	J2990	1738837.6	561938.4	8.21	405	706	937	1,154	1,393	423	735	975	1,199	1,445
24	O6	1739594.3	561938.4	8.24	406	708	940	1,158	1,397	425	739	979	1,204	1,450
25	J3056	1746404.4	565646.1	13.40	599	1,083	1,435	1,763	2,111	630	1,133	1,498	1,837	2,197
26	J3027	1751852.5	571321.2	21.97	934	1,735	2,309	2,842	3,411	972	1,795	2,386	2,933	3,516
27	J3090	1752079.5	572456.2	24.76	1,031	1,925	2,566	3,164	3,797	1,069	1,988	2,647	3,259	3,909
28	J3134	1756468.2	580098.7	31.53	1,177	2,176	2,889	3,554	4,263	1,219	2,243	2,975	3,656	4,382
29	J3157	1762446.0	588876.1	37.89	1,282	2,342	3,099	3,804	4,553	1,325	2,410	3,185	3,906	4,671
30	J3165	1762748.7	589103.1	40.74	1,309	2,390	3,169	3,891	4,657	1,351	2,459	3,254	3,991	4,775
31	J3210	1776747.2	598259.0	53.78	1,512	2,703	3,568	4,374	5,233	1,559	2,776	3,659	4,481	5,356
32	P45	1781968.3	598637.3	54.91	1,522	2,717	3,586	4,395	5,257	1,572	2,796	3,683	4,509	5,388
33	J_Marvin_Creek	1782662.0	598938.5	54.99	1,523	2,719	3,589	4,398	5,261	1,574	2,799	3,686	4,513	5,393
34	J3305	1750187.8	618159.6	6.06	289	605	764	908	965	326	668	841	997	1,063

Hydrologic Results for Potato Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	Year	2-Year	10-Year	25-Year	50-Year	100-Year
35	J3239	1749279.8	610895.5	3.32	159	331	414	488	525	201	403	501	588	636
36	J3265	1753744.2	614300.5	12.38	570	1,197	1,512	1,796	1,929	657	1,345	1,693	2,006	2,160
37	J3275	1760403.0	615359.9	19.92	893	1,849	2,357	2,824	3,058	987	2,010	2,556	3,054	3,312
38	J3286	1766683.4	615359.9	21.41	932	1,921	2,449	2,933	3,181	1,026	2,081	2,646	3,163	3,435
39	J3387	1766532.1	626331.7	5.52	263	559	710	847	901	269	570	723	862	918
40	J3278	1772358.5	616419.2	34.02	1,351	2,755	3,499	4,180	4,533	1,446	2,920	3,704	4,421	4,798
41	J_Cole_Creek	1778832.6	616755.9	36.80	1,400	2,827	3,592	4,294	4,647	1,494	2,988	3,793	4,529	4,906
42	J101	1781968.3	632612.2	2.88	178	310	408	514	619	178	310	408	514	619
43	O11	1799144.9	542870.1	19.70	802	1,568	1,932	2,321	2,536	802	1,568	1,932	2,321	2,536
44	O2	1793999.5	622397.0	1.47	101	206	287	366	447	101	205	287	366	447
45	J3343	1794302.2	624818.4	2.50	182	358	491	617	748	182	358	490	617	747
46	J2834	1800885.3	542491.7	19.54	800	1,562	1,925	2,313	2,527	800	1,562	1,925	2,313	2,528
47	O11	1799144.9	542870.1	19.70	802	1,568	1,932	2,321	2,536	802	1,568	1,932	2,321	2,536
48	J2893	1797555.9	544005.1	24.40	994	1,925	2,372	2,865	3,136	994	1,925	2,372	2,865	3,136
49	J2932	1793621.2	550663.9	40.92	1,654	3,090	3,826	4,607	5,021	1,655	3,092	3,829	4,610	5,024
50	J2869	1792713.2	555052.6	49.40	1,845	3,460	4,274	5,123	5,593	1,846	3,462	4,277	5,126	5,596
51	O9	1793545.5	562165.4	51.61	1,824	3,405	4,192	5,007	5,475	1,827	3,410	4,198	5,014	5,482
52	J3021	1793318.5	563300.4	61.78	1,890	3,600	4,458	5,338	5,915	1,907	3,627	4,491	5,375	5,957
53	J3067	1794075.2	570261.8	70.33	2,010	3,811	4,717	5,649	6,277	2,039	3,854	4,769	5,708	6,343
54	J3093	1793394.2	572607.5	78.82	2,200	4,124	5,117	6,142	6,869	2,240	4,182	5,186	6,220	6,956
55	P91	1793696.8	573893.9	79.00	2,202	4,127	5,120	6,146	6,873	2,243	4,187	5,192	6,227	6,964
56	J3126	1792940.2	576088.3	87.78	2,345	4,371	5,434	6,527	7,327	2,410	4,467	5,547	6,651	7,466
57	J3142	1791502.5	580855.3	92.58	2,423	4,525	5,617	6,738	7,599	2,494	4,628	5,740	6,873	7,751
58	J3151	1789913.4	584184.7	96.56	2,476	4,622	5,734	6,875	7,763	2,548	4,726	5,858	7,013	7,918
59	J3162	1786054.4	590919.2	101.72	2,499	4,639	5,745	6,877	7,786	2,571	4,748	5,875	7,024	7,956
60	P46	1783103.3	598259.0	104.58	2,522	4,682	5,794	6,931	7,852	2,596	4,793	5,928	7,083	8,027
61	J3217	1783027.7	599015.6	161.23	4,015	7,371	9,327	11,254	13,044	4,144	7,569	9,570	11,535	13,376
62	USGS 03009680	1783179.0	599469.6	161.25	4,005	7,354	9,305	11,227	13,014	4,135	7,553	9,550	11,510	13,350
63	P64	1783708.7	602799.0	161.72	4,000	7,342	9,289	11,206	12,991	4,130	7,543	9,536	11,492	13,332
64	J3252	1785373.4	609306.5	164.77	3,965	7,269	9,189	11,081	12,861	4,097	7,476	9,448	11,383	13,225
65	J3292	1780076.6	616646.2	204.29	4,377	7,971	10,056	12,101	14,043	4,528	8,213	10,367	12,478	14,509
66	J3283	1788400.1	621640.3	212.49	4,454	8,113	10,228	12,300	14,299	4,606	8,359	10,544	12,684	14,778
67	J3340	1792486.2	624364.4	219.49	4,508	8,193	10,328	12,420	14,444	4,665	8,450	10,661	12,825	14,952
68	J3348	1793999.5	625196.7	222.31	4,530	8,231	10,377	12,479	14,515	4,688	8,491	10,715	12,891	15,031

Hydrologic Results for Potato Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	Year	2-Year	10-Year	25-Year	50-Year	100-Year
69	Outlet-Potato	1797707.2	628526.1	222.91	4,509	8,193	10,327	12,418	14,445	4,672	8,464	10,682	12,851	14,988

Hydrologic Parameters for Allegheny A HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Allegheny River	W529	1.07	62.6	47.3	62.6	47.3
	W531	0.96	72.8	29.9	73.0	29.7
	W586	4.92	74.5	68.7	74.6	68.6
	W587	0.03	94.6	12.5	94.6	12.5
	W588	0.10	79.5	11.6	79.6	11.5
	W589	0.21	81.5	29.5	81.5	29.5
	W590	1.24	79.5	38.1	80.2	37.2
	W591	0.09	72.7	8.7	74.2	8.4
	W592	0.88	78.7	32.6	79.4	31.9
	W593	0.01	85.4	3.5	87.7	3.2
	W594	0.11	81.3	12.7	84.0	11.6
	W595	1.08	72.8	37.9	72.9	37.9
	W596	1.35	68.4	51.4	68.7	51.1
	W597	0.01	68.0	5.9	71.9	5.3
	W598	4.53	66.5	41.8	66.5	41.7
	W599	0.24	68.0	20.2	68.0	20.2
Baker Run	W532	0.96	58.1	39.0	60.1	37.1
	W537	1.74	62.9	51.0	63.7	49.9
Barden Brook	W530	2.23	59.2	64.2	59.3	64.0
	W560	0.89	58.7	28.4	58.7	28.4
	W561	1.17	61.3	47.4	61.4	47.3
	W562	0.04	68.3	9.5	68.6	9.4
	W563	3.13	65.7	70.2	66.5	68.8
Bells Brook	W552	2.89	65.9	77.8	65.9	77.8
Butternut Brook	W553	2.79	67.2	70.1	67.2	70.1
Canfield Creek	W558	1.54	62.4	48.9	62.5	48.9
	W559	0.09	82.2	11.3	83.2	10.9
Carpenter Creek	W555	1.81	63.3	45.2	63.3	45.2
	W556	1.04	77.5	30.1	77.6	30.0
	W557	0.02	96.0	4.9	96.0	4.9
Fowler Brook	W554	2.12	62.5	58.1	62.5	58.1
Indian Creek	W526	1.20	59.6	53.1	59.6	53.1
	W574	4.29	62.0	80.5	62.0	80.5
	W575	0.46	68.7	19.5	68.7	19.5
	W576	1.27	68.1	54.8	68.9	53.7
Kansas Branch	W535	2.81	60.9	64.0	61.0	63.9
	W536	0.47	66.2	29.0	68.2	27.5
Kings Run	W549	2.37	60.2	47.7	60.2	47.8
	W550	3.42	61.9	47.4	61.9	47.4
	W551	2.05	65.1	47.8	65.1	47.8
Knapp Creek	W525	1.35	61.7	48.1	61.7	48.1
	W527	1.79	63.9	48.4	63.9	48.4
	W528	0.15	70.8	24.4	73.5	22.6
	W564	2.17	64.8	44.4	64.8	44.4

Hydrologic Parameters for Allegheny A HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Knapp Creek	W565	2.12	63.1	47.5	63.2	47.5
	W566	0.23	68.7	15.9	69.7	15.5
	W567	0.03	74.7	10.7	80.6	9.0
	W568	0.35	65.1	30.0	67.3	28.3
	W569	0.47	68.0	27.1	69.0	26.4
	W570	2.55	66.9	42.1	67.2	41.8
	W571	3.21	65.4	69.1	65.6	68.7
	W572	0.11	68.8	19.5	69.2	19.2
	W573	1.43	74.9	56.9	76.7	53.9
Little Genesee Creek	W545	24.22	63.2	137.3	63.2	137.3
	W546	19.40	63.5	166.6	63.5	166.6
Louds Creek	W578	2.81	66.4	51.2	66.4	51.1
McCrea Run	W579	2.81	67.2	54.8	67.4	54.4
Mix Creek	W577	4.51	64.7	79.6	64.8	79.5
North Branch Indian Creek	W543	2.51	61.7	56.8	61.7	56.8
	W544	0.04	72.3	9.2	72.3	9.2
Oswayo Creek	W547	0.97	69.5	38.1	69.6	38.0
	W548	0.07	63.8	23.7	63.8	23.7
	W580	0.64	66.0	52.7	66.3	52.3
	W581	1.88	69.0	75.5	69.0	75.5
	W582	0.02	60.6	13.7	60.6	13.7
	W583	0.45	74.4	25.8	75.0	25.4
	W584	3.38	66.8	84.3	66.8	84.3
	W585	0.98	69.1	55.6	69.1	55.6
South Branch Knapp Creek	W538	3.04	61.5	57.9	62.1	57.0
	W539	0.04	73.1	5.6	78.1	4.8
	W540	1.63	61.7	41.4	62.3	40.7
	W541	0.25	69.3	16.6	69.5	16.5
	W542	1.34	63.6	52.5	63.9	52.0
Tram Hollow Run	W533	2.78	59.8	47.1	59.8	47.1
	W534	2.05	61.1	44.5	61.1	44.5

Hydrologic Parameters for Allegheny A HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Allegheny River	W529	62.6	65.9	62.4	59.9	58.2	56.2
	W531	72.8	73.7	69.6	67.2	65.7	63.9
	W586	74.5	60.8	55.1	55.1	55.1	55.1
	W587	94.6	94.4	93.7	93.1	92.6	92.1
	W588	79.5	78.9	76.8	74.9	73.5	72.0
	W589	81.5	81.0	79.1	77.2	76.0	74.6
	W590	79.5	61.9	61.9	61.9	61.9	61.9
	W591	72.7	72.0	69.5	67.2	65.6	63.9
	W592	78.7	78.0	75.9	73.9	72.5	71.0
	W593	85.4	84.9	83.3	81.8	80.7	79.5
	W594	81.3	80.8	78.9	77.0	75.7	74.3
	W595	72.8	62.8	56.7	54.5	53.0	53.0
	W596	68.4	65.5	58.5	55.2	52.9	50.5
	W597	68.0	69.2	64.5	62.0	60.3	58.5
	W598	66.5	62.9	57.5	54.0	51.6	49.3
	W599	68.0	69.1	64.5	62.0	60.3	58.5
Baker Run	W532	58.1	59.3	54.3	51.6	49.8	47.9
	W537	62.9	68.1	62.1	59.4	57.7	54.8
Barden Brook	W530	59.2	65.7	62.9	59.7	58.5	56.5
	W560	58.7	65.1	54.9	52.2	50.5	48.6
	W561	61.3	68.0	62.5	59.6	58.2	56.3
	W562	68.3	67.5	64.9	62.4	60.7	58.9
	W563	65.7	68.2	62.7	59.9	58.0	56.2
Bells Brook	W552	65.9	69.7	64.1	61.5	59.8	58.1
Butternut Brook	W553	67.2	69.1	63.5	60.9	59.2	57.4
Canfield Creek	W558	62.4	68.1	62.4	59.8	58.0	56.3
	W559	82.2	81.6	79.8	78.0	76.7	75.3
Carpenter Creek	W555	63.3	66.6	61.7	59.0	57.1	55.2
	W556	77.5	61.4	59.1	59.1	59.1	59.1
	W557	96.0	95.9	95.4	94.9	94.5	94.1
Fowler Brook	W554	62.5	67.7	61.5	58.5	56.5	54.4
Indian Creek	W526	59.6	66.8	62.7	59.5	58.4	54.9
	W574	62.0	67.1	62.3	59.3	57.4	53.3
	W575	68.7	68.5	65.2	62.7	61.1	57.0
	W576	68.1	64.3	58.0	54.4	52.0	47.3
Kansas Branch	W535	60.9	68.0	62.4	59.2	57.6	54.9
	W536	66.2	67.3	62.6	60.1	58.3	55.4
Kings Run	W549	60.2	66.9	60.8	57.8	56.0	53.9
	W550	61.9	64.7	60.4	57.5	55.5	53.5
	W551	65.1	64.1	61.9	59.2	57.4	55.5
Knapp Creek	W525	61.7	67.9	62.3	59.4	57.7	54.9
	W527	63.9	66.9	62.0	59.3	57.5	54.5
	W528	70.8	71.9	67.5	65.1	63.5	60.7
	W564	64.8	65.9	60.5	57.6	55.6	52.5

Hydrologic Parameters for Allegheny A HEC-HMS Model

Subwatershed Name	Subbasin	Existing CN (ARC=2)	Calibrated Existing Conditions (Year 2010) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Knapp Creek	W565	63.1	65.6	59.9	56.7	54.6	51.3
	W566	68.7	69.8	65.2	62.8	61.1	58.2
	W567	74.7	75.6	71.6	69.3	67.8	65.2
	W568	65.1	66.2	61.5	58.9	57.2	54.2
	W569	68.0	69.1	64.5	62.0	60.3	57.4
	W570	66.9	65.3	59.0	55.8	53.6	50.1
	W571	65.4	66.2	59.3	55.9	53.6	50.0
	W572	68.8	69.9	65.4	62.9	61.2	58.4
	W573	74.9	62.0	55.6	55.6	55.6	55.6
Little Genesee Creek	W545	63.2	69.0	62.9	59.8	57.8	55.5
	W546	63.5	70.5	65.5	62.4	61.0	58.9
Louds Creek	W578	66.4	66.3	60.7	57.7	55.6	53.8
McCrea Run	W579	67.2	67.2	62.2	59.4	57.6	55.8
Mix Creek	W577	64.7	68.9	63.1	60.3	58.5	56.6
North Branch Indian Creek	W543	61.7	66.3	61.3	58.4	56.4	52.3
	W544	72.3	72.2	69.1	66.7	65.1	63.4
Oswayo Creek	W547	69.5	68.7	66.1	63.6	62.0	60.2
	W548	63.8	63.0	60.1	57.5	55.8	53.9
	W580	66.0	67.1	62.4	59.9	58.1	56.3
	W581	69.0	69.2	65.2	62.8	61.2	59.6
	W582	60.6	61.8	56.8	54.1	52.4	50.5
	W583	74.4	75.4	71.4	69.1	67.6	65.9
	W584	66.8	66.4	60.4	57.0	54.7	52.2
	W585	69.1	68.4	65.7	63.2	61.6	59.8
South Branch Knapp Creek	W538	61.5	67.5	61.5	58.7	56.8	53.8
	W539	73.1	74.0	69.9	67.6	66.0	63.3
	W540	61.7	66.0	60.8	58.0	56.0	53.1
	W541	69.3	69.2	65.9	63.4	61.8	58.9
	W542	63.6	66.9	61.6	58.7	56.7	53.7
Tram Hollow Run	W533	59.8	66.5	60.4	57.2	55.3	52.4
	W534	61.1	65.7	60.6	57.7	55.7	52.7

Hydrologic Parameters for Allegheny A HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Allegheny River	W529	62.6	65.9	62.4	59.9	58.2	56.2
	W531	73.0	73.9	69.8	67.5	65.9	64.2
	W586	74.6	60.9	55.2	55.2	55.2	55.2
	W587	94.6	94.4	93.7	93.1	92.6	92.1
	W588	79.6	79.0	76.9	75.0	73.6	72.1
	W589	81.5	81.0	79.1	77.2	76.0	74.6
	W590	80.2	63.0	63.0	63.0	63.0	63.0
	W591	74.2	73.5	71.1	68.8	67.3	65.6
	W592	79.4	78.8	76.7	74.7	73.4	71.9
	W593	87.7	87.3	86.0	84.6	83.7	82.6
	W594	84.0	83.5	81.8	80.1	79.0	77.7
	W595	72.9	62.8	56.8	54.5	53.0	53.0
	W596	68.7	65.8	58.8	55.5	53.2	50.8
	W597	71.9	72.9	68.6	66.3	64.7	62.9
	W598	66.5	63.0	57.5	54.0	51.6	49.3
	W599	68.0	69.1	64.5	62.0	60.3	58.5
Baker Run	W532	60.1	61.3	56.3	53.7	51.9	50.0
	W537	63.7	68.9	62.9	60.3	58.5	55.7
Barden Brook	W530	59.3	65.8	63.0	59.8	58.5	56.6
	W560	58.7	65.1	54.9	52.2	50.5	48.6
	W561	61.4	68.0	62.6	59.7	58.3	56.5
	W562	68.6	67.8	65.1	62.6	61.0	59.2
	W563	66.5	68.9	63.6	60.8	58.9	57.1
Bells Brook	W552	65.9	69.7	64.1	61.5	59.8	58.1
Butternut Brook	W553	67.2	69.1	63.5	60.9	59.2	57.4
Canfield Creek	W558	62.5	68.1	62.5	59.8	58.0	56.3
	W559	83.2	82.7	80.9	79.2	78.0	76.7
Carpenter Creek	W555	63.3	66.6	61.7	59.0	57.1	55.2
	W556	77.6	61.5	59.3	59.3	59.3	59.3
	W557	96.0	95.9	95.4	94.9	94.5	94.1
Fowler Brook	W554	62.5	67.7	61.5	58.5	56.5	54.4
Indian Creek	W526	59.6	66.8	62.8	59.5	58.4	54.9
	W574	62.0	67.1	62.3	59.3	57.4	53.3
	W575	68.7	68.5	65.2	62.7	61.1	57.0
	W576	68.9	65.2	58.9	55.3	52.9	48.2
Kansas Branch	W535	61.0	68.1	62.5	59.3	57.7	55.0
	W536	68.2	69.3	64.7	62.2	60.5	57.7
Kings Run	W549	60.2	66.9	60.8	57.8	56.0	53.9
	W550	61.9	64.7	60.4	57.5	55.5	53.5
	W551	65.1	64.1	61.9	59.2	57.4	55.5
Knapp Creek	W525	61.7	67.9	62.3	59.5	57.8	54.9
	W527	63.9	66.9	62.0	59.3	57.5	54.5
	W528	73.5	74.5	70.4	68.1	66.6	63.8
	W564	64.8	65.9	60.5	57.6	55.6	52.5

Hydrologic Parameters for Allegheny A HEC-HMS Model

Subwatershed Name	Subbasin	Future CN (ARC=2)	Calibrated Future Conditions (Year 2020) Curve Numbers				
			2-Year	10-Year	25-Year	50-Year	100-Year
Knapp Creek	W565	63.2	65.7	59.9	56.8	54.7	51.4
	W566	69.7	70.8	66.3	63.9	62.2	59.4
	W567	80.6	81.4	78.1	76.2	74.8	72.5
	W568	67.3	68.4	63.8	61.2	59.5	56.6
	W569	69.0	70.0	65.5	63.0	61.4	58.5
	W570	67.2	65.6	59.3	56.1	54.0	50.4
	W571	65.6	66.4	59.6	56.2	53.8	50.3
	W572	69.2	70.3	65.8	63.3	61.7	58.8
	W573	76.7	64.3	58.0	58.0	58.0	58.0
Little Genesee Creek	W545	63.2	69.0	62.9	59.8	57.8	55.5
	W546	63.5	70.5	65.5	62.4	61.0	58.9
Louds Creek	W578	66.4	66.3	60.7	57.7	55.7	53.8
McCrea Run	W579	67.4	67.4	62.4	59.7	57.8	56.1
Mix Creek	W577	64.8	68.9	63.1	60.4	58.5	56.6
North Branch Indian Creek	W543	61.7	66.3	61.3	58.4	56.4	52.3
	W544	72.3	72.2	69.1	66.7	65.1	63.4
Oswayo Creek	W547	69.6	68.8	66.2	63.7	62.1	60.3
	W548	63.8	63.0	60.1	57.5	55.8	53.9
	W580	66.3	67.4	62.8	60.2	58.5	56.7
	W581	69.0	69.3	65.2	62.8	61.2	59.6
	W582	60.6	61.8	56.8	54.1	52.4	50.5
	W583	75.0	75.9	72.0	69.7	68.2	66.6
	W584	66.8	66.4	60.4	57.0	54.7	52.2
	W585	69.1	68.4	65.7	63.2	61.6	59.8
South Branch Knapp Creek	W538	62.1	68.1	62.1	59.3	57.4	54.4
	W539	78.1	79.0	75.4	73.3	71.9	69.4
	W540	62.3	66.7	61.5	58.6	56.7	53.8
	W541	69.5	69.3	66.1	63.6	61.9	59.1
	W542	63.9	67.2	62.0	59.1	57.1	54.1
Tram Hollow Run	W533	59.8	66.5	60.4	57.2	55.3	52.4
	W534	61.1	65.7	60.7	57.8	55.8	52.7

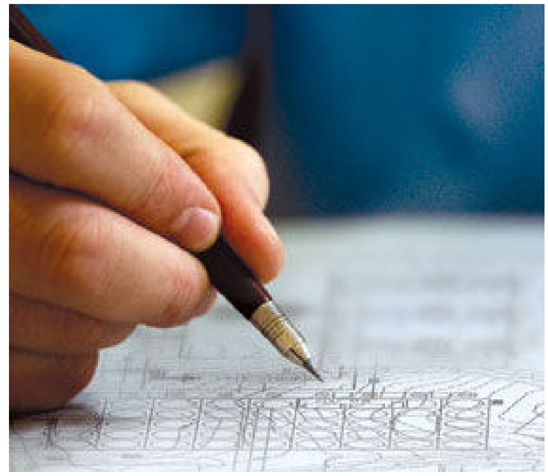
Hydrologic Results for Allegheny A HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	J103	1849237.1	687017.4	24.22	1,025	1,655	2,137	2,575	3,005	1,025	1,655	2,137	2,575	3,005
2	P27	1798615.3	644340.7	1.81	120	240	327	407	492	120	240	327	407	492
3	J2866	1796950.6	645021.7	2.85	149	331	492	653	836	150	332	494	655	838
4	P26	1798161.2	647291.7	1.54	119	209	284	355	431	119	209	284	355	431
5	P36	1814732.5	654631.5	0.89	65	64	98	133	169	65	64	98	133	169
6	J2921	1808300.7	654404.5	4.30	250	472	629	819	992	253	476	635	826	999
7	P37	1807695.4	654480.2	4.34	251	474	632	823	995	254	478	638	830	1,003
8	J2975	1761386.7	656750.2	2.78	179	310	408	512	567	179	310	408	512	567
9	P77	1760554.3	647367.4	0.96	18	51	78	106	135	30	74	109	144	181
10	P82	1774250.2	653193.8	2.81	178	314	405	514	577	181	317	409	519	582
11	J2843	1763959.4	642222.0	5.74	324	593	807	1,009	1,137	374	660	895	1,116	1,262
12	P78	1764716.0	642222.0	5.78	326	596	810	1,013	1,142	376	663	899	1,121	1,267
13	P79	1767364.4	643508.3	7.41	398	725	985	1,228	1,379	448	802	1,083	1,346	1,517
14	P80	1769331.8	644492.0	7.66	406	738	1,003	1,250	1,403	456	816	1,101	1,368	1,541
15	P19	1788324.4	652285.8	1.79	120	232	316	394	434	120	232	316	394	435
16	J3013	1764110.7	663484.7	2.17	134	256	346	432	469	134	256	346	432	469
17	P81	1769029.1	654253.2	4.30	221	407	546	679	736	221	408	547	680	737
18	P76	1769180.4	651983.1	4.53	228	419	562	697	756	229	420	563	699	758
19	J2959	1769407.5	651453.5	9.39	487	871	1,157	1,443	1,581	489	873	1,160	1,446	1,585
20	J2926	1771374.8	648956.4	13.03	686	1,217	1,604	2,007	2,218	693	1,227	1,616	2,020	2,233
21	J2890	1773796.2	646383.7	22.50	1,135	2,033	2,701	3,368	3,743	1,192	2,117	2,807	3,494	3,888
22	J2863	1779319.9	644870.4	26.41	1,218	2,166	2,874	3,576	3,969	1,275	2,254	2,983	3,705	4,117
23	P18	1789913.4	652285.8	29.61	1,229	2,155	2,845	3,524	3,900	1,281	2,238	2,949	3,647	4,040
24	J2942	1789989.1	653647.8	31.66	1,226	2,144	2,825	3,492	3,884	1,278	2,226	2,928	3,613	4,028
25	J_Knapp_Creek	1792557.5	659273.8	33.09	1,232	2,150	2,838	3,510	3,910	1,287	2,235	2,945	3,636	4,058
26	P20	1781892.7	665376.4	2.51	138	271	363	449	448	138	271	363	449	448
27	J3051	1782119.7	664468.3	6.85	336	654	864	1,065	1,064	336	654	864	1,065	1,064
28	J3005	1785070.7	663938.7	8.51	406	796	1,046	1,302	1,313	406	796	1,046	1,302	1,313
29	J_Indian_Creek	1792480.6	660331.3	9.77	438	850	1,115	1,385	1,391	441	854	1,119	1,390	1,397
30	P35	1825174.7	664998.0	0.97	96	222	296	364	434	97	224	299	367	437
31	J2937	1824191.0	652512.8	2.37	160	275	368	466	555	159	274	367	464	553
32	J2966	1824720.7	658566.3	5.80	314	616	827	1,037	1,249	313	615	825	1,035	1,247
33	J5000	1832959.6	665676.0	182.07	4,256	8,249	11,050	12,676	14,660	4,256	8,249	11,050	12,676	14,660
34	J3035	1831682.1	666738.4	226.32	5,661	10,657	14,138	16,456	19,014	5,662	10,657	14,138	16,457	19,014

Hydrologic Results for Allegheny A HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi²)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	Year	2-Year	10-Year	25-Year	50-Year	100-Year
35	J3018	1822980.3	665679.0	229.25	5,674	10,684	14,172	16,506	19,067	5,674	10,684	14,173	16,507	19,068
36	J3024	1822148.0	665981.7	237.12	5,656	10,699	14,204	16,562	19,139	5,656	10,699	14,204	16,562	19,140
37	J3032	1819499.6	667797.7	240.46	5,623	10,621	14,089	16,433	18,978	5,624	10,621	14,090	16,434	18,979
38	J3062	1811403.1	673926.8	246.63	5,691	10,734	14,231	16,603	19,172	5,691	10,734	14,231	16,603	19,172
39	J_Oswayo_Creek	1806495.2	678474.1	247.61	5,591	10,589	14,050	16,405	18,941	5,592	10,590	14,051	16,406	18,941
40	J3325	1798717.9	629808.8	527.60	9,712	17,819	22,266	26,592	30,499	9,877	18,092	22,623	27,027	31,028
41	J2852	1796269.5	644492.0	534.64	9,525	17,410	21,765	26,014	29,879	9,697	17,706	22,157	26,497	30,467
42	J2880	1797026.2	645702.7	537.53	9,533	17,420	21,784	26,043	29,920	9,706	17,719	22,179	26,528	30,511
43	J2896	1796723.6	647216.1	539.26	9,549	17,445	21,815	26,080	29,964	9,721	17,743	22,210	26,566	30,557
44	J2901	1795664.2	647443.1	540.54	9,550	17,444	21,814	26,079	29,964	9,723	17,743	22,210	26,566	30,559
45	J2947	1794831.9	654934.2	549.24	9,506	17,326	21,666	25,905	29,778	9,684	17,639	22,082	26,415	30,398
46	USGS 03010500	1795437.2	655312.5	549.33	9,506	17,327	21,668	25,906	29,780	9,685	17,641	22,084	26,417	30,400
47	J2972	1793318.5	660155.3	583.31	9,782	17,755	22,211	26,567	30,545	9,972	18,088	22,654	27,111	31,204
48	J2980	1793015.8	660457.9	593.09	9,856	17,880	22,370	26,760	30,758	10,048	18,216	22,816	27,309	31,422
49	J2993	1792940.2	662501.0	597.71	9,882	17,914	22,413	26,812	30,820	10,075	18,252	22,862	27,364	31,488
50	J3010	1797101.9	664468.3	601.60	9,892	17,920	22,421	26,819	30,833	10,086	18,260	22,872	27,374	31,504
51	J2996	1803760.7	663863.0	603.91	9,863	17,855	22,338	26,717	30,717	10,060	18,200	22,795	27,278	31,393
52	J2987	1804290.3	663863.0	606.73	9,881	17,886	22,377	26,764	30,772	10,079	18,231	22,835	27,326	31,450
53	J3081	1806257.7	678693.9	858.87	12,678	22,913	29,321	35,506	41,846	12,946	23,438	30,211	36,544	43,044
54	Outlet-Allegheny	1807090.1	681569.3	859.11	12,679	22,916	29,325	35,510	41,851	12,947	23,441	30,215	36,549	43,049

Appendix B – Supporting Calculations for the Design Example



The *Model Ordinance* has been developed to implement a variety of control standards in order to achieve a holistic approach to stormwater management. The overall design process has been addressed in *Section VIII* of this Plan. The following example calculations have been provided to further clarify the design method. These calculations parallel the calculations that are made on the worksheets provided in the *Pennsylvania Stormwater Best Management Practices Manual* (PA BMP Manual) a copy of which are provided at the back of this appendix.

SUPPORTING CALCULATIONS - DESIGN EXAMPLE 1

NON-STRUCTURAL BMP CREDITS

Protect Sensitive Natural Resources
(Refer to Worksheet 2 & Worksheet 3)

Stormwater Management Area = Total Drainage Area – Protected Area

= 9.78 – 1.31(woods) – 0.37 (minimum disturbance)
= **8.1-Acres**

This is the total area used for pre-development and post-development volume calculations.

Minimum Soil Compaction
(Refer to *Worksheet 3*)

Lawn Area (post development) protected from compaction = 16,165-ft^2

16,165-ft^2 x 1/4" x 1/12 = **337-ft^3**

To be eligible for this credit, areas must not be compacted during construction and be guaranteed to remain protected from compaction. Minimum soil compaction credits for lawn area (Open Space) are applicable for this example because specific measures were utilized to protect the back yard lawn areas of Lots 9 & 10 and this area has been placed in a permanent minimum soil compaction easement. Credits for the meadow area can be applied for areas that are not disturbed during construction and will remain in pre-development vegetated cover condition.

Disconnect Non-Roof Impervious to Vegetated Areas
(Refer to *Worksheet 3*)

Lot Impervious Area = 10 (Lots) x 1,000 (ft^2/lot) = 10,000-ft^2.
10,000-ft^2 x 1/3" x 1/12 = **278-ft^3**

This credit is applied for the impervious surfaces (driveways and sidewalks) which direct runoff to vegetated surfaces and not directly into a stormwater collection system. The 1/3" credit is used because runoff discharges across the lawn area and is received by rain gardens, which are structures specifically placed to receive and infiltrate runoff. The 1/4" credit would be used for runoff not discharged to a specific infiltration structure or an area that has been protected from soil compaction.

Summation of Non-Structural BMP Credits
= 337-ft^3 + 278-ft^3 = **615-ft^3**

CHANGE IN RUNOFF VOLUME FOR THE 2-YEAR STORM EVENT

(Refer to *Worksheet 4*)

2-year, 24-hour Rainfall Depth = 2.76"

Pre-Development 2-yr Runoff Volume = 5,682 ft^3

Post-Development 2-yr Runoff Volume = 18,281 ft^3

Change in Runoff Volume for the 2-year, 24-hour storm event:

= 18,2813-ft^3 – 5,682-ft^3 = **12,599-ft^3**

This is the volume that must be managed through a combination of non-structural BMP credits and structural BMP credits.

25% LIMIT FOR NON-STRUCTURAL BMP CREDITS

(Refer to *Worksheet 5*)

Per Chapter 8 of the Pennsylvania Stormwater BMP Manual, Non-Structural Credits may be ***no greater than 25%*** *of the total required control volume.*

Check 25% Non-Structural Credit Limit:

= 615-ft^3 / 12,599-ft^3 = **4.9%**

Calculated credits are under the allowable 25% limit for non-structural credits.

STRUCTURAL CONTROL VOLUME REQUIREMENT

(Refer to *Worksheet 5*)

Required Structural BMP infiltration volume:

= Change in Runoff Volume – Non-Structural BMP Credits
= 12,599-ft^3 – 615-ft^3 = **11,984-ft^3**

STRUCTURAL BMP VOLUME CREDITS

The sizing of structural infiltration BMPs is based on two primary criteria:

1. Maximum loading ratios – There are two different loading ratios that are important when determining the size of a structural BMP. These ratios are derived from guidelines found in the *Pennsylvania Stormwater BMP Manual*.
    a. Maximum loading ratio of Impervious Area to Infiltration Area = 5:1
    b. Maximum loading ratio of Total Drainage Area to Infiltration Area = 8:1

2. Expected runoff volume loading – Structural BMPs must be sized to accommodate the runoff volume they are expected to receive from the contributing drainage area. Some of this volume will be removed and the remainder must be safely conveyed through an overflow device. The removed volume, or infiltration volume, is the important component for sizing the infiltration BMP. A good starting point for infiltration volume is to calculate the contributing area runoff volume for the 2-year, 24-hour design storm. This volume may not be suitable for a particular site design, but starting with this volume will usually result in a design that is close to what is appropriate, and it can be adjusted as necessary. Additional design restrictions may exist for certain BMPs, so these should be considered prior to using this sizing method.

Dry Wells
(Example calculations shown for Lot #1; Refer to *Worksheet 5A* for additional calculations)

Surface Area:
Find the minimum dry well surface area for each lot based on the maximum loading ratios.

Maximum impervious area to infiltration area loading ratio = 5:1 (3:1 for Karst areas)
Tributary impervious area = 2,150-ft^2 (typ.)
= 2,150-ft^2 / 5 = **430-ft^2**
= minimum surface area of dry well per impervious loading ratio

Maximum total drainage area to infiltration area loading ratio = 8:1
Total drainage area = 2,590-ft^2 (typ.)
= 2,590-ft^2 / 8 = **324-ft^2**
= minimum surface area of dry well per pervious loading ratio

The larger of the two calculated areas is the total minimum surface area required for each lot. An individual dry well is placed at each of the four major corners of the house to promote distribution of impervious area runoff. However, the total surface area is used throughout the remaining volume credit calculations for simplicity. The surface area of each dry well is calculated below:

Total Minimum Dry Well Surface Area ÷ Number of Dry Wells
=430 ft^2 / 4 = **107.5-ft^2**

Each dry well will be 10' x 11' to meet the minimum surface area requirements.

Volume:
Find the infiltration volume for each dry well based on the expected runoff volume.

Land Use	Soil Type	Area	Area	CN	S	I_a	Runoff Depth$_{2\text{-yr}}$	Runoff Volume$_{2\text{-yr}}$
	(HSG)	(sf)	(acres)			(0.2*S)	(in)	(ft^3)
Open Space (good)	B	110	0.00	61	6.393	1.279	0.28	3
Impervious	B	540	0.01	98	0.204	0.041	2.53	114
TOTAL:		**650**	**0.01**				**2.81**	**116**

Runoff volume = **116-ft^3**

Depth:
Each dry well will be filled with aggregate. The in-place aggregate will have a 40% voids ratio; therefore the volume is divided by the available void space to get a total volume.

Depth = Total Volume / Surface Area

= (116-ft^3 / 0.40) / 110-ft^2 = **2.64-ft or approximately 2'-8"**

An overflow spillway or drain is then sized to convey any runoff that exceeds the design volume to the peak rate management facility.

Rain Gardens
(Example calculations shown for Lot #1; Refer to Worksheet 5A for additional calculations)

Surface Area:
Find the minimum surface area for each rain garden based on the maximum loading ratios.

Maximum impervious area to infiltration area loading ratio = 5:1 (3:1 for Karst areas)
Tributary impervious area = 1,000-ft^2
= 1,000-ft^2 / 5 = **200-ft^2**
= minimum surface area of rain garden per impervious loading ratio

Maximum total drainage area to infiltration area loading ratio = 8:1
Total drainage area = 6,000-ft^2 (typ.)
= 4,775-ft^2 / 8 = **597-ft^2**
= minimum surface area of rain garden per pervious loading ratio

The larger of the two calculated areas is the minimum surface area required for the facility.

Minimum Rain Garden Surface Area = **597-ft^2**

Depth:
Design guidelines, from the *PA BMP Manual*, for rain gardens limit ponding depth within the facility to 12 inches or less. The rain gardens in this example have been designed with a total ponding depth of 12 inches. The overflow outlets are positioned 6 inches above the bottom elevation of the rain gardens and 6 inches of freeboard is provided above the overflow outlets.

Volume:
The total detention volume of the rain garden is calculated by multiplying the surface area of the rain garden by the total depth. The 6 inches of water below the overflow outlet will be infiltrated and the remaining depth is used as short-term retention while flow is regulated through the overflow device. When calculating the infiltration volume, the bottom surface area of the BMP must be used.

Infiltration Volume = Surface Area x Depth
= 700-ft^2 x 0.5-ft = **350-ft^3**

Bioretention
(Refer to *Worksheet 5A* for additional calculations)

Surface Area:
Find the minimum surface area for the bioretention facility based on the maximum loading ratios.

Maximum impervious area to infiltration area loading ratio = 5:1 (3:1 for Karst areas)
Tributary impervious area = 9,700-ft^2 (typ.)
= 9,700-ft^2 / 5 = **1,940-ft^2**
= minimum surface area of Infiltration Trench per impervious loading ratio

Maximum total drainage area to infiltration area loading ratio = 8:1
Total drainage area = 41,400-ft^2
= 41,400-ft^2 / 8 = **5,175-ft^2**
= minimum surface area of Infiltration Trench per pervious loading ratio

The larger of the two calculated areas is the minimum surface area required for the facility.

Minimum Infiltration Trench Surface Area = **5,175-ft^2**

Depth:
The bioretention facility in this example has been designed with a total depth of 18 inches. The overflow outlets are positioned 6 inches above the bottom elevation, and 12 inches of freeboard is provided above the overflow outlets.

Volume:
The total detention volume of the bioretention facility is calculated by multiplying the surface area by the total depth. The 6 inches of water below the overflow outlet will be infiltrated and the remaining depth is used as short-term retention while flow is regulated through the overflow device. When calculating the infiltration volume, the bottom surface area of the BMP must be used.

Infiltration Volume = Surface Area x Depth
= 5,175-ft^2 x 0.5-ft = **2,487.5-ft^3**

STRUCTURAL CONTROL VOLUME REQUIREMENT CHECK

(Refer to *Worksheet 5*)

Check the total structural volume to be certain it is adequate to meet the structural volume requirement.

= Total Structural Volume - Structural Volume Requirement
=14,613-ft^3 – 11,984-ft^3 = 2,629-ft^3

The structural volume requirement has been exceeded by 2,629-ft^3 and no further BMP calculations are necessary.

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

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 1. GENERAL SITE INFORMATION

INSTRUCTIONS: Fill out *Worksheet 1* for each watershed

Date: 2/29/2010

Project Name: DESIGN EXAMPLE 1

Municipality: NORWICH TOWNSHIP

County: MCKEAN

Total Area (acres): 9.78

Major River Basin: OHIO RIVER BASIN
http://www.dep.state.pa.us/dep/deputate/watermgt/wc/default.htm#newtopics

Watershed: POTATO CREEK

Sub-Basin: N/A

Nearest Surface Water(s) to Receive Runoff: MILL RUN

Chapter 93 - Designated Water Use: CWF
http://www.pacode.com/secure/data/025/chapter93/chap93toc.html

Impaired according to Chapter 303(d) List? Yes [ ] No [X]
http://www.dep.state.pa.us/dep/deputate/watermgt/wqp/wqstandards/303d-Report.htm
List Causes of Impairment:

Is project subject to, or part of:

Municipal Separate Storm Sewer System (MS4) Requirements? Yes [ ] No [X]
http://www.dep.state.pa.us/dep/deputate/watermgt/wc/Subjects/StormwaterManagement/GeneralPermits/default.htm

Existing or planned drinking water supply? Yes [ ] No [X]

If yes, distance from proposed discharge (miles): ______

Approved Act 167 Plan? Yes [X] No [ ]
http://www.dep.state.pa.us/dep/deputate/watermgt/wc/Subjects/StormwaterManagement/Approved_1.html

Existing River Conservation Plan? Yes [ ] No [X]
http://www.dcnr.state.pa.us/brc/rivers/riversconservation/planningprojects/

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

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 2. SENSITIVE NATURAL RESOURCES

INSTRUCTIONS:

1. Provide Sensitive Resources Map according to non-structural BMP 5.4.1 in Chapter 5 of PA Stormwater BMP Manual. This map should identify waterbodies, floodplains, riparian areas, wetlands, woodlands, natural drainage ways, steep slopes, and other sensitive natural areas.

2. Summarize the existing extent of each sensitive resource in the Existing Sensitive Resources Table (below, using Acres). If none present, insert 0.

3. Summarize Total Protected Area as defined under BMPs in Chapter 5.

4. Do not count any area twice. For example, an area that is both a floodplain and a wetland may only be considered once.

EXISTING NATURAL SENSITIVE RESOURCE	MAPPED? yes/no/n/a	TOTAL AREA (Ac.)	PROTECTED AREA (Ac.)
Waterbodies	yes	0.00	
Floodplains	no	0.00	
Riparian Areas	no	0.00	
Wetlands	no	0.00	
Woodlands	yes	2.29	1.31
Natural Drainage Ways	N/A	0.00	
Steep Slopes, 15% - 25%	N/A	0.00	
Steep Slopes, over 25%	N/A	0.00	
Other:	N/A		
Other:	N/A		
TOTAL EXISTING:		**2.29**	**1.31**

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

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 3. NON-STRUCTURAL BMP CREDITS

PROTECTED AREA

1.1 Area of Protected Sensitive/Special Value Features (see WS 2)	1.31	Ac.
1.2 Area of Riparian Forest Buffer Protection	0.00	Ac.
3.1 Area of Minimum Disturbance/Reduced Grading	0.37	Ac.
TOTAL	1.68	Ac.

Site Area	minus	Protected Area	=	Stormwater Management Area
9.78	-	1.68	=	8.10

VOLUME CREDITS

3.1 Minimum Soil Compaction						
Lawn	16,165	ft^2	x 1/4"	x 1/12	=	337 ft^3
Meadow	N/A	ft^2	x 1/3"	x 1/12	=	0 ft^3
3.3 Protect Existing Trees						
For Trees within 100 feet of impervious area:						
Tree Canopy	N/A	ft^2	x 1/2"	x 1/12	=	0 ft^3
For Trees within 20 feet of impervious area:						
Tree Canopy	N/A	ft^2	x 1"	x 1/12	=	0 ft^3
5.1 Disconnect Roof Leaders to Vegetated Areas						
For runoff directed to areas protected under 5.8.1 and 5.8.2						
Roof Area	N/A	ft^2	x 1/3"	x 1/12	=	0 ft^3
For all other disconnected roof areas						
Roof Area	N/A	ft^2	x 1/4"	x 1/12	=	0 ft^3
5.2 Disconnect Non-Roof Impervious to Vegetated Areas						
For Runoff directed to areas protected under 5.8.1 and 5.8.2						
Impervious Area	10,000	ft^2	x 1/3"	x 1/12	=	278 ft^3
For all other disconnected non-roof impervious areas						
Impervious Area	N/A	ft^2	x 1/4"	x 1/12	=	0 ft^3

TOTAL NON-STRUCTURAL VOLUME CREDIT* 615 ft^3

** For use on Worksheet 5*

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

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 4. CHANGE IN RUNOFF VOLUME FOR 2-YR STORM EVENT

PROJECT: **DESIGN EXAMPLE 1**
Drainage Area: **8.10** (acres)
2-Year Rainfall: **2.49 inches** *(From NOAA Atlas 14)*

Total Site Area: **9.78 acres**
Protected Site Area: **1.68 acres**
Stormwater Management Area: **8.10 acres** *(From Worksheet 3)*

Existing Conditions:

Land Use	Soil Type (HSG)	Area (sf)	Area (acres)	CN	S	Ia (0.2*S)	Q Runoff[1] (in)	Runoff Volume[2] (ft^3)
Woods (good)	B	42,500	0.98	55	8.1818	1.6364	0.08	286
Meadow	B	310,255	7.12	58	7.2414	1.4483	0.13	3,387
								-
								-
								-
								-
TOTAL:		**352,755**	**8.10**					**3,673**

Developed Conditions:

Land Use	Soil Type (HSG)	Area (sf)	Area (acres)	CN	S	Ia (0.2*S)	Q Runoff[1] (in)	Runoff Volume[2] (ft^3)
Meadow	B	54,060	1.24	58	7.2414	1.4483	0.13	590
Open Space (good)	B	243,035	5.58	61	6.3934	1.2787	0.19	3,908
Impervious	B	55,660	1.28	98	0.2041	0.0408	2.26	10,486
								-
								-
								-
TOTAL:		**352,755**	**8.10**					**14,984**

2-Year Volume Increase (ft^3): **11,311**

2-Year Volume Increase = Developed Conditions Runoff Volume - Existing Conditions Runoff Volume
= 14,984 - 3,673 = 11,311 ft^3

1. Runoff (in) = Q = $(P - 0.2S)^2 / (P + 0.8S)$ where
   P = 2-Year Rainfall (in)
   S = (1000/ CN)-10

2. Runoff Volume (CF) = Q x Area x 1/12
   Q = Runoff (in)
   Area = Land use area (sq. ft)

Note: Runoff Volume must be calculated for EACH land use type/condition and HSG. The use of a weighted CN value for volume calculations is not acceptable.

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

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 5. STRUCTURAL BMP VOLUME CREDITS

SUB-BASIN: N/A

Check 25% Limit for Non-Structural BMP Credits: 615
÷ 11,311
5.4%

Required Control Volume (ft^3): 11,311
Allowable Non-structural Volume Credit (ft^3): - 615

Structural Volume Reqmt (ft^3): **10,696**
(Required Control Volume minus Non-structural Credit)

Proposed BMP		Area (ft^2)	Infiltration Volume (ft^3)
6.4.1	Porous Pavement		
6.4.2	Infiltration Basin		
6.4.3	Infiltration Bed		
6.4.4	Infiltration Trench		
6.4.5	Rain Garden/Bioretention	11,915	8,827
6.4.6	Dry Well / Seepage Pit	4,400	5,787
6.4.7	Constructed Filter		
6.4.8	Vegetated Swale		
6.4.9	Vegetated Filter Strip		
6.4.10	Berm		
6.5.1	Vegetated Roof		
6.5.2	Capture and Re-use		
6.6.1	Constructed Wetlands		
6.6.2	Wet Pond / Retention Basin		
6.6.3	Dry Extended Detention Basin		
6.6.4	Water Quality Filters		
6.7.1	Riparian Buffer Restoration		
6.7.2	Landscape Restoration / Reforestation		
6.7.3	Soil Amendment		
6.8.1	Level Spreader		
6.8.2	Special Storage Areas		
Other			

Total Structural Volume (ft^3): 14,613
Structural Volume Requirement (ft^3): 10,696

DIFFERENCE: 3,917 *(excess)*

* Complete BMP Design Checklist for each measure proposed

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

Project Name: DESIGN EXAMPLE 1
Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
Checked: Date:

WORKSHEET 5.A - INFILTRATION BMP SUPPORTING CALCULATIONS

Instructions: Complete this worksheet for each Point of Interest / Discharge (at a minimum)

Point of Interest / Discharge: ***Basin Outfall***
Total Drainage Area to POI: 352,755 ft^2
Total Impervious Area: 55,660 ft^2

	Proposed Infiltration BMP(s)	Infiltration Rate			Design Runoff Volume	Infiltration Period			Hydraulic Loading: Imperv. Drainage Area Loading				Hydraulic Loading: Total Drainage Area Loading				Target BMP Area[5]	Actual BMP Area[6]	Computed Infiltration Volume
		Measured Infilt Rate[1] *in/hr*	FOS	Design Infilt Rate *in/hr*	*cu. ft.*	Infilt. Period[2] *hrs*	Active Infilt.[3] *hrs*	Total Infilt Period *hrs*	Imperv. DA *sq. ft.*	% area draining to BMP	Imperv Area Loading Ratio	Imperv Target Area *sq. ft.*	Total Drainage Area *sq. ft.*	% area draining to BMP[4]	Total Area Loading Ratio	Total Target Area *sq. ft.*	*sq. ft.*	*sq. ft.*	*cu. ft.*
BMP 6.4.1	**Porous Pavement w. Infilt. Bed**							***Subtotal:***			5				8				
BMP 6.4.2	**Infiltration Basin**							***Subtotal:***			5				8				
BMP 6.4.3	**Subsurface Infiltration Bed**							***Subtotal:***			5				8				
BMP 6.4.4	**Infiltration Trench**							***Subtotal:***			5				8				
BMP 6.4.5	**Rain Garden/Bioretention**							***Subtotal:***	***19,700***		***5***		***89,685***		***8***			***11,915***	***8,827***
	Rain Garden (Lot #1)	0.93	2	0.47	350	12.9	6	18.9	1,000	100.0		200	4,775	100.0		597	597	700	513
	Rain Garden (Lot #2)	0.95	2	0.48	350	12.6	6	18.6	1,000	100.0		200	5,600	100.0		700	700	700	516
	Rain Garden (Lot #3)	0.98	2	0.49	350	12.2	6	18.2	1,000	100.0		200	5,080	100.0		635	635	700	522
	Rain Garden (Lot #4)	1.01	2	0.51	300	11.9	6	17.9	1,000	100.0		200	3,625	100.0		453	453	600	452
	Rain Garden (Lot #5)	1.02	2	0.51	458	11.8	6	17.8	1,000	100.0		200	7,005	100.0		876	876	915	691
	Rain Garden (Lot #6)	1.08	2	0.54	350	11.1	6	17.1	1,000	100.0		200	5,310	100.0		664	664	700	539
	Rain Garden (Lot #7)	0.91	2	0.46	300	13.2	6	19.2	1,000	100.0		200	4,395	100.0		549	549	600	437
	Rain Garden (Lot #8)	0.99	2	0.50	238	12.1	6	18.1	1,000	100.0		200	3,000	100.0		375	375	475	355
	Rain Garden (Lot #9)	1.05	2	0.53	300	11.4	6	17.4	1,000	100.0		200	4,520	100.0		565	565	600	458
	Rain Garden (Lot #10)	1.03	2	0.52	375	11.7	6	17.7	1,000	100.0		200	4,975	100.0		622	622	750	568
	Bioretention 1	0.92	2	0.46	2588	13.0	6	19.0	9,700	100.0		1,940	41,400	100.0		5,175	5,175	5,175	3,778
BMP 6.4.6	**Dry Well / Seepage Pit**							***Subtotal:***	***21,500***		***5***		***25,900***		***8***			***4,400***	***5,787***
	Dry Well (Lot #1)	0.98	2	0.49	468	26.0	6	32.0	2,150	100.0		430	2,590	100.0		324	430	440	576
	Dry Well (Lot #2)	0.91	2	0.46	468	28.1	6	34.1	2,150	100.0		430	2,590	100.0		324	430	440	568
	Dry Well (Lot #3)	1.06	2	0.53	468	24.1	6	30.1	2,150	100.0		430	2,590	100.0		324	430	440	585
	Dry Well (Lot #4)	1.02	2	0.51	468	25.0	6	31.0	2,150	100.0		430	2,590	100.0		324	430	440	580
	Dry Well (Lot #5)	0.93	2	0.47	468	27.4	6	33.4	2,150	100.0		430	2,590	100.0		324	430	440	570
	Dry Well (Lot #6)	1.07	2	0.54	468	23.9	6	29.9	2,150	100.0		430	2,590	100.0		324	430	440	586
	Dry Well (Lot #7)	0.97	2	0.49	468	26.3	6	32.3	2,150	100.0		430	2,590	100.0		324	430	440	575
	Dry Well (Lot #8)	1.01	2	0.51	468	25.3	6	31.3	2,150	100.0		430	2,590	100.0		324	430	440	579
	Dry Well (Lot #9)	1.04	2	0.52	468	24.5	6	30.5	2,150	100.0		430	2,590	100.0		324	430	440	582
	Dry Well (Lot #10)	1.07	2	0.54	468	23.9	6	29.9	2,150	100.0		430	2,590	100.0		324	430	440	586
BMP 6.4.7	**Constructed Filter**[7]										5				8				
BMP 6.4.8	**Vegetated Swale**[7]										5				8				
BMP 6.4.9	**Vegetated Filter Strip**[7]										5				8				
BMP 6.4.10	**Infilt. Berm & Ret. Grading**										5				8				
																		TOTAL:	**14,613**

1 Assumes a soil testing procedure which finds hydraulic conductivity. (e.g. perc tests may also require a reduction factor)
2 Time it takes for BMP to empty once it is full. (Minimum = 24 hrs, Maximum = 72 hours; Applicable to retention and detention facilities only.)
3 Infiltration that occurs during the storm (before becoming full). Not to exceed 6 hours.
4 A portion of the total area draining to BMP from non-pervious area may be diverted.
5 Inherent in these calculations are the allowable loading ratios (5:1 and 8:1) from the BMP Manual. Higher loading ratios will need to be justified. In Karst Areas, the max. loading ratio should be 3:1.
6 Actual BMP Area may be larger than (but not smaller than) the Target BMP Area.
7 These BMPs are not well represented by this computational process. See worksheet 5.C for vegetated swales and filter strips.

PEAK RATE CONTROL ANALYSIS

According to the National Engineering Handbook (NRCS, 2008), the direct runoff for watersheds having more than one hydrologic soil-cover complex can be estimated in either of two ways. Runoff can be estimated for each complex and then weighted to get the watershed average. Alternatively, the CN values can be weighted, based on area, to obtain a single CN value to represent the entire drainage area. Then runoff is estimated with the single CN value. If the CN for the various hydrologic soil-cover complexes are close in value, both methods of weighting give similar results for runoff. However, if there exists a large difference in curve number value, the CN weighting method can provide drastically different results.

As described in the *National Engineering Handbook*, "the method of weighted runoff always gives the correct result (in terms of the given data), but it requires more work than the weighted CN method, especially when a watershed has many complexes. The method of weighted CN is easier to use with many complexes or with a series of storms. However, where differences in CN for a watershed are large, this method either under- or over-estimates runoff, depending on the size of the storm." This often occurs when impervious area exists in a subarea. When the relatively low curve number of lawn areas is combined with the high curve number of impervious areas, the weighted CN method will minimize the impact of the impervious surface and under-estimate the amount of runoff.

The spatial distribution of the different soil-cover complexes becomes the controlling factor in selection of the appropriate method. When different land uses behave as independent watershed the areas should be analyzed as separate drainage subareas. For example, when a large parking area is surrounded by lawn area that all flows to the same collection point, runoff from the impervious surface will occur much differently than runoff from the lawn. However, when impervious area is dispersed amongst other land uses and not directly connected to a stormwater collection system, the weighted CN method may be appropriate. The decision of whether or not to use a weighted curve number is often a site specific judgment that should be discussed between the designer and the Municipal Engineer in the early planning stages of a project.

Pre-Development Soil-Cover Complex Data

Because the wooded area along the north property line will remain unchanged, and will not be tributary to the stormwater facilities, this area has been removed from the peak rate analysis drainage areas. The weighted CN method was used for pre-development calculations in this example because Curve Numbers for the hydrologic soil-cover complexes are close in value. The drainage area and land cover information necessary to calculate the pre-development runoff is shown in the table below:

Land Use	Soil Type (HSG)	Area (ft^2)	Area (acres)	CN
Woods (good)	B	42,500	0.98	55
Meadow	B	310,255	7.12	58
TOTAL:		352,755	8.10	58

Pre-Development Time of Concentration

The *Model Ordinance* requires use of the NRCS Lag Equation for all pre-development time of concentration calculations unless another method is pre-approved by the Municipal Engineer.

$$T_{lag} = L^{0.8} \frac{(S+1)^{0.7}}{1900\sqrt{Y}}$$

Where:

T_{lag} = Lag time (hours)
L = Hydraulic length of the watershed (feet)
Y = Average overland slope of watershed (percent)
S = Maximum retention in the watershed, as defined by: S = [(1000/CN) – 10]
CN = NRCS Curve Number for the watershed

Lag time is related to time of concentration by the following equation:

Time of Concentration = T_c = [(T_{lag}/.6) * 60] (minutes)

One method of calculating the average overland slope of a watershed is to select locations that represent the various slopes found in the watershed and weight the slope based on the area it represents. This method is shown in the table on the following page.

Slope Line	End Elevation High	End Elevation Low	Distance (ft)	Slope (%)	Percent of Total Area	Product (% x %)
AA	909	902	148	4.7%	5%	0.24%
BB	941	909	475	6.7%	50%	3.37%
CC	956	942	245	5.7%	15%	0.86%
DD	960	943	180	9.4%	15%	1.42%
EE	943	930	265	4.9%	15%	0.74%
					Sum of Products =	6.61%

This is an estimation of the land slope value, so the calculated number is rounded to the nearest whole number for use in the Lag Equation. The hydraulic length of the watershed was measured at 1050 ft. Therefore,

$$T_{lag} = (1050)^{0.8} \frac{((1000/CN)-10)+1)^{0.7}}{1900\sqrt{7}}$$

T_{lag} = 0.23 hours

Time of Concentration = T_C = (T_{lag} / 0.6) * 60
= (0.23 / 0.6) * 60
= 23 minutes

Pre-Development Peak Rate Flows

All of this information was used to perform a pre-development peak rate analysis using a software package based on the NRCS TR-20 procedures. The results of the analysis are as follows:

	1-year	2-year	10-year	25-year	50-year	100-year
Peak Runoff Flows (cfs)	0.1	0.6	4.1	7.6	11.1	15.3
Runoff Volume (ac-ft)	0.060	0.136	0.449	0.726	0.997	1.322
Runoff Depth (in)	0.09	0.20	0.66	1.08	1.48	1.96

Table B.1. Pre-Development Runoff Summary

Post-Development Soil-Cover Complex Data

Due to the disconnection of impervious areas and overland flow paths used in this design, the area weighted CN method was deemed appropriate and used to reduce the complexity of the model. The drainage area and land cover information for the drainage sub-area directly tributary to the bioretention facility is shown in the table below:

Land Use	Soil Type (HSG)	Area (ft^2)	Area (acres)	CN
Lawn (good condition)	B	9,700	0.22	61
Impervious	B	31,700	0.73	98
TOTAL:		41,400	0.95	70

Post-Development Time of Concentration

The Segmental Method was used for all post-development time of concentration calculations in this example. This method is covered in more detail in various NRCS publications (NRCS, 1986; NRCS, 2008). The following segments were used to calculate a time of concentration for the drainage sub-area directly tributary to the bioretention facility:

T_t*-1*: Sheet flow, 100' of lawn at 5% = 10.7 min
T_t*-2*: Shallow concentrated flow, 110' unpaved at 5.9% = 0.5 min
T_t*-3*: Channel flow, 80' at 4.0% = 0.2 min
T_t*-4*: Channel flow, 156' at 3.85% = 0.5 min
T_t*-5*: Pipe flow, 38' of 15" HDPE pipe at 5.2% = 0.1 min

$T_C = T_t\text{-}1 + T_t\text{-}2 + T_t\text{-}3 + T_t\text{-}4 + T_t\text{-}5$ = 12 minutes

Post-Development Peak Rate Flows

The hydrologic model for this example contains a considerable level of detail. Each structural BMP was modeled as a pond with a unique drainage area and time of concentration. Runoff was routed through each BMP and linked to downstream BMPs for subsequent routing. A detention basin with an outlet control structure was also added to the model. A graphical representation of the model is provided in *Figure B.1*.

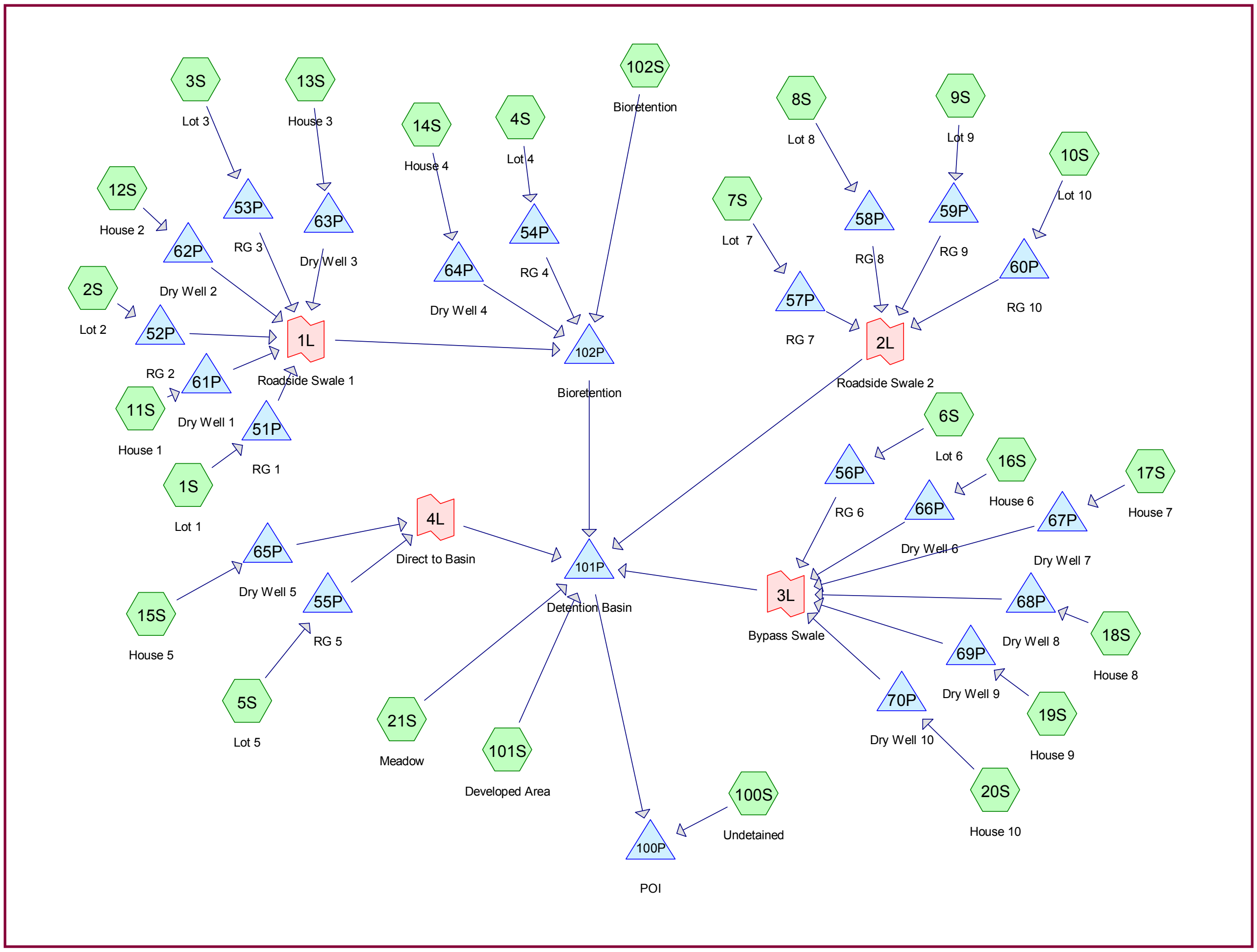


Figure B.1. Hydrologic Model of Post-Development Conditions

This model was used to estimate the post-development peak rate flows. The final configuration of the outlet structure was completed through an iterative process using the results of the model runs. This design meets the peak rate control requirements through a combination of volume removed by the structural `BMPs and the detention basin and outlet control structure. *Table B.2* shows a summary of the runoff results for the final post-development design:

	1-year	2-year	10-year	25-year	50-year	100-year
Peak Runoff Flows (cfs)	0.1	0.4	4.1	7.4	10.6	15.2
Runoff Volume (ac-ft)	0.079	0.147	0.445	0.717	1.011	1.367
Runoff Depth (in)	0.12	0.22	0.66	1.06	1.50	2.03

Table B.2. Summary of Post-Development Runoff with Stormwater Controls

INITIAL CONSTRUCTION COST - DESIGN EXAMPLE

Initial construction costs were estimated for each layout. The estimates include the costs incurred by the developer to complete earthwork, paving and curbing, and stormwater management facilities. All of these costs are summed to determine an initial construction cost for these facilities. This cost was then divided by the total sellable acreage of the project to determine a cost / sellable acre for each layout.

Estimate of Initial Construction Cost
Mill Run Residential – Traditional Layout

ITEM NO.	ITEM & DESCRIPTION	EST.	UNIT	UNIT PRICE	EXTENSION
EARTHWORK				**Subtotal =**	**$ 23,950**
1	Clearing & Grubbing	2.3	AC	$ 6,000.00	$ 13,800
2	Topsoil Removal/Stockpiling	5.8	AC	$ 1,750.00	$ 10,150
STORM DRAINAGE				**Subtotal =**	**$ 102,769**
3	Storm Sewer, 18" HDPE	600	LF	$ 55.00	$ 33,000
4	Storm Inlets	7	EA	$ 2,100.00	$ 14,700
5	Swales	490	LF	$ 10.00	$ 4,900
6	Install Detention Basin	1,525	CY	$ 25.00	$ 38,125
7	Anti Seep Collars	2	EA	$ 775.00	$ 1,550
8	Outlet Structure	1	EA	$ 4,000.00	$ 4,000
9	Outlet Pipe, 18" HDPE	50	LF	$ 55.00	$ 2,750
10	DW Endwall 24"	1	EA	$ 2,750.00	$ 2,750
11	Rip Rap Apron	144	SF	$ 6.90	$ 994
PAVING & CURBING				**Subtotal =**	**$ 138,657**
12	Paving - Final Subgrade, 6" Stone, 3" 19MM, 1-1/2" 9.5mm	2,325	SY	$ 30.00	$ 69,750
13	Curbing w/Excavation & Backfill	1,465	LF	$ 27.00	$ 39,555
14	Sidewalk plain w/4" - stone	4,285	SF	$ 6.85	$ 29,352
				Initial Construction Cost =	**$ 265,376**
				Cost / Sellable Acre =	**$ 42,734**

Table B.3. Estimate of Construction Cost for Residential Design Example (Traditional Layout)

Estimate of Initial Construction Cost ***Mill Run Residential – LID Layout***					
ITEM NO.	ITEM & DESCRIPTION	EST.	UNIT	UNIT PRICE	EXTENSION
EARTHWORK				**Subtotal =**	**$ 14,925**
1	Clearing & Grubbing	1.0	AC	$ 6,000.00	$ 6,000
2	Topsoil Removal/Stockpiling	5.1	AC	$ 1,750.00	$ 8,925
STORM DRAINAGE				**Subtotal =**	**$ 114,172**
3	Swales	1,620	LF	$ 10.00	$ 16,200
4	Storm Sewer, 18" HDPE	136	LF	$ 55.00	$ 7,480
5	DW Headwall 18"	1	EA	$ 2,750.00	$ 2,750
6	Storm Inlets	1	EA	$ 2,100.00	$ 2,100
7	Install Detention Basin	600	CY	$ 25.00	$ 15,000
8	Anti Seep Collars	2	EA	$ 775.00	$ 1,550
9	Outlet Structure	1	EA	$ 4,000.00	$ 4,000
10	Outlet Pipe, 18" HDPE	50	LF	$ 55.00	$ 2,750
11	Level Spreader	44	LF	$ 5.50	$ 242
12	Bioretention Area	5,175	SF	$ 12.00	$ 62,100
PAVING & CURBING				**Subtotal =**	**$ 53,790**
13	Paving - Final Subgrade, 6" Stone, 3" 19MM, 1-1/2" 9.5mm	1,645	SY	$ 30.00	$ 49,350
14	Gravel Shoulder	370	SY	$ 12.00	$ 4,440
				Initial Construction Cost =	**$ 182,887**
				Cost / Sellable Acre =	**$ 28,355**

Table B.4. Estimate of Construction Cost for Residential Design Example (LID Layout)

The cost of constructing the stormwater BMPs on each individual lot was not included in the comparison of initial construction costs. This is a cost that will be borne by the owner of each individual lot. This must be included in the cost comparison analysis. *Table B.5* shows an estimate of these costs.

Estimate of Stormwater BMP Construction Cost ***Mill Run Residential – LID Layout***					
ITEM NO.	ITEM & DESCRIPTION	EST.	UNIT	UNIT PRICE	EXTENSION
STORMWATER BMPS					
1	Rain Gardens	6,740	SF	$ 10.00	$ 67,400
2	Dry Wells	450	CY	$ 32.00	$ 14,400
				Construction Cost =	**$ 81,800**
				Cost / Sellable Acre =	**$ 12,682**

Table B.5. Estimate of Stormwater BMP Construction Cost

Determining how this additional cost to homeowners will be reflected in the market value of developed land is presumptive at best. For this example, we have assumed that some of the cost of constructing the stormwater BMPs will result in a dollar for dollar reduction in the market value of the sellable land. So, the BMP construction cost per sellable acre is subtracted from the per acre market value price of the land.

The initial construction cost is subtracted from the land sale value to determine the developers profit for each layout.

Cost = Land Sale Value - Initial Construction Cost

Traditional Layout
Cost = $310,500 - $265,376
= $45,124

LID Layout
Cost = $240,701 – $182,887
= $57,814

The final cost comparison is completed by determining the difference in profit between the two layouts. For this example, a total profit increase of $12,690 is realized by the developer using the LID layout with no additional cost to the individual homeowners.

Appendix C – Significant Problem Area Modeling and Recommendations

The following is a more detailed overview for each problem area and obstruction. *Plate 7* illustrates the location of the reported problem areas and obstructions throughout the county.

Due to funding constraints, no individual solutions were proposed.

Problem Area Hydrology

Although no hydrology was developed for the individual problem areas, the modeling effort as described in *Section 6* provided discharge estimates at some problem area locations, indicated in *Table C.1*.

Problem Area	Cumulative Area (mi²)	2010 Discharges with Existing SWM (cfs)					Data Source
		2-Year	10-Year	25-Year	50-Year	100-Year	
O10	6.92	278	597	723	834	901	HEC-HMS
O11	19.70	802	1,568	1,932	2,321	2,536	HEC-HMS
O12	8.55	520	1,002	1,345	1,688	2,045	HEC-HMS
O2	1.47	101	206	287	366	447	HEC-HMS
O3	5.29	224	457	589	706	850	HEC-HMS
O5	4.59	232	444	552	608	732	HEC-HMS
O6	8.24	406	708	940	1,158	1,397	HEC-HMS
O7	2.66	153	297	399	493	586	HEC-HMS
O9	51.61	1,824	3,405	4,192	5,007	5,475	HEC-HMS
P18	29.61	1,229	2,155	2,845	3,524	3,900	HEC-HMS
P19	1.79	120	232	316	394	434	HEC-HMS
P20	2.51	138	271	363	449	448	HEC-HMS
P26	1.54	119	209	284	355	431	HEC-HMS
P27	1.81	120	240	327	407	492	HEC-HMS
P28	8.03	408	1,303	1,937	2,518	3,057	HEC-HMS
P29	8.48	417	882	1,008	1,201	1,639	HEC-HMS
P35	0.97	96	222	296	364	434	HEC-HMS
P36	0.89	65	64	98	133	169	HEC-HMS
P37	4.34	251	474	632	823	995	HEC-HMS
P40	37.17	1,424	2,911	3,882	4,414	5,087	HEC-HMS
P41	8.80	370	706	956	1,138	1,303	HEC-HMS
P42	11.69	309	616	819	915	1,096	HEC-HMS
P43	0.58	66	128	159	199	235	HEC-HMS
P45	54.91	1,522	2,717	3,586	4,395	5,257	HEC-HMS
P46	104.58	2,522	4,682	5,794	6,931	7,852	HEC-HMS
P55	1.87	119	293	381	461	518	HEC-HMS
P58	11.71	556	1,406	1,665	2,015	2,447	HEC-HMS
P60	5.85	256	701	862	1,009	1,183	HEC-HMS
P61	5.00	235	652	806	942	1,100	HEC-HMS
P64	161.72	4,000	7,342	9,289	11,206	12,991	HEC-HMS
P65	5.22	237	490	630	756	911	HEC-HMS
P66	4.44	227	436	542	596	718	HEC-HMS
P67	15.53	640	1,306	1,626	2,124	2,410	HEC-HMS
P69	57.10	1,859	3,644	4,821	5,513	6,336	HEC-HMS

Table C.1. Problem Area Hydrology

Problem Area	Cumulative Area (mi^2)	2010 Discharges with Existing SWM (cfs)					Data Source
		2-Year	10-Year	25-Year	50-Year	100-Year	
P76	4.53	228	419	562	697	756	HEC-HMS
P77	0.96	18	51	78	106	135	HEC-HMS
P78	5.78	326	596	810	1,013	1,142	HEC-HMS
P79	7.41	398	725	985	1,228	1,379	HEC-HMS
P80	7.66	406	738	1,003	1,250	1,403	HEC-HMS
P81	4.30	221	407	546	679	736	HEC-HMS
P82	2.81	178	314	405	514	577	HEC-HMS
P84	21.06	795	1,659	2,194	2,468	2,834	HEC-HMS
P91	79.00	2,202	4,127	5,120	6,146	6,873	HEC-HMS
P93	1.99	113	319	336	403	567	HEC-HMS

Table C.1 (continued). Problem Area Hydrology

Hydraulics

Due to funding constraints, no hydraulic calculations were provided at individual problem areas.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Keating Township **ID:** O01

Location: Kent Hollow Rd **Stream:**

Problem Description:

Bridge is in poor condition and appears to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Keating Township **ID:** O02

Location: East Valley Rd **Stream:** Piece Brook

Problem Description:

Bridge appears to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Bradford City **ID:** O03

Location: Seward St Bridge **Stream:**

Problem Description:

Bridge is in poor condition and appears to have inadequate hydraulic capacity.




McKean County Act 167 Plan

Problem Area Summary

Municipality: Bradford City **ID:** O04

Location: South Ave, Chataqua Place **Stream:**

Problem Description:

It appears that there is no conveyance system along Chataqua Place.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Bradford City **ID:** O05

Location: Bennett/Interstate Parkway **Stream:**

Problem Description:

Conveyance system has accumulated debris. This system may have been impacted by Bradford High School that is located upstream.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Hamlin Township **ID:** O06

Location: Orchard St **Stream:**

Problem Description:

Conveyance system appears to be insufficient.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Hamlin Township **ID:** O07

Location: Marvindale-Kaison Rd **Stream:**

Problem Description:

Beaver dam.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Otto Township **ID:** O08

Location: Grant St **Stream:**

Problem Description:

The conveyance system (all 18" diameter pipe) appears to be insufficient.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Norwich Township **ID:** O09

Location: West Valley Rd **Stream:** Redmill Creek

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Norwich Township **ID:** O10

Location: West Valley Rd **Stream:** Brewer Run

Problem Description:

Bridge appears to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Norwich Township **ID:** O11

Location: SR 46 - White Hollow SEG 220 **Stream:**

Problem Description:

Bridge appears to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Norwich Township **ID:** O12

Location: TR 470 **Stream:** Portage Creek

Problem Description:

Bridge appears to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Hamilton Township

ID: P01

Location: South Hillside Ave

Stream:

Problem Description:

Unable to locate problem area during field visit.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Hamilton Township **ID:** P02

Location: Wetmore Rd - Johnson to Niver Rds **Stream:**

Problem Description:

Improve roadside channels and install cross pipes.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Hamilton Township **ID:** P03

Location: Curtis Rd (behind Ludlow Fire Dept) **Stream:**

Problem Description:

Upslope runoff flows to the rear of the firehouse.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Hamilton Township **ID:** P04

Location: FR 133 RR crossing **Stream:**

Problem Description:

Upslope channel bank is un-vegetated. Runoff erodes bank and sediments blocks the culvert intake. Downstream channel is un-vegetated.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Mt Jewett Borough **ID:** P05

Location: Route 6 **Stream:**

Problem Description:

Inlet junction box collects runoff and directs concentrated flow under the railroad. Channel is eroding.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Wetmore Township **ID:** P06

Location: Jo Jo Road Bridge **Stream:**

Problem Description:

Bridge appears to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Wetmore Township **ID:** P07

Location: Jo Jo Road - both sides **Stream:**

Problem Description:

Erosion protection and sufficient roadside conveyance structures are needed.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Wetmore Township **ID:** P08

Location: Old Mill Road **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Wetmore Township **ID:** P09

Location: Sleepy Hollow Road **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Wetmore Township **ID:** P10

Location: Dwights Road **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Wetmore Township **ID:** P11

Location: Mosier Hill Road **Stream:**

Problem Description:

Unable to locate problem area during field visit.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Wetmore Township **ID:** P12

Location: Reigle Road **Stream:**

Problem Description:

The Conservation District applied for a Dirt and Gravel Road project but this site was not high on the priority list. SWM conveyance structures and roadside channels are needed.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Wetmore Township **ID:** P13

Location: Spring Street **Stream:**

Problem Description:

Culvert is blocked with debris and appears to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Foster Township **ID:** P14

Location: Foster Brook thru Derrick City **Stream:**

Problem Description:

Foster Brook appears to be eroding at various sections thru Derrick City. Photos were taken near "The Model T Inn"

McKean County Act 167 Plan

Problem Area Summary

Municipality: Foster Township **ID:** P15

Location: Bolivar Run **Stream:**

Problem Description:

It appears that Bolivar Run is beginning to erode properties that border the stream.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Foster Township **ID:** P16

Location: Lafferty trib to Kendall Creek **Stream:**

Problem Description:

It appears rock protection has been placed in Lafferty Tributary since survey was submitted.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Foster Township **ID:** P17

Location: Tunungwant Creek **Stream:**

Problem Description:

Erosion is present at various locations. Erosion appears to be present along the entire creek. The photos were taken at the creek at the Crook Farm Trail.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Township **ID:** P18

Location: Derrick Road **Stream:**

Problem Description:

Roadway flooding in floodplain




McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Township **ID:** P19

Location: Windfall Road **Stream:**

Problem Description:

Drainage channels along Windfall Rd need maintenance. Many of the culverts are blocked and flow backs up and discharges on to the road.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Township **ID:** P20

Location: N. Branch Road **Stream:**

Problem Description:

Large woody debris is blocking the upstream area of culvert inlet.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Township **ID:** P21

Location: Driscoll Rd **Stream:**

Problem Description:

Driscoll Rd floods during storm events due to steep slopes and lack of additional drainage structures.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Township **ID:** P22

Location: Bells Hollow **Stream:**

Problem Description:

Dirt ATV path was build directly along stream.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Township **ID:** P23

Location: Moody Loop Road **Stream:**

Problem Description:

Culverts appear to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Township **ID:** P24

Location: W. Eldred Road **Stream:**

Problem Description:

Unable to locate problem area during field visit.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Township **ID:** P25

Location: Route 346 **Stream:**

Problem Description:

Outlet of culvert under SR 346 has a gravel bar 50' downstream blocking flow to creek. Install erosion protection and implement prudent floodplain measures.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Township **ID:** P26

Location: Canfield Creek **Stream:**

Problem Description:

Stream is accumulating sediment and debris.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Township **ID:** P27

Location: Carpenter Creek **Stream:**

Problem Description:

Unable to locate problem area during field visit.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Township **ID:** P28

Location: Newell Creek **Stream:**

Problem Description:

Install upstream mitigation necessary to prevent sediment deposition.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Port Allegheny Borough **ID:** P29

Location: Route 6 Bridge over Allegheny River **Stream:**

Problem Description:

problem fixed in 2008.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Corydon Township **ID:** P30

Location: Willow Creek **Stream:**

Problem Description:

Bank erosion & log jams have been reported. Areas with slight erosion were observed during field visit. There are current stream bank restoration projects occurring along certain sections.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Ceres Township **ID:** P31

Location: Chapman Brook Rd **Stream:**

Problem Description:

Storm drainage appears to have been recently improved.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Ceres Township **ID:** P32

Location: Coon Hollow Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Ceres Township **ID:** P33

Location: Taylor Brook Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity. The downstream channel has been severely eroded from poor culvert installation.

McKean County Act 167 Plan

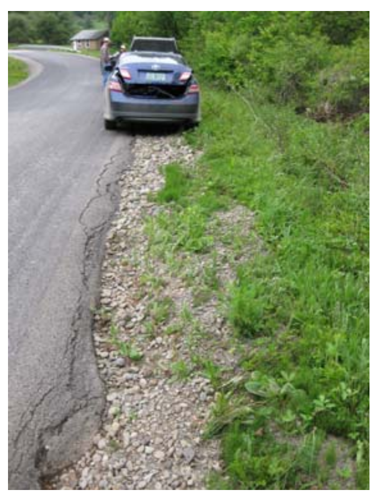
Problem Area Summary

Municipality: Ceres Township **ID:** P34

Location: Church Hollow Rd **Stream:**

Problem Description:

Stream floods 200' of the low lying road area. Erosion protection is needed for high water storm events.



McKean County Act 167 Plan

Problem Area Summary

Municipality: Ceres Township **ID:** P35

Location: Kings Run Rd **Stream:**

Problem Description:

A culvert is needed where wetlands have been disconnected by roadway installation.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Ceres Township **ID:** P36

Location: Hanson Hollow Rd **Stream:**

Problem Description:

Unable to locate problem area during field visit.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Ceres Township **ID:** P37

Location: Barden Brook Rd **Stream:**

Problem Description:

Upslope driveway gravel washes down to Barden Brook and Whitetail Roads. Upslope driveway and logging road needs to be stabilized.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Ceres Township **ID:** P38

Location: Whitetail Rd **Stream:**

Problem Description:

The entire dirt road experiences some degree of erosion during storm events.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Ceres Township **ID:** P39

Location: Austin Rd **Stream:**

Problem Description:

Upslope debris and sediment flows from onto Austin Rd.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Bradford Township **ID:** P40

Location: Browntown Rd **Stream:**

Problem Description:

A section of Browntown Rd is in a low lying floodplain area.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Bradford Township **ID:** P41

Location: Pear Street **Stream:**

Problem Description:

Culvert has recently been replaced.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Bradford Township **ID:** P42

Location: Marilla Creek **Stream:**

Problem Description:

There is a tree that is lying across the creek at this location. This large woody debris can cause flooding for properties located in or close to the floodplain.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Bradford Township **ID:** P43

Location: Gates Hollow Rd **Stream:**

Problem Description:

The Gates Hollow Rd composed of steep slopes. The storm system may be inadequate.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Smethport Borough **ID:** P44

Location: Black Smith Brook **Stream:**

Problem Description:

Stream bank erosion. Concrete slabs were placed in stream to prevent erosion.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Smethport Borough **ID:** P45

Location: Marvin Creek **Stream:**

Problem Description:

Ice builds up in neighboring yard during winter. Property is in the floodplain.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Smethport Borough **ID:** P46

Location: Potato Creek **Stream:**

Problem Description:

The banks of Potato Creek are vegetated. Stream stabilization may be necessary at various locations along Potato Creek to prevent excessive erosion and sedimentation.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Smethport Borough **ID:** P47

Location: West Willow **Stream:**

Problem Description:

It appears the inlets along West Willow are beginning to accumulate debris.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Smethport Borough **ID:** P48

Location: West High School **Stream:**

Problem Description:

The inlet located towards the bottom of the school driveway has accumulated with debris. The school is in the process of repaving their driveway. The conveyance system may be improved.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Smethport Borough **ID:** P49

Location: East High School **Stream:**

Problem Description:

Several inlets in area are in need of maintenance or replacement.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Smethport Borough **ID:** P50

Location: East Rosehil **Stream:**

Problem Description:

Debris accumulating near inlets may block SWM conveyance system.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Smethport Borough **ID:** P51

Location: East High School outfall **Stream:**

Problem Description:

A 24" diameter RCP is blocked by a water main that was place directly across the RCP, obstructing a major portion of the flow. It appears the 8" diameter was added as an overflow and spills back into 24" Dia. RCP.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Smethport Borough **ID:** P52

Location: Fulton Franklin **Stream:**

Problem Description:

Runoff from steep hillside discharges down Fulton and Franklin St. Erosion protection and additional stormwater conveyance structures may be needed.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Smethport Borough **ID:** P53

Location: State St **Stream:**

Problem Description:

Runoff from steep upslope hill side is directed down State St. The roadside channels along the road need to be stabilized.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Smethport Borough **ID:** P54

Location: Upper Hamlin **Stream:**

Problem Description:

Runoff from hillside is diverted to Hamlin Rd. Roadside channels are eroded and appear to be insufficient.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Annin Township **ID:** P55

Location: Two Mile Rd **Stream:**

Problem Description:

Culverts appear to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Annin Township **ID:** P56

Location: Two Mile Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity. The downstream channel has been eroded.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Annin Township **ID:** P57

Location: Sun Valley Road **Stream:**

Problem Description:

Water from an unnamed tributary to Newell Creek overtops its banks, flows over Sun Valley Rd and washes out its gravel surface. The roadway appears to be located in a floodplain.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Annin Township **ID:** P58

Location: Champlain Hill Rd **Stream:**

Problem Description:

The roadway appears to be located in a floodplain.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Annin Township **ID:** P59

Location: Peich Run Rd **Stream:**

Problem Description:

Unable to locate problem area during field visit.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Annin Township **ID:** P60

Location: Turtlepoint Park **Stream:**

Problem Description:

Stream is severely incised. Stream assessment is needed to determine causes and possible solutions to erosion and deposition.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Annin Township **ID:** P61

Location: Open Brook **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Keating Township **ID:** P62

Location: Galico Cross Rd **Stream:**

Problem Description:

Upslope runoff washes away the shoulders along Galico Cross Rd.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Keating Township **ID:** P63

Location: Valley Cross Rd **Stream:**

Problem Description:

Shoulder is eroding along Valley Cross Rd.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Keating Township **ID:** P64

Location: Dugout Rd **Stream:**

Problem Description:

Several small areas have eroded road shoulders. Runoff from upslope driveways discharges at several areas along Dugout Rd.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Bradford City **ID:** P65

Location: Bolivar Run **Stream:**

Problem Description:

Bridge appears to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Bradford City **ID:** P66

Location: Bennet Brook **Stream:**

Problem Description:

Rip rap has been installed along Bennet Brook for streambank stabilization. Erosion protection could be placed on sections upstream of Bradford Stadium.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Bradford City **ID:** P67

Location: Kendall Creek at Melvin Ave **Stream:**

Problem Description:

It appears that upstream disturbance is eroding the creek at this location. The neighboring properties are in the floodplain at this location.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Bradford City **ID:** P68

Location: Neva Drive **Stream:**

Problem Description:

It appears a conveyance network was recently installed to correct the problem.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Bradford City **ID:** P69

Location: Bedford St **Stream:**

Problem Description:

Bedford St does not have a swm conveyance system in place except for a channel running parallel to Bedford St.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Hamlin Township **ID:** P70

Location: Dewey Ave **Stream:**

Problem Description:

Locations adjacent to Marvin Creek frequently flood. The areas are located within a floodplain.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Hamlin Township **ID:** P71

Location: Marvin Creek **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Hamlin Township **ID:** P72

Location: S. of Hazel Hurst. Brites Road. **Stream:**

Problem Description:

Roadside ditches appear to be recently cleaned out. Property owner stated that in the winter and spring the area will flood on both sides of Marvin Creek because it is in the floodplain.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Hamlin Township **ID:** P73

Location: Kiln Rd **Stream:**

Problem Description:

Upslope runoff washes sediment onto Kiln Rd.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Hamlin Township **ID:** P74

Location: Guffey Rd **Stream:**

Problem Description:

Guffey road is a dirt road. Erosion protection and improved drainage channels are needed.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Hamlin Township **ID:** P75

Location: Old Bradford Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.




McKean County Act 167 Plan

Problem Area Summary

Municipality: Otto Township **ID:** P76

Location: Brooklyn St **Stream:**

Problem Description:

It appears that concrete debris may have been placed in channel to prevent erosion. Streambank stabilization is needed along with a stream assessment to best determine potential solution.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Otto Township **ID:** P77

Location: Baker Trussel Bridge **Stream:**

Problem Description:

Upstream channel meanders downward and erodes until it reaches the bridge. Stream assessment is needed to provide solutions to erosion and deposition problems.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Otto Township

ID: P78

Location: Clark St bridge

Stream:

Problem Description:

The channel upstream of bridge is beginning to encroach on properties within the floodplain.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Otto Township **ID:** P79

Location: Depot St bridge **Stream:**

Problem Description:

The channel upstream of bridge is beginning to encroach on properties within the floodplain.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Otto Township **ID:** P80

Location: Burger Hollow bridge **Stream:**

Problem Description:

Upstream and downstream channel instabilities (i.e., erosion and deposition) area evident. Stream assessment is needed.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Otto Township **ID:** P81

Location: Oil Valley Rd **Stream:**

Problem Description:

Channel running along properties at Gilespie Hollow Rd is beginning to erode owners land.




McKean County Act 167 Plan

Problem Area Summary

Municipality: Otto Township **ID:** P82

Location: Kansas Branch **Stream:**

Problem Description:

Upstream and downstream channel instabilities (i.e., erosion and deposition) area evident. Concrete slabs have been placed in the stream to prevent erosion. Stream assessment is needed.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Otto Township **ID:** P83

Location: Burger Hollow **Stream:**

Problem Description:

Roadside channel along Burger Hollow Rd is beginning to encroach on neighboring properties.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Lewis Run Borough **ID:** P84

Location: Bridge over EB Tunungwant Creek **Stream:**

Problem Description:

Deposition and excessive sedimentation has been report near bridge. There was no obvious sedimentation problems observed during the field visit.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Borough **ID:** P85

Location: Main St (Rt 446) **Stream:**

Problem Description:

storm drain unable to handle heavy rains. collection system appears to be completely blocked. clean system and install upstream mitigation necessary to prevent sediment deposition.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Borough **ID:** P86

Location: Elm St **Stream:**

Problem Description:

The SWM collection system appears to be completely blocked.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Borough **ID:** P87

Location: Clif-Nel Dr **Stream:**

Problem Description:

Gravel driveway leading to housing development does not have any functioning drainage structures. The other structures through out the development do appear to have been installed or designed correctly.




McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Borough **ID:** P88

Location: Railroad Ave **Stream:**

Problem Description:

There is no existing SWM conveyance system.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Borough **ID:** P89

Location: Main St (SR 446) **Stream:**

Problem Description:

SWM collection system appears to be completely blocked.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Eldred Borough **ID:** P90

Location: Main St (SR 446) **Stream:**

Problem Description:

SWM collection system appears to be completely blocked.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Norwich Township **ID:** P91

Location: Crosby Cross Rd - TR 375 **Stream:**

Problem Description:

Unable to locate problem area during field visit.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Norwich Township **ID:** P92

Location: Keystone Cross Rd - TR 373 **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity due to clogging.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Liberty Township **ID:** P93

Location: Buchenauer Rd area **Stream:**

Problem Description:

Beaver dam. It appear the reported beaver dam may have been removed prior to field visit.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Liberty Township **ID:** P94

Location: Fogel Crossing Rd **Stream:**

Problem Description:

Property located in the floodplain.

McKean County Act 167 Plan

Problem Area Summary

Municipality: Hamlin Township **ID:** P95

Location: Guffey Rd **Stream:**

Problem Description:

Two 24" and 15" diameter culverts enter a PennDOT inlet box and exits through a short 18" diameter culvert, apparently installed due to the limiting depth of the inlet box.

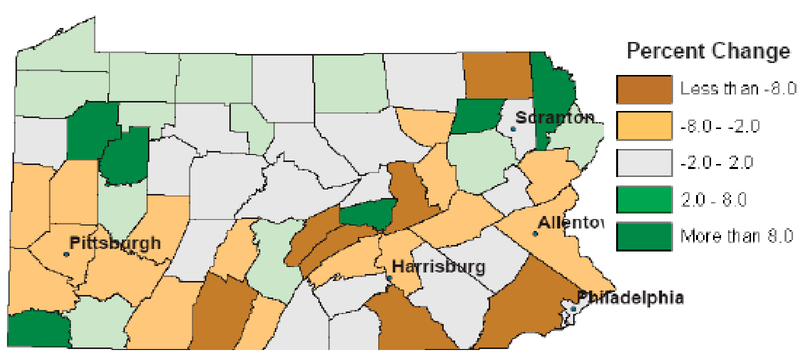
Appendix D – Natural Resource Activities Impacting Water Quality

As demonstrated throughout this Plan, land use is a key factor in both the generation and control of stormwater runoff. In Pennsylvania, most types of land use can be regulated by the county or local government through land use ordinances (e.g. zoning). However, the Pennsylvania Municipalities Planning Code (MPC) limits local government control of certain land use categories. Certain types of natural resource activities such as agriculture, forestry, and mining are among the land uses protected by the MPC. Two land use categories that fall within this category were identified by the Plan Advisory Committee, and the municipalities they represent, as land uses that greatly affect the water resources of the county – timber harvesting and oil and gas wells.

Amendments made to the Pennsylvania Municipalities Planning Code by Act 67 and Act 68 of 2000, limit the regulatory control of municipalities on forestry and timber harvesting. The amendments specify Forestry activities and timber harvesting as "permitted uses by right" in all zoning districts in every municipality. The MPC amendments further clarify that zoning ordinances may not unreasonably restrict forestry activities.

Oil and gas well development in Pennsylvania is regulated by several chapters of the Pennsylvania Code and various state acts. The state's oil and gas laws (Oil and Gas Act – Act 223, Coal and Gas Resource Coordination Act – Act 214, and Oil and Gas Conservation Law – Act 359), as well as environmental protection laws that include the Clean Streams Law, the Dam Safety and Encroachments Act, the Solid Waste Management Act, and the Water Resources Planning Act delegate the authority to regulate these activities to DEP, while limiting the regulatory control of municipalities.

FORESTRY IN PENNSYLVANIA



Change in Forest Land Area, 1989-2004 (McWilliams et al., 2007)

According to U.S. Forest Service inventories, forest once covered more than 90% (27.3 million acres) of Pennsylvania's land area in the pre-European settlement era (1630s). By the early 1900s, industrial timber harvesting and agricultural land clearing had diminished the forest land base to only 32% (9.2 millions acres). Forest land increased steadily from that point forward and has been relatively stable, at 58% of Pennsylvania's total area, for the last quarter century. Although no significant net change in total area has occurred, there have been losses of acreage to development, agriculture and mining. These losses have been offset by agricultural and other lands naturally reverting back to forests. Slightly more than 70% of the nearly 17 million acres of forests in the state are privately owned, with only a small percentage (< 5%) owned by forest product companies. The remaining 30% of the forest land in Pennsylvania is owned by state and federal government entities.

Pennsylvania is known throughout the world as a leading source of high quality hardwood products. The state leads the nation in the production of hardwood lumber (typically more than one billlion board feet), accounting for about 10% of the country's annual production (Pennsylvania Forest Products Association, 2008). Pennsylvania also ranks nationally in the production of value added wood products such as millwork and flooring; kitchen cabinets; pallets and containers.

The forest products industry is important in Pennsylvania, where it accounts for 11% of all manufacturing jobs. The forest products industry has a significant impact on the state's economy. In 2005, the state's annual forest product industry sales was $16.7 billion. The total economic impact of the forest product industry in the state was $24.7 billion. Three-quarters of this economic impact was generated by sectors depending on locally harvested hardwood timber (Pennsylvania Forest Products Association, 2008). In 2006, there were 2,420 forest prduct establishments in Pennsylvania, employing 79,910 individuals. In many rural parts of the state the forest products industry is the primary source of economic activity.

FORESTRY IN MCKEAN COUNTY

Approximately 77% of McKean County is forested. A large portion of this is within the Allegheny National Forest (ANF). The northwestern Pennsylvania communities surrounding the Allegheny National Forest (ANF) receive the bulk of their annual funds for schools and roads from payments in lieu of taxes from the federal government and 25% of all timber sale revenues in the ANF. The four counties surrounding the ANF (including McKean County) receive $6 million from timber sale receipts. Municipalities with publicly owned State Forests, State Game Lands, and State Parks within their borders also receive in lieu of tax payments from the Commonwealth.

Although it is not a dominant sector, the wood products industry provides important economic opportunities in the county. In 2007, there were 32 wood products establishments employing five hundred and one thousand people (U.S. Census Bureau, 2008). Timber management encourages the preservation of open space. Through timber harvesting, forests are able to provide landowners with income that can be an incentive for them to maintain woodland on their property. According to a study conducted by the American Famland Trust, timberland and farmland yield an average of $3 in taxes for every $1 in required governmental services, while residential land costs $1.11 in services for every $1 collected in tax revenue (The Pennsylvania State University, 2004).

FORESTRY ACTIVITIES AFFECTING WATER QUALITY

As discussed in *Section IX - Water Quality Impairments and Recommendations*, forestry is one of the basic sources of nonpoint source pollution. On a national level, forestry management activities are estimated to contribute approximately 9 percent of the water quality problems in surveyed rivers and streams (EPA, 1996). Water quality concerns related to forestry were addressed in the 1972 Federal Water Pollution Control Act Amendments and later, more comprehensively, as nonpoint sources under section 208 of the 1977 Clean Water Act and section 319 of the 1987 Water Quality Act.

Forestry is listed as the primary cause for impairment in 0.02% of all non-attaining stream miles in Pennsylvania. There are no stream segments in McKean County listed on the *2009 Integrated List of All Waters* as non-attaining, with forestry as the primary source of impairment. However, this does not mean that the potential impacts of forestry operations on water quality can be neglected. Local impacts of timber harvesting and road construction can be severe, especially in smaller headwater streams. Many activities associated with forest management can increase the potential for erosion to occur. For this reason, sediment is the primary pollutant of concern associated with forestry activities. Other pollutants include nutrients, organic matter, chemicals and others. The fundamental forestry activities with the potential to affect water quality include road construction and use, timber harvesting, mechanical equipment operation, and forest management.

ROAD CONSTRUCTION AND USE

Roads are considered to be the major source of sediment from forested lands. The comparatively small area of roads contributes the vast majority of the total sediment produced from forestry operations. The greatest potential for erosion from roads occurs during road construction and during the first few years afterward. The potential for erosion on forest roads is particularly high because they are exposed to direct rainfall, they are not protected by vegetative cover, road surfaces tend to channelize runoff, and vehicle traffic continually disturb the road surface. Erosion potential is greatly increased when roads are built on cut or fill slopes, when built on steep slopes, and when they are not stabilized with stone or some other means.

Compacted road surfaces also generate increased runoff which compounds erosion problems. Other negative impacts of forest roads include concentrated overland flow on the road surface and in channels, point discharges created by culvert road crossings, and altered subsurface water flow.

TIMBER HARVESTING

Timber harvesting involves many activities that alter the forest landscape. Erosion and sedimentation resulting from these alterations is the primary concern associated with timber harvesting. Facilities used for timber harvesting such as staging (or yarding) areas, skid trails, and access roads are susceptible to increased erosion. These facilities are also at high risk for pollutants such as petroleum products, lubricants, herbicides, pesticides, and other chemicals associated with timber harvesting operations. Many detrimental effects of harvesting are related to the access and movement of vehicles and machinery. These effects include soil disturbance, soil compaction, and direct disturbance of stream channels.

Landscape changes that occur as a result of harvesting can also negatively impact water quality. Timber harvesting disturbs forest litter and changes the vegetative cover which alters the hydrologic response of a watershed. This can lead to increased runoff and erosion. Removing trees from riparian areas disturbs the sensitive ecosystem, exposes the area to pollutants associated with machinery, and reduces shade which can increase water temperatures. Utilizing appropriate timber harvesting and transport practices techniques for a given site can drastically decrease sediment production from these activities.

FOREST MANAGEMENT

Forest management activities such as site preparation for regeneration of harvested sites, prescribed burning, herbicide and pesticide application, and fertilizer application have the potential to negatively affect water quality. Sites that have been intensely harvested can be prepared for regeneration using wheeled or tracked machinery, by prescribed burning, through application of chemicals (i.e. herbicides), or a combination of these methods. These techniques can disturb the soil over large areas, remove vegetation and forest litter, and compact soil. All of these leave the area vulnerable to increased erosion and sedimentation.

FORESTRY POLLUTANTS AND IMPAIRMENTS

Nearly all forestry activities increase the potential for erosion and sediment delivery to streams. Some of these activities have long-term effects (e.g. road building and clear-cutting), while the impacts of others diminish within a few years of the occurrence. Erosion and sedimentation is the primary water quality concern related to forestry activities. Sedimentation is closely related to nutrient transport. Nutrients that are immobilized in forest soils are transported along with the sediment to surface waters through erosion. Other water quality pollutants resulting from forestry activities include organic debris, nutrients, chemicals, temperature, and flow variability. These pollutants, how they are generated through forestry activities, and their potential impacts on the county's waters are discussed below.

SEDIMENT

Sediment is often the primary pollutant associated with forestry activities. Accelerated overland erosion often occurs in harvested areas due to vast areas that are destabilized by removal of vegetation. Erosion of these areas discharges sediment and fine silt particles into receiving streams. Sediment transported to waterbodies by erosion can be particularly detrimental to the stream ecosystem, especially to many fish species. Suspended sediments in runoff increase water turbidity limiting the ability of sight-feeding fish to find and obtain food. In addition, the increased turbidity limits the depth to which light can penetrate and adversely affecting aquatic vegetation, increase water temperatures and lower dissolved oxygen concentrations. These effects also compromise recreational values.

When suspended sediment settles, it can fill gravel spaces in streambeds, destroying fish spawning areas and food sources. With large areas of accumulated sediment, the flow capacity of stream channels are reduced. The in stream storage capacity is also reduced, which leads to increasing flooding and decreased water supplies. In addition, nutrients and other pollutants may become adsorbed to sediment particles and be subsequently transported downstream.

ORGANIC DEBRIS

Organic material is an important part of a balanced ecosystem. Organic debris includes plant matter, residual logs, leaves, twigs and other forest litter. This material serves as a source of enefgy and provides nutrients for plants and animals. This is the primary source of nutrients for headwater streams, where upstream sources of nutrients are limited. Forestry activities can upset the balance of organic material by creating excess debris during timber havesting or by creating a debris shortage during site preparation for regeneration or by over harvesting in the riparian zone.

Excess organic debris can adversely affect water quality by causing increased biochemical oxygen demand, resulting in decreased dissolved oxygen levels (which are critical for many aquatic species) in watercourses. Logging slash and debris in or near streams can alter stream flows by forming debris dams, and can also redirect flow in the channel, increasing bank cutting and resulting in sedimentation.

NUTRIENTS

Erosion is the primary transport mechanism for nutrient pollution related to forestry activities. Forest soils act as a filter that collects and holds nutrients from decomposing organic matter such as leaves and woody debris. The soil holds many of these nutrients until they are removed by growing plants and used for plant growth. Some nutrients, like nitrogen, are easily dissolved in water and are easily moved throughout the environment. Other nutrients, such as phosphorus, bind to soil particles and are relatively immobile unless relocated by some transport mechanism (e.g. erosion). Excess nutrients in surface waters can result in eutrophication, or a proliferation of plant life, especially algae. Eutrophication causes dissolved oxygen levels to decrease, harming other aquatic organisms.

CHEMICALS

Chemicals such as herbicides, pesticides, and fertilizers used for forestry operations can contaminate surface water through direct application, transport by surface runoff, or groundwater contamination. These chemicals can poison fish and wildlife or kill unintended plant species. Generally speaking, herbicides, pesticides, and fertilizers pose minimal threat to water quality when handled and applied properly. However, improper application and spills can have severe and long lasting effects. The petroleum products and lubricants used for machinery are of greater concern. These chemicals can be toxic to plants and animals and can contaminate drinking water supplies.

TEMPERATURE

Relatively constant water temperature is important for aquatic biota. When too much vegetation is harvested from the area surrounding stream, the loss of shade can result in increased water temperatures. Temperature increases can be dramatic in smaller (lower order) streams, adversely affecting fish and aquatic invertebrates which have adapted to cooler water temperatures. Suspended solids from sedimentation can also lead to increased stream temperatures as darker particles absorb heat (EPA, 1997). As water temperatures rise, dissolved oxygen levels (which are critical for many aquatic species) decrease. Temperature changes can be a substantial contributor to aquatic life impairments.

STREAM FLOW

The hydrologic response of a watershed can change as a result of timber harvesting. The change resulting from large scale removal of vegetation is often increased stream flow that results from more rapid delivery of runoff to streams. When fewer trees are available to perform the function of evaporation and transpiration, more water becomes availabe as surface runoff. Increased runoff results in increased stream flow. The amount of stream flow increase is related to the total area harvested, topography, soil type, and harvesting practices (Curtis et al. 1990). Increased stream flow can lead to a variet of problems including scoured channels, erode streambanks, increase sedimentation, and increase peak flows.

FORESTRY MANAGEMENT MEASURES FOR WATER QUALITY

Current forestry management practices and timber harvest techniques have drasticly reduced the water quality impacts that occurred from practices of the past century. The water quality impacts of forestry activities can be further minimized by implementing appropriate management measures. Management measures are steps to be taken and guidelines for operations (EPA, 2005). Best Management Practices (BMPs) are specific activities, processes, or technologies designed to serve specific functions, which are used to attain a management measure. These are simple, often low cost, practices and techniques that can be incorporated into forestry operations to diminish impacts to water quality. Additional guidance on BMPs can be found in the following resources developed specifically for Pennsylvania forests:

- Timber Harvest Operations Field Guide for Waterways, Wetlands and Erosion Control (3930-BK-DEP4016), 2009. Pennsylvania Department of Environmental Protection.
- Best Management Practices for Pennsylvania Forests, 2001. The Pennsylvania State University.

A brief overview of EPA's (2005) forestry management measures developed to protect water quality throughout the various phases of forestry activites is presented on the following pages.

Preharvest Planning

Purpose	Ensure that forestry activities are planned with water quality considerations in mind and conducted in a manner to minimize delivery of nonpoint source pollutants to surface waters.
Target Pollutant(s)	Primarily sediment. Organic matter, thermal modification, nutrients pesticides and toxics are also controlled.
Description	Preharvest planning includes consideration of all stages of a timber harvest including the road system, the harvesting system, the yarding system, and post harvest activities. Site conditions are considered and appropriate BMPs are prescribed to reduce water quality impacts. Contingency plans are developed to reduce the effects of potential problems.

Streamside Management Areas

Purpose	Protect surface waters, the ecologically sensitive areas in riparian zones and wetlands, and maintain the function of floodplains.
Target Pollutant(s)	Sediment, organic debris, and thermal modification. Nutrients, pesticides and toxics are also controlled.
Description	Establish and maintain a buffer zone along surface waters that includes a sufficient number of canopy species, and is wide enough to shade the water, provide bank stability, and filter runoff. Limit forestry activities within the buffer.

Road Construction

Purpose	Reduce erosion and sedimentation which is common during, and immediately after, construction of forestry roads.
Target Pollutant(s)	Sediment. Petroleum products and lubricants.
Description	Design and construction of roads that are planned for the topography, soils, and drainage patterns of a site. Appropriate construction methods and BMPs are used to minimize erosion from high risk areas such as the road surface, steep slopes, water crossings, and runoff conveyance structures (i.e. culverts, ditches, etc.).

Road Management

Purpose	To ensure that management of existing roads maintains their utility and minimizes polluted runoff from roads and road structures.
Target Pollutant(s)	Sediment. Petroleum products and lubricants.
Description	Minimize use during wet weather and thaw conditions. Perform routine maintenance of road surface, stream crossings, and drainage structures. Immediately repair eroding areas and implement BMPs to address problem areas. Close and decommission roads that are no longer needed.

Timber Harvesting

Purpose	Minimize the likelihood of water quality impacts resulting from timber harvesting operations.
Target Pollutant(s)	Sediment, petroleum products.
Description	Follow the plan for timber harvest operations developed during preharvest planning. Conduct operations to avoid sedimentation to the extent practicable. Use appropriate areas for high risk activities such as equipment maintenance, and petroleum and chemical storage and dispensing.

Site Preparation for Regeneration

Purpose	Minimize erosion and runoff from areas disturbed by site preparation for forest regeneration.
Target Pollutant(s)	Sediment, organic debris, and nutrients.
Description	Select methods of site preparation for regeneration which are suitable for site conditions. Complete site preparation in sensitive areas such as steep slopes and riparian zones using low impact methods and utilizing appropriate BMPs. Leave adequate organic material but protect surface waters from debris and slash material.

Fire Management

Purpose	Minimize nonpoint source pollution and erosion resulting from prescribed burning.
Target Pollutant(s)	Sediment, organic debris, and nutrients.
Description	Use of prescribed fire should be planned and implemented in a manner to protect against excessive erosion. Area to be burned and severity of burn should be prescribed based on site conditions and erosion potential. Appropriate BMPs should be employed to reduce impacts to sensitive areas.

Revegetation of Disturbed Areas

Purpose	Reduce erosion and sedimentation of areas disturbed by forestry activities.
Target Pollutant(s)	Sediment and nutrients.
Description	Reduce erosion and sedimentation by revegetating disturbed areas with appropriate plant species immediately upon completion of earth-disturbing activities. Focus initial efforts on highly susceptible areas such as steep slopes and riparian areas.

Forest Chemical Management

Purpose	Minimize the potential of water pollution by chemicals used for forest management due to environmental transport of chemicals during and after application.
Target Pollutant(s)	Pesticides (i.e. Insecticides, herbicides, and fungicides) and fertilizers.
Description	Risks associated with the use of forest chemicals can be reduced through careful prescription of type and amount of chemicals to be used; delineation of buffer zones; and careful transport and application of chemicals. Spill prevention and contingency plans can reduce the potential impact of spills.

OIL AND GAS DEVELOPMENT IN PENNSYLVANIA

The petroleum (oil and gas) industry has played a significant role in the history of Pennsylvania. In 1859, Edwin L. Drake drilled one of the first successful oil wells near Titusville, PA. In the years that followed, Venango and Crawford Counties became the center of an industry focused on the drilling, refining, and transporting crude oil and oil products (Harper, 1998). Although not the first natural gas well, the Drake Well (which captured natural gas and piped it to Titusville) is also attributed as the beginning of the natural gas industry in America (NaturalGas.org, 2004). Oil and gas wells are a common part of the landscape throughout much of Pennsylvania. Until recently, the petroleum industry in Pennsylvania had faded to a small fraction of what it had been during its prime.

The Marcellus Shale Formation is a Middle Devonian-age (397.5 – 385.3 million years ago), black, low density, carbonaceous shale that lies nearly a mile or more below the surface of approximately two-thirds of Pennsylvania and large portions of New York, West Virginia, and Ohio as well as small areas of Maryland, Kentucky, Tennessee, and Virginia. Organic rich shales, such as the Marcellus Formation, have been known to hold significant reservoirs of natural gas for more than 75 years (Harper, 2008). Once thought cost prohibitive to extract, recent advances in drilling technology and recent price increases for natural gas have increased interest in this extensive gas reservoir. In 2002, the United States Geological Survey's "Assessment of Undiscovered Oil and Gas Resources of the Appalachian Basin Province" calculated that the Marcellus Shale contained an estimated resource of about 1.9 trillion cubic feet of gas (USGS, 2003).

In 2003, Range Resources – Appalachia, LLC drilled a well in Washington County, Pennsylvania and found a promising flow of natural gas from the Marcellus shale. Borrowing drilling and fracturing techniques that had worked in the Barnett Shale of Texas, they began producing Marcellus gas in 2005 (Harper, 2008). In early 2008, Terry Engelder, a geoscience professor at Pennsylvania State University, and Gary Lash, a geology professor at the State University of New York at Fredonia, "said the Marcellus shale conservatively contains 168 trillion cubic feet of natural gas, but the figure might be as high as 516 trillion cubic feet" (UPI, 2008). The recoverable portion of this reserve is estimated to be around 10 percent of this total. By the end of February 2008 more than 450 suspected Marcellus wells had been permitted in Pennsylvania (Harper, 2008). The stage has been set for an extensive Marcellus Shale gas play in Pennsylvania.

OIL AND GAS ACTIVITIES AFFECTING WATER QUALITY

The potential impacts of oil and gas development on water quality are a concern across the Commonwealth. Of particular concern are: water withdrawals, storm water runoff from construction activities, pollution from drilling processes, groundwater contamination from hydraulic fracturing, and disposal of waste fluids. Water quality concerns related to oil and gas operations are addressed by a variety of federal and state regulations. The 1972 Federal Water Pollution Control Act Amendments and the 1977 Clean Water Act were the first regulations to subject the oil and gas producing industry to direct dealings with a federal agency on environmental protection issues (DOE, 2009a). Other regulations such as the Safe Drinking Water Act (1974) and the Resource Conservation and Recovery Act in (1976) authorize further federal regulation of the oil and gas industry. However, regulation of petroleum activities remains primarily a state responsibility.

In Pennsylvania, oil and gas activities are regulated by several chapters of the Pennsylvania Code and various state acts. The state's oil and gas laws (Oil and Gas Act – Act 223, Coal and Gas Resource Coordination Act – Act 214, and Oil and Gas Conservation Law – Act 359), as well as environmental protection laws that include the Clean Streams Law, the Dam Safety and Encroachments Act, the Solid Waste Management Act, and the Water Resources Planning Act give DEP the authority to regulate these activities while limiting the regulatory control of municipalities.

PERMIT	SOURCE/NOTES
Well Drilling Permit and Addendum	Pursuant to the Oil and Gas Act; an application addendum outlining a water management plan for that operation, pursuant to PA Code, Title 25, Chapter 78.11-33.
Earth Disturbance Permit (ESCGP-1)	Required from PA DEP regulating implementation of E&S controls, including SWM, if disturbance >5 acres. E&S plan is required if under 5 acres. PA Code, Title 25, Chapter 102.
Preparedness, Prevention and Contingency (PPC) Plan	The PPC Plan must address the types of wastes generated, disposal methods and a spill prevention plan. Construction and operation of on-site storage impoundments must also be described.
Water Withdrawal Permits	A permit is required from DEP for all withdrawals of surface or ground water. Separate withdrawal permits for projects in the Delaware or Susquehanna Basin or Susquehanna River Basin Commission.
Chapter 105 Obstruction and Encroachment Permit	Permit from DEP for work in a wetland, stream, or body of water. PA Code, Title 25, Chapter 105 (also required under the Oil and Gas Act).
Water Quality Management Permit	Permit if a centralized impoundment will hold fluids other than fresh water (such as drilling or fracing fluids). The siting, construction, use and closure of temporary pits are regulated under PA Code, Title 25, Chapter 78. Permits are only required if the pit is part of a treatment facility.

Development assciated with the Marcellus shale gas play includes construction of new roads, pipelines, compressors, water impoundments, well sites and other facilities. The development of this resource requires the use of large amounts of water and may expand to cover extensive areas. Marcellus shale gas development in Pennsylvania is a matter of local, regional, and national interest. Petroleum activities are listed as the primary cause for impairment in 0.2% of all non-attaining stream miles in Pennsylvania. Recent interest in the Marcellus shale play has the potential to greatly increase this number.

The large volumes of water required to complete a Marcellus Shale natural gas well, and the resulting large. Directional drilling and hydraulic facturing techniques used to extract gas from the Marcellus shale formation require large volumes of water to complete development of a natural gas well. These approaches require as much as 20 times the water volume as that used in conventional well completions (Harper, 2008). The hydraulic fracturing process for a typical Marcellus shale well uses approximately 3.5 million gallons of water (Harper and Kostelnik, 2010). The resulting large volume of waste water increases the environmental risk of this type of well development.

There are 1.66 miles of stream in McKean County listed on the *2009 Integrated List of All Waters* as non-attaining, with petroleum activities as the primary source of impairment. This is just over one percent of all impaired streams in the county. However, this does not indicate that water quality impacts from petroleum activities are neglibible. Local impacts to surface water and groundwater resulting from petroleum activities can be severe. Oil and gas development activities with the potential to affect water quality include construction activies, well development, and gas production.

CONSTRUCTION ACTIVITIES

Construction activities related to well development are the primary concern for impacts to surface water. Gas well construction can involve extensive earth disturbance for access roads, pad sites, and pipelines. For deeper wells the drilling pads alone can create a four to six acre disturbed area (Swistock, 2010). Earth disturbances related to well development present the potential for increased erosion and sedimentation in a manner similar to other construction activities. Well sites in remote locations can present increased risk due to the length of roads and pipelines necessary to support the facility. Other site factors such as slope, proximity to surface water, and soil type can increase the potential for impacts to surface water.

WELL DEVELOPMENT

Once the pad site and supporting facilities have been constructed well drilling begins. This is done with a drilling rig through a multi-stage process in which the wellbore is drilled, cased, and encased with concrete. A typical well can be drilled in 15-30 days if the rig is operating 24-hours a day. Well drilling requires a significant amount of water to lubricate and cool the drill bit and remove the cuttings from the borehole. Large quantities of wastewater are generated during this process. Along with the cuttings, present as suspended solids, the wastewater can contain pollutants such as sodium, chloride, iron, manganese, barium, arsenic, and organics used during the drilling process (e.g. surfactants, detergents, oil, grease, benzene, toluene) (Swistock, 2010).

Once a well has been drilled, a process called hydraulic fracturing, or fracing, is used to create additional permeability in the shale to improve the flow of gas toward the wellbore. Fracing involves pumping a fracturing fluid (typically water-based with other additives to improve performance) into a formation to generate fractures in the target formation to improve release of the natural gas trapped in the rock (DOE, 2010b). Additives used for hydraulic fracturing include sand, oils, gels, acids, alcohols, and various other chemicals. Some portion of the frac water (estimated at 10 to 70 percent) returns to the surface as "flow back" wastewater, with the rest remaining underground.

Various stages throughout well development have the potential to negatively impact water resources. Improperly sealed wells can contaminate drinking water sources; storage, transportation, and disposal of wastewater present opportunities for leaks or spills; additives injected with hydrofracing fluid may contaminate groundwater sources; or methane gas can migrate from gas wells into nearby water supply wells.

GAS PRODUCTION

The production phase of well development generally presents the lowest level of risk to water quality. Once well development is complete water continues to be pumped into the well to improve the flow of natural gas. The return fluids, called production fluids, generally contain high concentrations of salts from ancient underground saltwater deposits. Production fluids also contain some of the pollutants noted in drilling and hyrdofracturing fluids.

OIL AND GAS WATER RESOURCE CONCERNS

As previously noted, considerable quantities of water are necessary for the development of a Marcellus Shale gas well. The substantial amount of water utilized presents several challenges in protecting the Commonwealth's water resources. In a report issued by USGS (Soeder and Kappel, 2009), three principal water-resource concerns are noted in regards to Marcellus Shale gas production:

WATER SUPPLY MANAGEMENT

Water for drilling and hydraulic fracturing of wells typically comes from surface water bodies such as lakes. Groundwater sources, municipal water sources, and re-used process water are also sometimes used for these processes. Some concern exists about where the immense volumes of water necessary to sustain large scale well development will be obtained. Other concerns include what the potential consequences might be for local water supplies and the effects of withdrawing this amount of water when it is needed for drilling activities.

The water volumes necessary to sustain petroleum activities are large; however they generally represent a small percentage of the total water used when considered from a basin-wide surface water budget (DOE, 2010b). To put shale gas water use in perspective, the consumptive use of fresh water for electrical generation in the Susquehanna River Basin is nearly 150 million gallons per day, while the projected total demand for peak Marcellus Shale activity in the same basin is 8.4 million gallons per day (Gaudlip et al., 2008). When these withdrawals are examined at a local level, they represent a much larger percentage of the available resource. Rapid withdrawal of large quantities can have short and long-term effects on a water supply. Surface water withdrawal during dry periods could affect aquatic life, recreational activities, potable water supplies, and other industries.

WATER RESOURCE CONTAMINATION

As discussed in the previous section, petroleum activities have the potential to negatively impact water quality at several stages throughout the drilling and production process. Construction activities necessary to construct access roads, pipelines, and prepare well sites have the potential to cause increased erosion and sedimentation. Access roads and well pad sites are rarely, if ever, fully stabilized which increases the duration of potential erosion problems. Similarly, transporting large amounts of equipment, vehicles, and supplies to remote well sites can damage low capacity rural roads (often constructed of dirt and gravel) and cause accelerated erosion. These effects of these activities can be mitigated through use of common construction BMPs.

Other activities such as well drilling, hydraulic fracturing a well, and gas production all present unique challenges to protecting water quality. The various pollutants found in the process water and flowback fluids used during these activities have the potential to contaminate groundwater supplies or impair surface waters if not handled and disposed of properly. These activities require specialized practices to reduce the risk of contaminating water resources.

WASTEWATER DISPOSAL

The wastewater produced during well development and production is one of the main threats to water quality. The large volumes of liquid produced present logistical and economic challenges for recovery and disposal of the wastewater in a manner that minimizes impacts to water resources. In addition, the pollutants often present in the liquid can require wastewater treatment prior to disposal. Although the percentage of chemical additives in a typical hydrofrac fluid is typically less than 0.5 percent by volume, the quantity of fluid used is so large that the additives in an average three million gallon well development would result in about 15,000 gallons of chemicals in the wastewater (Soeder and Kappel, 2009). In addition to the chemical additives found in hydrofrac fluid, the wastewater may contain a variety of naturally occurring pollutants such as brines, organics, heavy metals, and radionuclides removed from subsurface formations. High concentrations of sodium, chloride, and bromide are often found in brine from well drilling.

Common disposal methods include processing them through wastewater treatment plants (the most common method in Pennsylvania), re-injecting the fluids into the ground, and evaporating the liquid and disposing the remaining solids as dry waste. The effectiveness of standard wastewater treatment for processing wastewater is not well understood. In particular, salts and other dissolved solids are not usually removed by standard treatment processes. Re-injecting the wastewater into the ground (shallow re-injection and deep re-injection) may result in groundwater contamination or other unknown problems. The evaporation method is not a very practical technique in the humid climate of Pennsylvania. Further study of these disposal methods and a better understanding of their effects are necessary to effectively protect the water resources of the Commonwealth.

OIL AND GAS MANAGEMENT PRACTICES FOR WATER QUALITY

Many standard practices in the oil and gas industry are currently being implemented in recognition of the need to protect other natural resources while extracting petroleum resources. The water quality impacts of oil and gas activities can be futher minimized by implementing appropriate management measures and by utilizing suitable Best Management Practices (BMPs). As presented here, management measures are guidance for operations and steps to be taken that will promote the sound, efficient, and environmentally appropriate development of all oil and gas activities, with a particular focus on Marcellus Shale natural gas developments. BMPs are specific activities, processes, or technologies designed to serve specific functions, which are used to attain a management measure.

Management measures and BMPs for activities associated with oil and gas development can determine what resources may be impacted, the extent of the impacts, and mitigation strategies. Use of the following management measures and BMPs does not replace the need to meet Federal and State requirements, their use (when appropriate) will aid in compliance with the applicable regulations:

- Predevelopment Planning
- Wetland and Riparian Management Areas
- Access Road Construction
- Road Management
- Pipeline Construction
- Well Site Development
- Chemical Management

Predevelopment Planning

Purpose	Ensure that oil and gas activities are planned with water quality considerations in mind and conducted in a manner to minimize delivery of nonpoint source pollutants to surface waters and groundwater.
Description	A development plan established during the early stages of anticipated development provides the framework for avoiding or minimizing surface disturbance, protecting other resources, mitigating environmental impacts, and alleviating or addressing concerns of landowners and communities. It serves as a tool for comprehensive, coordinated planning to guide strategic development. It can also assist in meeting the requirements of the Clean Water Act, the Clean Air Act, the Endangered Species Act, and other applicable Federal, and State laws.

GUIDANCE: Develop plans to provide a comprehensive description of the characteristics of the area, along with the anticipated nature of the proposed development. Plans should address potential impacts to water quality, existing natural resources, and the potential for habitat fragmentation in sensitive areas where there are high levels of biodiversity, or sensitive and critical habitats.

Planning needs will differ by location and should be applied in different ways, depending on such things as subsurface geology, terrain, and existing and proposed land use. Plans may be simple or complex, depending upon the circumstances, and will need to be customized to fit the site specific conditions for a project. The following items should be included in the plan:

- Identification of land ownership
- Identification of existing and expected surface uses (including number and spacing of wells, roads, pipelines, water disposal and treatment facilities, compression facilities, gathering and transmission pipelines, etc.)
- Identification of existing and required infrastructure and utility corridors
- Map of the area with location of existing facilities (i.e., wells) and potential (optimal) locations for future facilities, including production facilities (well sites, processing units, etc.), roads, and utility corridors. The map should include geographic features such as streams and other water bodies, and special ecosystems, as well as topographic information.
- Identification of opportunities to avoid, reduce, and mitigate adverse impacts
- Identification of regulatory requirements
- Water management plan (strategy)
- Identification of strategies for reclamation of disturbed areas
- Consider a strategy for establishing a baseline and monitoring and steps to apply monitoring information to existing and future actions

Water Quality BMPs:

• Non-Structural (refer to PA Stormwater BMP Manual)
BMP 4.3.1. Background Site Factors
BMP 4.3.2. Site Factors Inventory
BMP 4.3.3. Site Factors Analysis

Wetland and Riparian Management Areas

Purpose	Protect the ecological function and hydrologic features of riparian areas, wetlands, and floodplains.
Description	Establish and maintain a buffer zone along surface waters and wetlands that is wide enough to filter runoff, provide bank stability, and shade the water. Limit oil and gas activities within the buffer.

GUIDANCE: Establish a buffer zone around riparian areas, wetlands, and floodplains. Locate all well pads and other nonlinear facilities outside of the buffer zones.

GUIDANCE: Avoid crossings of wetland and riparian areas by pipelines and roads to the maximum extent practicable. Where crossings cannot be avoided, impacts can be minimized through use of the following measures.

- Develop site-specific avoidance and mitigation plans prior to approval process for all proposed disturbance to wetland/riparian areas, including their buffer areas
- Construct any crossings perpendicular to wetland/riparian areas
- Schedule construction adjacent to wetland areas to minimize the duration of construction activity, and to concentrate such activity during dry conditions, or when the ground is frozen during the winter
- Locate stockpiles outside the buffer areas
- Locate drilling mud pits outside of buffer areas
- Begin reclamation of disturbed wetland/riparian areas as soon as possible after project activities are complete
- Monitor any stream channel for erosion, sedimentation, degradation, and riparian health

Water Quality BMPs:

• Non-Structural (refer to PA Stormwater BMP Manual)
BMP 5.4.1 Protect Sensitive and Special Value Features
BMP 5.4.2 Protect/Conserve/Enhance Riparian Areas
BMP 5.4.3 Protect/Utilize Natural Flow Pathways in Overall Stormwater Planning and Design

Access Road Construction

Purpose	Reduce erosion and sedimentation which is common during, and immediately after, construction of oil and gas access roads.
Description	Design and construction of roads that are planned for the topography, soils, and drainage patterns of a site. Appropriate construction methods and BMPs are used to minimize erosion from high risk areas such as the road surface, steep slopes, water crossings, and runoff conveyance structures (i.e. culverts, ditches, etc.).

The location and construction of access roads require careful planning. Special attention should be given to steep slopes, surface waters, soils, and other potential hazards. Access roads should be designed with grades between 2 and 10%, located outside buffers of water features, and should have cuts and fills minimized.

GUIDANCE: Utilize existing roads to the maximum extent possible. Locate new roads in areas that will optimize year-round, all-weather access, and minimize surface disturbance and environmental impacts.

GUIDANCE: Minimize construction of roads where it is operationally feasible and safe. Construct roads to the minimum standard necessary to achieve intended use (i.e. use two-track access roads where possible).

GUIDANCE: Road Construction and Reclamation. Plan, maintain and construct all roads in conformance with road standards. Major access roads to the general development area should be constructed to a higher road standard to avoid excess maintenance caused by poor planning and constructed. Practices that can enhance reclamation include:

- Reclaim and re-vegetate all disturbed surface that will not be used for gas operations in a manner that restores topsoil and minimizes erosion.

- Use re-forestation as a reclamation strategy where forest land was impacted during the development.
- Use only certified and inspected seed that is free of noxious weeds for reclamation/re-vegetation.

Water Quality BMPs:

• Non-Structural (refer to PA Stormwater BMP Manual)	
BMP 5.7.1 Reduce Street Imperviousness	
BMP 5.7.2 Reduce Parking Imperviousness	
• Structural (refer to PA Stormwater BMP Manual)	
BMP 6.4.1 Pervious Pavement with Infiltration Bed	
BMP 6.4.7 Constructed Filter	
BMP 6.4.8 Vegetated Swale	
BMP 6.4.9 Vegetated Filter Strip	
• E&S (refer to PA E&S Pollution Control Manual)	
Sediment Barriers and Filters	Compost Filter Sock, Rock Filter Outlet, Super Silt Fence, Sediment Filter Log, Straw Bale Barrier, Rock Filter, Vegetative Filter Strip
Runoff Conveyance BMPs	Broad-based Dip, Access Road Swale, Ditch Relief Culvert, Turnout
Sediment Capture & Treatment	Construction Entrances, Compost Sock Sediment Trap
Stabilization Methods and Standards	

Road Management

Purpose	To ensure that management of existing roads maintains their utility and minimizes polluted runoff from roads and road structures.
Description	Minimize use during wet weather and thaw conditions. Perform routine maintenance of road surface, stream crossings, and drainage structures. Immediately repair eroding areas and implement BMPs to address problem areas. Close and decommission roads that are no longer needed.

GUIDANCE: Plan access routes for heavy equipment and the high volume of trucks to the site with input from the local municipality and PennDOT.

GUIDANCE: Consider operational traffic and plan for the long-term operations of the facility considering maintenance as well as potential issues with dust, compaction, and debris, as well as safety.

Water Quality BMPs:

• E&S (refer to PA E&S Pollution Control Manual)
Sediment Barriers and Filters
Runoff Conveyance BMPs
Stabilization Methods and Standards

Pipeline Construction

Purpose	Reduce erosion and sedimentation during, and immediately after, construction of oil and gas pipelines.
Description	Appropriate design and construction methods are used to minimize erosion from areas disturbed by pipeline construction. BMPs are used in high risk areas such as steep slopes and water crossings.

GUIDANCE: Use existing disturbance corridors whenever possible (ideally following access routes or existing pipeline routes).

GUIDANCE: Locate pipelines in the same trenches, or immediately parallel to, each other. Install pipelines at the same time if possible.

Water Quality BMPs:

• Non-Structural (refer to PA Stormwater BMP Manual)	
BMP 5.4.1 Protect Sensitive and Special Value Features	
BMP 5.4.2 Protect/Conserve/Enhance Riparian Areas	
BMP 5.4.3 Protect/Utilize Natural Flow Pathways in Overall Stormwater Planning and Design	
BMP 5.6.3 Re-Vegetate and Re-Forest Disturbed Areas, Using Native Species	
• E&S (refer to PA E&S Pollution Control Manual)	
Crossings	Roadways, stream, wetlands
Outlet Protection	
Stabilization Methods and Standards	

Well Site Development

Purpose	Minimize the likelihood of water quality impacts resulting from development of oil and gas well sites.
Description	Follow the plan for oil and gas operations developed during predevelopment planning. Conduct operations to avoid sedimentation to the extent practicable. Use appropriate areas for high risk activities such as equipment maintenance, and petroleum and chemical storage and dispensing.

GUIDANCE: Minimize surface disturbance to the maximum extent practicable. Utilize techniques such as drilling multiple wells from the same pad when technically feasible.

GUIDANCE: Remove all equipment not necessary for well operations.

GUIDANCE: Locate well construction activities with the following considerations:

- Locate well sites in stable, non-erosive soil areas, with grass or brush cover and on relatively level areas that minimize pad construction. Choose sites that avoid steep slopes, unstable soils, and close proximity to streams, floodplains, springs, and wetlands.
- Divert surface runoff from entering the constructed pad site to avoid transporting of pollutants.
- Locate facilities and roads away from occupied dwellings.
- Locate in visually acceptable areas (avoid dwelling view sheds) and paint facilities colors that blend in with the natural environment.
- Locate where safe access can be maintained year round.

Water Quality BMP's:

• Non-Structural (refer to PA Stormwater BMP Manual)	
BMP 5.5.1 Cluster Uses at Each Site; Build on the Smallest Area Possible	
BMP 5.6.1 Minimize Total Disturbed Area – Grading	
BMP 5.6.2 Minimize Soil Compaction in Disturbed Areas	
BMP 5.6.3 Re-Vegetate and Re-Forest Disturbed Areas, Using Native Species	
BMP 5.7.2 Reduce Parking Imperviousness	
BMP 5.9 Source Control	
• E&S (*refer* to PA E&S Pollution Control Manual)	
Sediment Barriers and Filters	Compost Filter Sock, Rock Filter Outlet, Super Silt Fence, Sediment Filter Log, Straw Bale Barrier, Rock Filter, Vegetative Filter Strip
Runoff Conveyance BMPs	Channels, Top of Slope Berm, Temporary Slope Pipe
Sediment Capture & Treatment	
Outlet Protection	
Stabilization Methods and Standards	
• *Structural* (refer to PA Stormwater BMP Manual)	
BMP 6.4.1 Pervious Pavement with Infiltration Bed	
BMP 6.4.7 Constructed Filter	
BMP 6.4.8 Vegetated Swale	
BMP 6.4.9 Vegetated Filter Strip	
BMP 6.6.1 Constructed Wetland	
BMP 6.6.2 Wet Pond/Retention Basin	
BMP 6.6.3 Dry Extended Detention Basin	
BMP 6.6.4 Water Quality Filters & Hydrodynamic Devices	
BMP 6.7.1 Riparian Buffer Restoration	
BMP 6.7.2 Landscape Restoration	
BMP 6.7.3 Soil Amendment & Restoration	
BMP 6.7.4 Floodplain Restoration	
BMP 6.8.1 Level Spreader	

Pollution Prevention

Purpose	Minimize the potential of water pollution caused by potential pollutants used for, or generated by, oil and gas operations.
Description	Risks associated with chemicals and other potential pollutants used for, and generate by, oil and gas operations can be reduced through careful transport, storage and use the substances. Spill Preparedness, Prevention, and Contingency Plans can reduce the potential impact of accidental spills.

GUIDANCE: Prepare a site specific Preparedness, Prevention, and Contingency Plan that identifies potential pollutants used or stored on site, outlines operational procedures to reduce the likelihood of accidental spills, and details a pollution incident response plan to be employed in the event of a spill.

GUIDANCE: Conduct personnel training programs to educate all employees of safe handling and disposal methods of all potential pollutants stored or generated on site. Pollution incident response should also be included in the training.

GUIDANCE: Implement pollution prevention practices when feasible. Use pollution source reduction techniques (i.e. alternative chemicals and additives), reduce or eliminate waste generated through process changes, and use new technologies to remove pollutants from wastewater to reduce the pollution potential of oil and gas activities.

Facility Reclamation and Decommissioning

Purpose	Reduce erosion and sedimentation of areas disturbed by oil and gas activities and minimize long-term impacts of oil and gas activities.
Description	Reduce erosion and sedimentation by stabilizing the work area around active facilities and establishing permanent vegetation on the surrounding area immediately upon completion of earth-disturbing activities. Remove and decommission facilities upon completion of planned use. Restore facility sites to pre-disturbance condition, or better.

GUIDANCE: Reduce facility size to the minimum area required for oil and gas production operations by restoring all areas temporarily disturbed during construction activities. Restoration should include the following:

- Re-contour disturbed areas to be compatible with existing grades.
- Replace topsoil to at least the depth and quality that existed prior to disturbance for final reclamation of the site upon abandonment of the well.
- Re-vegetate disturbed areas using native vegetation and including re-forestation.
- Remove all chemicals, equipment, materials, and waste not necessary for sustaining production from the well pad.

GUIDANCE: Stabilize facilities during operations with crushed stone or other appropriate methods.

GUIDANCE: Remove and decommission facilities as soon as reasonably possible after oil and gas production is completed. Restore the disturbed areas to their pre-disturbance condition, or better, by reshaping the site to the original contour, replacing topsoil, and re-establishing native vegetation.