Monongahela River Watershed
Act 167
Stormwater Management Plan

Volume 1
Main Plan Document

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CHESTER
ENVIRONMENTAL

Monongahela River Watershed
Act 167
Stormwater Management Plan

VOLUME 1
MAIN PLAN DOCUMENT

February 1993

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MONONGAHELA RIVER WATERSHED
STORMWATER MANAGEMENT PLAN

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MONONGAHELA RIVER WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION I
INTRODUCTION

BACKGROUND

GENERAL

Traditionally, curbs, gutters, underground and other drainage techniques have been designed to remove stormwater from developed properties as quickly as possible so as to minimize the possibility of flooding the properties served by the drainage systems. Little or no efforts were made to minimize increases in the volumes and rates of runoff which occurred as land was converted from a permeable, vegetated condition to an impervious, paved condition. Similarly, little consideration was given to the potential effects of accelerated runoff on downstream properties. Under this approach, progressive development in a watershed results in ever increasing stormwater runoff until damaging downstream problems develop. Problems attributable to inadequate control of stormwater runoff include flooding and accelerated erosion.

A significant change in the approach to stormwater management in Pennsylvania occurred with the passage of the Storm Water Management Act (Act 167) and its companion bill, the Flood Plain Management Act (Act 166). This legislation, passed by the Pennsylvania General Assembly on October 4, 1978, requires a comprehensive approach to planning and managing excess stormwater runoff. Acts 166 and 167 represent a recognition of the increasing problems caused by inadequately controlled stormwater runoff and the associated threats to public health and safety. The Storm Water Act sets up a program for managing accelerated runoff so that it does not lead to increased flooding, while the Flood Plain Act provides for the preservation and restoration of flood plains which are natural stormwater storage areas.

PENNSYLVANIA STORM WATER MANAGEMENT ACT

The statement of legislative findings at the beginning of the Storm Water Management Act sums up the critical interrelationship between development, accelerated runoff, and floodplain management:

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

A comprehensive program of storm water management, including reasonable regulation of development and activities causing accelerated runoff, is fundamental to the public health, safety and welfare and the environment.

The policy and purpose of the Storm Water Management Act as articulated in the legislation is to:

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

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

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

The general procedure established by the Act for achieving these goals consists of: 1) development of guidelines and regulations to be applied state wide; 2) the preparation of stormwater management plans for designated watersheds throughout the Commonwealth; 3) implementation of the stormwater management plans; and 4) adherence to the plan requirements by individuals involved in land development activities.

Act 167 establishes certain duties and responsibilities for individuals and various governmental agencies as follows:

PERSONS ENGAGED IN LAND DEVELOPMENT: Act 167 states that any landowner and any person engaged in the alteration or development of land which may affect stormwater runoff characteristics must implement such measures consistent with the provisions of the applicable stormwater management plan as are reasonably necessary to prevent injury of health, safety or other property. Such measures must include such actions as are required:

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

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

DEPARTMENT OF ENVIRONMENTAL RESOURCES (DER): Act 167 assigns the Department of Environmental Resources the primary

responsibility to carry out the policies and purposes of the Act. These responsibilities include providing guidelines for county stormwater management plans; designating watersheds for which stormwater management should be prepared; review and approval of the plans; providing technical assistance and model local ordinances; developing grants and reimbursement regulations governing the disbursement of grant monies; and generally coordinating stormwater management activities state wide.

COUNTIES: Counties are required to prepare and adopt a watershed stormwater management plan for each designated watershed in their jurisdiction.

MUNICIPALITIES: Municipalities are required to adopt new or to amend existing regulations as necessary to comply with and implement the stormwater management plans.

In 1980, the Department of Environmental Resources (DER) designated 353 watersheds for which plans are to be prepared. Model ordinances were made available to localities in September 1981, followed by detailed stormwater management guidelines in June 1983. These guidelines and model ordinances were approved by the Pennsylvania General Assembly in June 1985 and now have the force of law. In May 1984, Act 167 was amended to authorize DER to administer grants to municipalities and counties to pay 75% of the costs of preparing and administering stormwater management plans and regulations.

MONONGAHELA RIVER WATERSHED PLAN DEVELOPMENT APPROACH

GENERAL PLANNING REQUIREMENTS AND APPROACH

The general or overall scope of work and planning approach employed in the preparation of the Monongahela River Stormwater Management Plan were defined to a large extent by specific planning requirements contained in Act 167 and Storm Water Management Guidelines and Model Ordinances promulgated by the Department of Environmental Resources. The basic requirements of the plan as articulated in these documents are that the plan shall:

1. contain such provisions as are reasonably necessary to manage storm water 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

2. consider and be consistent with other existing municipal, county, regional and state environmental and land use plans.

Specific and more detailed plan requirements were also defined in the Act.

Beyond the general and specific plan requirements established by law and regulations, several additional considerations served as a guide to the development of the planning approach and scope employed during the preparation of this

Monongahela River Stormwater Management Plan. These additional planning goals are as follows:

1. The development of the technical standards contained in the plan should accurately reflect local conditions.

2. The development of the technical standards should employ accepted computational techniques familiar to the local planning agencies.

3. The computational procedures employed should be reproducible and amenable to direct application when the plan is updated.

4. The recommended stormwater management control standards and criteria should be attainable, clear, concise, broadly applicable and enforceable. The standards should clearly define performance requirements but allow sufficient latitude to permit creative stormwater control approaches.

5. The recommended stormwater management controls and associated institutional framework should represent a reasonable and measured approach to effectively managing stormwater runoff. The plan should not produce unnecessary impediments to development nor excessive local government responsibilities.

6. The recommended stormwater legal/institutional framework should be compatible with existing municipal and county financial, legal, technical and administrative capabilities.

TECHNICAL APPROACH

The technical approach was designed to satisfy the planning goals by employing accepted hydrologic modeling techniques to define existing conditions and quantify stormwater control criteria necessary to comply with the intent of Act 167. The technical analysis utilized the Penn State Runoff Model (PSRM) to estimate existing and future runoff characteristics. The model was also employed to define the hydrologic interactions throughout the watershed to provide a basis for establishing stormwater runoff control criteria on a watershed wide basis. The PSRM was selected for use because it is recognized by DER as an appropriate tool for watershed stormwater planning and it possesses several attributes of particular value in the development of specific stormwater control performance criteria.

The data collection effort was designed to take fullest advantage of available data sources and current data analysis and management techniques to maximize the accuracy of the physical features data base necessary to model the watershed. Land cover information was obtained from a number of sources, principally digital SPOT and Landsat Thematic Mapper images and National High Altitude Program (NHAP) color infrared photographs of the basin. Land cover was classified to a 30 meter resolution. Terrain characteristics, expressed in terms of slope and aspect, were derived from the United States Geological Service (USGS) Digital Elevation Model (DEM) and digital terrain models data bases and scan digitized contours from USGS 7.5 minute quadrangle maps.

Soil characteristics as reflected by hydrologic soil group classes were obtained through digitization of United States Soil Conservation Service (SCS) soils maps. These data were digitally overlaid and processed using geographic information system software to define the hydrologic characteristics of the watershed to a resolution approximating 30 meters. These data, in turn, were aggregated into approximately 386 subbasins comprising the Monongahela River watershed.

Additional information, including obstruction sizes and capacities, stream characteristics, stormwater collection system locations, and descriptions of stormwater and flood control and flood protection facilities were obtained by conducting field and mail surveys and a review of available data sources.

LEGAL/INSTITUTIONAL APPROACH

This portion of the study deals with four interrelated issues:

1. The primary laws governing stormwater management in Pennsylvania.

2. The institutional options for organizing an effective stormwater management effort in the watershed.

3. Institutional system initiatives and precedents established by previous watershed stormwater management planning efforts completed in the region.

4. Guidelines for incorporating stormwater provisions into municipal zoning, subdivision and land development ordinance, and building codes to implement the plan's technical recommendations.

5. Methods of fine-tuning stormwater control provisions to address issues encountered during the implementation of pilot stormwater management plans completed in the region.

As part of the analysis, various laws were reviewed to determine specific areas of concern, requirements, duties, penalties and remedies, along with interrelationships with the other statutes. In addition to the laws related directly to stormwater management, common law relative to private and public nuisances and state and local municipal immunity statues were reviewed, with attention to the remedies that provided for stormwater related problems.

The plan document includes proposals for ordinance provisions designed to implement the recommended technical measures. These ordinance standards are intended to provide a guide to the municipalities in enacting or amending their existing ordinances. These standards may not be appropriate for direct incorporation into an existing municipal ordinance. They do, however, indicate the types of provisions that are required and in which ordinances they properly belong.

Finally, the institutional section outlines alternative organizational arrangements for developing and managing stormwater control facilities and for administering the

local ordinances. Since the stormwater management plans cannot be implemented effectively on a piecemeal basis, a watershed-wide management approach and inter-governmental cooperation is required. Therefore, this study identifies several approaches that the municipalities, county, and state can take to implement a workable stormwater management system.

The nature of the optimal institutional system will be determined to a large extent by the roles and duties the system will be expected to fulfill. The system may be expected to perform a variety of duties, ranging from planning and regulation to construction, operation and maintenance, and financing. Consequently, this plan outlines the range of responsibilities associated with stormwater management, describes the capabilities, resources and legal authorities necessary to discharge those responsibilities, and discusses alternative institutional arrangements.

The selection of the recommended institutional framework will also depend upon the nature of existing institutional system and the current and anticipated future roles and capabilities of each level of government. This plan, therefore, presents an overview of the existing system and a discussion of expectations relative to the future role of each level of government in stormwater management issues.

CONTENTS OF THE PLAN

This Monongahela River Watershed Stormwater Management Plan report is presented in two volumes. Volume 1, the Plan Study Report, contains the plan text and describes the background and general characteristics of the study area, the method used for data collection, the analytical tools used, results of the analyses, and stormwater runoff control alternatives. Specific control requirements and management and regulatory responsibilities are identified as they relate to developers and local, county, and state agencies. Volume 2, the Executive Summary, contains a condensed overview of the plan development process and summarizes the findings and recommendations of the plan.

Copies of the materials and data developed during plan preparation and a working version of the Monongahela River PSRM hydrologic model are on file at the Allegheny County offices.

MONONGAHELA RIVER WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION II
LEGAL FRAMEWORK FOR STORMWATER MANAGEMENT

GENERAL

An analysis of stormwater management would not be complete without some discussion of the law that created the stormwater management program, along with the other laws that relate to its implementation. This is particularly true in the case of the Storm Water Management Act (Act 167), where there are relatively few administrative regulations or case law with which to interpret its meaning and provisions.

This is an area of law that is not widely understood by local officials, developers and property owners. Pennsylvania's common law relating to drainage rights has developed over decades into a vary complex system, and it is not always easy to determine who has what rights and when. Many persons are still not aware of the extent to which Act 167 redefines prior common law. Further, many municipal officials, engineers, and developers are not well informed on other laws which relate to stormwater, development regulation, and governmental liabilities.

In addition to the Storm Water Management Act, other laws that collectively provide the legal posers and mandates to implement a comprehensive stormwater management plan are:

- Dams Safety and Encroachments Act (Act 325-1978).
- Clean Streams Law (specifically, the erosion and sedimentation regulations adopted pursuant to the Law).
- Flood Plain Management Act (Act 166--1978).
- Municipalities Planning Code (Act 247, as amended).

As part of the analysis, each law was reviewed to determine its scope, standards, duties, penalties and remedies, and enforcement responsibilities. The interrelationships between the five statutes and regulations were also examined. Additionally, the common law relative to private and public nuisances, municipal codes, and state and municipal immunity statutes were researched, relative to the powers, duties, and remedies that they provide for stormwater related issues. A general overview is of the general background in the law is offered as a back drop to the discussion of the five statutes specifically impacting stormwater management.

Key provisions of each of the five primary statutes are presented here. Highlighted are the elements that are most pertinent to the watershed stormwater plans and management programs. A brief overview on governmental immunities is included because it is helpful for the municipalities to understand their potential liabilities.

It should be noted that the comments on these acts are not intended to be official legal opinions or to constitute advice on any specific issue or case. This is especially true for Act 167 where presently there are no administrative regulations or case law to interpret the Act. This section is provided to assist in a general understanding of the legal framework for stormwater management.

COMMON LAW BACKGROUND

Stormwater law developed in the courts of the Commonwealth of Pennsylvania and across the United States in cases between private landowners. Common law rights, duties and responsibilities in regard to drainage and flooding evolved as a result of the resultant court decisions. In the common law, a basic distinction is drawn between waters in a watercourse and surface waters. A watercourse was defined as a channel with defined bed and banks. Watercourse law also included lakes, ponds, marshes and swamps. Surface water, on the other hand, was defined as diffused water running overland, to a defined channel or watercourse. Flood water which overflowed the banks of a watercourse and followed the course of the stream, was also held to be governed by the laws of watercourses. However, flood waters which entirely lost their connection with a watercourse, spread out over the adjoining countryside and settled in low places, were governed by the law of surface waters.

WATERCOURSE LAW

Watercourse law is based on the rights and duties established between riparian property owners (owners of land along the banks of a river or lake). The fundamental principle of the riparian system is that each riparian owner has an equal right to make a reasonable use of the water of a stream subject to the equal rights for the other riparians to do likewise. A riparian right is reciprocal in character as to other riparian rights. Therefore, a riparian owner must exercise his rights in a reasonable manner and extent so as not to interfere unnecessarily with the corresponding rights of others.

As a general rule in most jurisidictions, a riparian owner does not have the right to construct an embankment or dike to protect his land from ordinary floods, if, in so doing, he causes damage to the lands of others. Expressed in slightly different terms: a riparian has the right to protect his land, but only if in exercising this right, he causes no damage to other riparian lands.

SURFACE WATER LAW

There are three basic doctrines which the courts have adopeted regarding surface waters. These are the 1) "common enemy rule", 2) "civil law rule" and 3) "reasonable use rule".

As originally conceived, under the civil law rule a landowner may do anything he pleases with surface waters regardless of the harm it might do to others. The upper land owner can divert or drain surface waters onto the lower land, and the lower landowner may put up a barrier even if it floods the upper property. Since the water must go somewhere, this would appear to inevitably result in contests in engineering where "might makes right". Therefore, some courts have modifications to the strict rule, resulting in a "modern common enemy rule" which can be stated as giving the

landowners the right to obstruct or divert surface waters, but only when such obstruction or diversion is incidental to the ordinary use, improvement or protection of their land, and is done without malice or negligence.

The civil law rule granted the owner of upland property the right to drain surface waters onto lower property; imposed a duty upon the lower property owner to receive surface water from upland property; granted the owner of upland property an easement of natural flow over the lower property; and prohibited the owner of lower property from obstructing the natural flow of diffused surface water from upland properties. The key word is natural, meaning those waters which flowed from the land before alteration or development. A legal cause of action on the part of the lower property owner was deemed to have arisen when the upland property owner or another party interferred with natural conditions or caused water to be discharged in a greater quantity or in a different manner than would naturally occur.

The reasonable use rule is based on tort rather than on property law. In tort law liability is based on negligence. A person can be held negligent if he has not acted like the "reasonably prudent man" in a given situation. This rule recognizes the common law rule that the use of one's property may occur in any reasonable manner which does not injure that of another. This test is basically a balancing test, and the common law considered the reasonable necessity to alter drainage to make use of one's property, their reasonable manner of accomplishing alterations so as to avoid injury, the utility of the conduct and the gravity of the injury to the other.

Pennsylvania jurisprudence has, at one time or another, applied all three of the doctrines in various cases.

The Pennyslvania Storm Water Management Act of 1978 more specifically and directly assigns responsibilities for stormwater control. The Act imposes an affirmative duty on any landowner and person (including municipalities) engaged in the alteration or development of land which may affect stormwater runoff to implement measures to prevent injury to health, safety or property.

STORM WATER MANAGEMENT ACT (ACT 167-1978)

There are two key sections of this Act: Section 5, which sets up the watershed stormwater planning programs, and Section 13, which establishes the basic standard to manage stormwater runoff to prevent harm to persons and property. A primary goal of the Act is to prevent future problems resulting from uncontrolled runoff, including flooding, erosion and sedimentation, land-slides, and pollution and debris often carried by storm runoff. A secondary intent is the elimination or correction of existing stormwater and flooding problems.

WATERSHED STORMWATER PLANS

As discussed in the preceding chapter, one of the Act's innovative features is the creation of a public stormwater planning, and management and control system at the watershed level. The plans are to be prepared for each watershed delineated by DER.

The counties must organize a watershed advisory committee composed of representatives from the municipalities in the watershed. The committee is to advise the county during the planning process, and the plans are to be adopted by the county commissioners and approved by DER, after public review and comment. The completed plans must be consistent with local land use plans and state plans, such as regional water quality management plans, the state water plan and floodplain programs.

After the adoption and approval of a watershed stormwater management plan, the location, design and construction of stormwater management systems, obstructions, flood control projects, subdivisions and major land developments, highways and transportation facilities, facilities for the provision of public utilities and facilities owned and financed in whole or in part by the Commonwealth (including PennDOT) shall be conducted in a manner consistent with the plan (Section 11). This provision gives the stormwater plan a definite legal status. Unlike municipal comprehensive plans, which are only advisory documents, watershed stormwater plans will be legally binding.

Also, within six months of the approval of the watershed stormwater management plan, each municipality in the watershed must adopt the land use and development ordinances to implement the plan (Section 11). These regulations must be consistent with the plan, as well as standards of the Storm Water Management Act. Failure to adopt and implement the necessary ordinances could result in the state withholding funds from the General Fund for which the municipality might be eligible.

BASIC STANDARD FOR STORMWATER MANAGEMENT

The basic premise of the Act is that those whose activities will generate additional runoff, or increase its velocity, or change the direction of its flow, should be responsible for controlling and managing it so that these changes will not cause harm to other persons or property either now or in the future. The policy is that Pennsylvania's legal system will no longer condone those who negligently disregard the impact of runoff from their activities. It will not allow them to shift the burden of runoff management to the public and downstream property owners.

Section 13 of Act 167 defines the legal duties owed by developers and others engaged in the alteration of land by setting performance standards for runoff management. This section of the Act became effective immediately upon the signing of the Act (October 4, 1978). These new standards essentially replace prior common law rules. Common law rules, however, will still apply to all developments and land alterations occurring prior to October 4, 1978.

Section 13 provides that:

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

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

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

Act 167 defines persons as individuals, private corporations, municipalities, counties, school districts, public utilities, sewer and water authorities, and state agencies. When, for example, public agencies build storm sewers, roads, buildings, or utility lines, they must implement runoff control measures that comply with Section 13 standards. With this coverage, Section 13 is a comprehensive standard for stormwater control.

Section 13's primary measure of sound stormwater management is the taking of reasonable steps to prevent harm or injury to health and property. This general duty is contained in the language which precedes Sections 13(1) and 13(2). Thus, the proverbial "bottom line" for stormwater management is: do not cause harm. The section then prescribes two alternatives [Section 13(1) and 13(2)] for meeting this basic objective.

Further, when Section 13 is read in conjunction with other portions of the Act, it becomes apparent that the intent of the Act is to apply the standard to protect persons and property downstream of the site being altered and not only immediately adjacent to the site. In other words, Section 13 is not spatially limited; it applies not only as the runoff leaves the site, but as far as its impact can be reasonably determined.

Section 2 of the Act states that the Legislature found that inadequate management of runoff has adverse impacts on downstream communities and that reasonable regulation of activities causing runoff is fundamental to the public welfare. Section 3 indicates that the Act was intended to manage runoff at the watershed level.

Further, Section 5(c)(1) requires that the watershed plans contain provisions to manage stormwater so that an activity in one municipality does not have adverse effects on persons or property in another municipality in the watershed to which the watershed is tributary. Therefore, it is clear that the stormwater plans and management activities must consider the watershed impact of land alteration activities, and runoff controls must be designed to prevent reasonably foreseeable harm, from the boundary of the site and downstream to the base of the watershed.

The Section 13(1) standard does not contain any limiting language from which it could be implied that no increase in maximum rate means only at a development's property line. Likewise, Section 13(2) contains no language to suggest that its "do not cause harm" standard applies only to neighboring or nearby property. Indeed, if this were the case, where would the line be drawn?

The language "runoff characteristics" is not a spatially limited term. Section 13(2) indicates that runoff characteristics include at least direction, volume, and velocity. Changes in any of these characteristics will affect a stream all the way to its mouth.

Downstream from the generator, these runoff changes may result in either an increase in peak rate or harm, or both.

SECTION 13(1)

Section 13(1) requires that any land alteration does not cause an increase in the "maximum rate" of stormwater runoff; that is, the maximum (peak) rate of runoff after development, for any level storm, may not be higher than the peak rate which would have been generated from the site before development. By using the terminology of rate rather than volume, Section 13(1) implies that total volume of runoff generated may increase; but any increased volume must be retained and discharged over time, so that the predevelopment maximum rate of flow will not be exceeded. This is an important point because a standard that did not permit any increase in volume could only be met at sites where additional runoff could be permanently stored or recharged on-site. Obviously, this would limit the use of many sites.

It is not clear whether no increase in "maximum rate" means only for the site as a whole or for any point where runoff was discharged from the site before development. However, since the purpose of Section 13 is to prevent harm from changes in runoff characteristics, and runoff characteristics include direction, it would seem that the no-increase in peak rate standard should apply to each predevelopment discharge point. This interpretation seems necessary to control runoff from large developments in a manner which can achieve the purpose of the Act. Peak rate of discharge from the site as a whole could be used where runoff is discharged to a storm sewer or public retention system.

Summary

Section 13(1) means that development cannot increase the maximum rate of runoff, at any point, from the boundary of the site to the bottom of the watershed. Also, development may not cause an increase in maximum rate of flow in any other watershed to which its watershed is a tributary. The cutoff point for purposes of Section 13(1) seems to turn on the foreseeability of harm. Where it is reasonably possible for the developer to foresee that a higher peak rate will result because of the activities, then the duty imposed by Section 13(1) applies.

SECTION 13(2)

One of the purposes of Section 13(2) is to make the statutory drainage standard more flexible. Section 13(2) permits changes in runoff characteristics provided they do not cause harm. For example, Section 13(2) permits increased rates of runoff to be discharged into storm sewer systems, when the storm sewers can handle increased volumes and velocities without, in turn, causing harm. The Act, however, does not define harm, thresholds (in any) of acceptable levels of potential harm, or speak to issues relating to how the potential for harm is to be assessed. It would appear that the burden of establishing no harm is assumed by the developer. Practical problems associated with proving such a negative hypothesis (i.e. establishing that an action will not produce harm or increase the potential for harm throughout a watershed) is a major concern in developing means of generally incorporating Section 13(2) into watershed plans.

VIOLATIONS, PENALTIES, REMEDIES

Section 15 of the Storm Water Management Act makes any violation of the provision of the Act or of the watershed stormwater plan a public nuisance. A public nuisance is a nuisance per se. This means it is a nuisance by its very existence and therefore, it is not necessary to wait and see if damage results. Any aggrieved person, affected municipality, or DER can institute suits at equity to restrain or abate a violation or a law for damages caused by a violation of this Act.

The state is not subject to penalty provisions and the municipalities, county and state agencies are protected to a large extent from private damage suits by governmental immunity statures (see later discussion). The rights and remedies created by the Act are in addition to rights and remedies which existed prior to the Act's passage. For example, private persons can still sue for private nuisances.

DAMS SAFETY AND ENCROACHMENTS ACT (ACT 325-1978)

Act 325 replaces several older state statutes dealing with dams safety, water obstructions and encroachments. This Act is the primary source of regulation for dams, existing and new obstructions, encroachments, fill in floodplains, culverts, bridges, retaining walls, and outfalls (e.g., of storm sewers) in a stream or a (100-year) floodplain. In some cases, retention / detention facilities may qualify as dams under the definition of the Act requiring a permit from the Department of Environmental Resources. The Act requires permits for the construction, or alteration or abandonment of dams, obstructions and encroachments. The owners of existing obstructions or encroachments are also required to obtain permits. Permits are issued by DER pursuant to the Act and regulations (25 Pa. Code Chapter 105).

By covering both new and existing structures, the Dams Safety and Encroachments Act is quite broad in its coverage.
It also requires permittee's and owners of obstructions to inspect, maintain, and repair the structures. For example, owners of culverts must inspect them annually and remove silt and debris if the carrying capacity is reduced by 10 percent or more (Regulations, Section 105.171). If conditions change such that the design of an obstruction or encroachment no longer conforms to the performance standards in the Act or regulations, the permittee or owner has a duty to make such alterations as are necessary to achieve compliance.

DER is the prime agency responsible for administering the Act. It must adopt regulations to implement the Act and is the permit issuing agency. The regulation [Section 105.14(b)(9)] requires DER to consider the project's consistency with state and local floodplain and stormwater management programs, when approving permits. Thus, the standards and provisions of the Storm Water Management Act and stormwater plans appear to be applicable to obstructions and encroachments. It is important to note that once the watershed stormwater plan is approved, then DER should review obstruction permits in consideration of local comments relative to the projects consistency with the standards and criteria presented in completed watershed stormwater management plans. Also, municipalities should not issue local building permits until any necessary obstruction permits are obtained.

Violations of the Act are treated as a public nuisance. Therefore, municipalities can sue to enjoin or abate the nuisance, or can make necessary repairs and assess costs against the property. A private person also can sue on a private nuisance.

As the prime enforcement agent, DER can issue orders to permittees and landowners to correct a violation of the Act or permit. Failure to comply can expose the violator to civil and criminal penalties. This provision includes municipalities and counties when they are the permittee for a structure.

If DER does not sue to correct the violation of the Act, any "affected municipality" may sue in the name of the Commonwealth. An affected municipality includes one where the violation occurs or where damage or harm results. The only limitation on these suits is that the municipality must give the State Attorney General 30 days notice of the municipality's intention to act.

CLEAN STREAMS LAW (EROSION/SEDIMENTATION REGULATIONS)

Pennsylvania's Clean Streams Law was enacted in 1937, and its original scope was limited to regulating discharges of sewage and industrial wastes. Since its original enactment, its scope and duties have expanded substantially. In 1972, DER determined that sediment constitutes a water pollutant under the provisions of the law and promulgated regulations for the control of erosion and sedimentation caused by earth moving activities (25 Pa. Code, Chapter 102).

The general requirement of the erosion/sedimentation regulations is that earth-moving activities (including excavations, land development, mineral extraction or any other activity that disturbs the surface of the land) be conducted in a manner to prevent accelerated erosion and resulting sedimentation of streams and other watercourses, such as culverts. Persons engaged in earth moving activities must prepare erosion/sedimentation control plans for the site.

These plans must be available on the site at all times; sites 25 acres or larger must obtain an erosion/sedimentation permit prior to commencing any activity. As with obstructions and floodplain permits, local building permits should not be issued prior to receiving the erosion/sedimentation permit, if required.

The erosion plans must consider all factors which might contribute to increased erosion during and after land disturbance activities. Plans should include both temporary and permanent control measures, as well as a maintenance program for all control facilities. Since many of these temporary facilities can also serve as permanent stormwater runoff control measures, it is important that erosion/sedimentation and stormwater management controls be designed and reviewed as a package.

The adequate enforcement of erosion control plans will be critical if stormwater controls are to function as designed. If culverts, storm sewers, detention ponds, or other control measures are filled with silt, they cannot function properly to control stormwater flows. As is discussed in subsequent sections of this Plan, problems of localized flooding often are caused by structures filled with sediment and debris. Implementing adequate erosion controls will reduce the need and costs for maintenance of structures.

Since the Clean Streams Law antedates the Storm Water Management Act, it does not specially mention the Storm Water Act. However, it can be assumed that erosion/sedimentation controls should be consistent with the Storm Water Act, and certainly an approved watershed stormwater plan. Since they could affect stormwater runoff management for the site, they would have to comply with Act 167 standards. Also, the Dams Safety and Encroachments Act requires that obstruction permits comply with the Clean Streams Law including the erosion regulations, which in turn must be consistent with stormwater management programs.

DER has major administrative and regulatory responsibilities for implementing the Clean Streams Law. DER may issue enforcement orders, and failure to comply with an order is a nuisance and exposes the violator to abatement actions as well as civil and criminal penalties.

DER or an affected municipality may sue to abate or restrain anyone who is in violation of the law (i.e., erosion regulations). Again, a municipality can act in the name of the Commonwealth after due notice to the Attorney General.

It is important to note that both private parties and municipalities may be subject to abatement actions. For example, DER or a neighboring municipality may sue a municipal violator to compel action. When performing proprietary functions (e.g., constructing a road or sewer), a municipality (or authority) must comply with the same regulations as private individuals.

FLOOD PLAIN MANAGEMENT ACT (ACT 166 - 1978)

The Flood Plain Management Act requires municipalities with floodplain areas to participate in the National Flood Insurance Program, and to adopt floodplain management regulations that control new development, at least, in accordance with the minimum requirements established by the Federal Insurance Administration.

Municipalities participating in the National Flood Insurance Program must require building permits for all construction and development occurring within identified floodplain areas. Such permits are not to be issued until all other required federal and state permits have been received by the applicant. Thus, municipalities should not issue building permits for development within floodplain areas unless the applicant has obtained any necessary obstruction and erosion/sedimentation permits. Of course, building permits should not be issued unless the proposed activity complies with the stormwater management regulations which have been adopted by the municipality.

Through this interrelated permitting process, the Flood Plain Management Act encompasses a comprehensive control of all activities in a floodplain. It assures that there is compatibility among the actions governed by the different laws.

As noted earlier, preservation of natural floodplains and a comprehensive program of floodplain management are a key part of effective overall stormwater management. Natural flood areas should be maintained as part of the watershed's natural stormwater control system. Similarly, effective future stormwater

management will help to preserve floodplain areas and assure that properties not now subject to flooding do not become so in the future.

MUNICIPALITIES PLANNING CODE (ACT 247, AS AMENDED)

The Municipal Planning Code (MPC) is related to stormwater management because of the authorities it grants to municipalities and counties. The MPC enables communities to prepare comprehensive land use plans and capital facilities programs. It also empowers them to prepare and adopt zoning (including regional zoning), subdivision and land development, planned residential development, and official map ordinances. The various municipal codes (borough, township, etc.) authorize communities to adopt building/housing codes pursuant to their health, safety, and general welfare powers.

These are the major planning and regulatory mechanisms that municipalities will use to implement the watershed plans. Section 11 of the Storm Water Management Act specifically requires municipalities to adopt "...such ordinances..., including zoning, subdivision and development, building code, and erosion and sedimentation ordinances..." to regulate development activity consistent with the watershed plan and Act 167. The specification of these ordinances by Section 11 implies that the municipalities are supposed to utilize the land use and development authorities granted by the MPC.

It is necessary to understand that these various ordinances - zoning, subdivision and land development, and building - regulate different and distinct aspects or parts of the land use and development process. It is not possible to adopt one type of ordinance, zoning for example, and simply include the items and controls covered by the other types of regulations. In other words, a community cannot regulate land usage or lot size in a subdivision and land development ordinance because that is a zoning power, or establish structural standards for building construction in a subdivision and land development ordinance because that is a building code regulation, and so forth. Therefore, a comprehensive development regulation system requires, in most cases, the utilization of all three types of ordinances.

The applicable stormwater controls should be included in the proper ordinance whenever stormwater is being regulated for a land use or development activity that falls within the scope of one of the enabling authorities contained in the Planning Code (i.e., zoning, subdivision/land development, planned residential development) or under the building code's powers in the municipal codes. For example, if the activity being regulated is a subdivision, then the relative stormwater provisions belong in the subdivision ordinance. If a community utilizes a separate, single purpose stormwater ordinance, the ordinance should be clearly referenced into the appropriate sections of the municipality's zoning, subdivisions/land development and building codes. Also, the preamble of a separate stormwater ordinance should indicate that it is being adopted pursuant to the Municipalities Planning Code, Storm Water Management Act, and applicable sections of the municipal code. Under either approach, when a development activity is within the scope of the MPC, then the municipality should be sure to follow the various plan review processes and other administrative procedures prescribed in the MPC, including the procedures for enacting and amending zoning and development regulations. The inclusion of specific procedural requirements in the MPC clearly demonstrates the Legislature's

concern that all development applications be given a fair and timely review. Since most stormwater management activities will relate to zoning, subdivision/land development or building applications, the stormwater reviews would adhere to the procedures required by the respective ordinances.

GOVERNMENTAL TORT IMMUNITY

Municipal immunity is becoming a concern to local communities and officials who will be adopting and implementing stormwater management regulations. Also, Pennsylvania and municipal immunity statutes have been the subject of recent changes and litigation. This last section identifies the laws specifically dealing with federal, state, municipal, and public official immunity. The discussion summarizes the basic scope of the laws, with some analysis of the relationship of the new (1979) Subdivision Torts Claims Act to stormwater management issues in local municipalities. Municipal officials, of course, will have to be guided by the advice of their solicitors on potential liabilities as specific cases or situations arise.

FEDERAL AND STATE IMMUNITY

In common law there were three distinct levels of governmental tort immunity: sovereign immunity, political subdivision immunity, and public official immunity. Sovereign immunity was part of the common law from its very beginnings and became part of the law of this country and the Commonwealth when the common law of England was adopted after independence. The concept behind the doctrine was that the king was sovereign and could be sued only if he consented. In fact, the rule of law came to be that "the king could do no wrong" (Russel vs. Men of Devon, 100 Eng. Rep. 359). After independence, the federal and state governments became sovereign and invested themselves with the king's immunity.

Congress, by statute, has dramatically limited the doctrine of sovereign immunity as applied to the federal government. The Federal Tort claims Act (Title 28 U.S.C. 1346, 2671 et. seq.) provides (subject to certain enumerated exceptions) that the federal government can be held liable to the same extent as a private individual for the negligent acts or omissions of its employees.

With respect to the state sovereign immunity, the trend among states is to abolish or severely limit the doctrine by statute or case law. The belief is that the doctrine is unfair and not suited to the times. The Pennsylvania courts grudgingly applied the sovereign immunity doctrine, while pointing out its unjust results and strongly suggesting the need for legislation to reform the law; and, finally, the Pennsylvania Supreme court abolished the doctrine in Maybe vs. Pennsylvania Department of Highways, 479 Pa. 384 (1978).

Maybe was decided in mid-July, 1978. Before the end of September of that year, the Legislature had recreated sovereign immunity by statute (42 Pa. C.S.A. 58521 et. seq). This new statute does provide for some very limited specifically enumerated exceptions, most of which go to negligent failure to adequately enforce state statutes and regulations. The statute also limits the amounts which can be recovered in suits brought under the exceptions. It is important to note that state immunity extends to state agencies, such as PenDOT and DER.

MUNICIPAL IMMUNITY

The second level of government tort immunity which developed as common law was applied to political subdivisions (i.e., municipalities, counties, municipal authorities, municipal agencies, commissions and departments, including planning commissions and zoning hearing boards). The historical basis of the doctrine was that local governments were the agents of the king.

A substantial number of states have abolished municipal immunity by statute of judicial decision. The Pennsylvania Supreme Court first limited the doctrine by holding that it only applied to torts arising out of governmental function (i.e., those activities which are typically performed by government; e.g., police, fire, regulatory, etc.) and not to torts arising out of a municipality's proprietary activities (i.e., activities that could be done by private corporations, such as owning and operating utilities).

Finally, in 1973, the court abolished the municipal immunity doctrine in Ayala vs. Philadelphia of Public Education, 453 Pa. 584. The court's rationale was that compensating the victims of negligent public employees should be properly regarded as a cost of the administration of government and should be distributed by taxes to the public which benefits from that government. This decision exposed political subdivisions to unlimited liability (i.e., the same degree of liability to which private persons and corporations have always been exposed) for their negligent acts or omissions and those of their employees and agents.

This was the situation until 1978, when the Pennsylvania Legislature enacted the Political Subdivision Tort Claims Act. The result of this legislation is that since its effective date (January 24, 1979), the doctrine of municipal immunity, with certain statutory exceptions, has been resurrected in Pennsylvania. (The provisions of this Act have been amended and recodified as 42 Pa. C.S. 38501 et. seq.)

The Tort Claims Act applies to municipalities, municipal authorities (e.g., sewer and stormwater authorities), and counties. The purpose of the statute is to limit the liability of political subdivisions for the torts of their agencies, appointed and elected officials, and their employees. Under the Act, a municipality is not liable for damages caused by the negligence of an officer, employee, or agent unless all three of the following preconditions are met (see Section 8542):

- Damages would be recoverable under common law or a statute, if the defendant was not a municipality.
- The injury was caused by the negligence of the municipality or its officers, employees, or agents operating within the scope of his or her office or employments.
- The negligent acts or omissions by a local agency or its officer or employer fall within eight specified categories of activity. The specified categories are:
    - Operation of a motor vehicle.

- Care, custody, and control of personal property of others.
- Care, custody, and control of real property in the possession of the local agency.
- Dangerous condition of trees, traffic signs, lights, or other traffic controls under care, custody, or control of the local agency.
- Dangerous condition of stream, sewer, water, gas, or electric systems owned by the local agency.
- Dangerous condition of streets owned by the local agency.
- Dangerous condition of sidewalks within the right-of-way of streets owned by the local agency.
- Care, custody and control of animals within the possession of the local agency, [Note: The numbers used here correspond to the numbering of these categories under Section 8542(b)].

Categories the final four categories above are further conditioned by the requirement that a plaintiff must prove that the local agency had actual notice or could reasonably be charged with notice of the dangerous condition at a sufficient time prior to the event to have taken measures to protect against the danger.

It is important to note that the Torts Claims Act limits municipal liability to eight express areas of activity. If an activity does not fit into any of the eight categories, then it appears that the municipality is not subject to any liability.

For example, a municipality does not seem to be liable for damage caused by runoff from a development constructed according to subdivision plans negligently approved by municipal officials or employees. Under the Torts Claims Act, failure to use reasonable care (i.e., negligence) in the plan review and ordinance enforcement process does not fit into any of the eight categories. Therefore, even though there was negligence on the part of the official in performing the duty prescribed in the subdivision regulations and harm may have resulted, the Act appears to prevent the injured party from recovering damages against the municipality. After the Ayala case and before the effective date of the Tort Claims Act, the case law in Pennsylvania would have imposed liability on the municipality in this situation.

The Political Subdivisions Tort Claims Act probably would be held to be controlling with respect to suits of injured parties (e.g., those injured by runoff that would not have occurred but for the negligent enforcement of a municipal ordinance), although the other acts (e.g., Storm Water Management) appear to create municipal liability. Both acts would be read together. Since the Tort Claims Act is directly on

point, unless the court finds a clear express Legislative intent to impose liability, the Tort Claims Act would control. An affected municipality (or aggrieved person) could take action under Section 15(c) of the Storm Water Management Act to enjoin a municipality from taking an action, such as a negligent plan approval, because such action was a violation of the Act. Similarly, an aggrieved party may be able to force the municipality (or official) to enforce liability. If "streets" includes culverts and bridges supporting them, as it would seem it should, any culvert or bridge which does not meet the requirements of the Obstructions Act (which incorporates the Storm Water Management Act standards) could expose the municipality to action for damages. For example, damages which result from backwater flooding due to failure to clean culverts or undersized culverts under a municipal street might be recoverable.

Also, the Torts Claims Act only protects municipalities and their officials from private suits. It does not protect them from enforcement orders issued by a state agency or from any criminal penalties provided by a state statute. Both the Obstructions Act and Clean Streams Law provide for DER enforcement orders and criminal penalties for violations of the statutes.

OFFICIAL IMMUNITY

The final area of tort immunity is that immunity given to public officials, employees, and agents themselves. Section 8545 and 8546 of Title 42 Pa. C.S. generally codify the common law rule with respect to official immunity. These sections provide that an elected and appointed officer, employee, and agent when carrying out official duties (i.e., when acting within the scope of his or her employment) is liable for damages caused by his or her negligence only to the same extent as is the governmental unit (i.e., provisions of Paragraph 8542 of the Tort Claims Act are applied to public officials). This coverage does not extend to independent contractors under contract with the governmental unit, where the unit has no right of control. This could be the case for many consulting engineers.

In one respect, official immunity is broader than municipal immunity since the official may assert certain defenses. These include those available to employees at common law, good faith, and that the action was discretionary (there is no liability for discretionary as opposed to ministerial acts). Thus, most actions of members of the governing body of a municipality would be immune.

In another respect, however, officials may be held totally liable. Title 42 Pa. C.S. Paragraph 8550 provides that when the conduct of the official is a willful criminal act or involves actual malice or actual fraud, the immunity statute does not apply. Thus, if an official intentionally (knowingly) fails to enforce a regulation, he or she may be held personally liable to the extent of all of their private assets for any damage that their act causes. However, as noted above, the municipality is not liable.

In some cases, larger retention/detention facilities may qualify as dams under the definition of the Act and regulations and, therefore, require a permit from DER.

MONONGAHELA RIVER WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION III
WATERSHED CHARACTERISTICS

GENERAL DESCRIPTION

The portion of the Monongahela River watershed included in this project is located within Allegheny County in southwestern Pennsylvania. The watershed, which spans approximately 9 miles in an east-west direction and extends approximately 21 miles north to south, encompasses approximately 98 square miles. A general watershed map is presented as Plate III-1.

The watershed includes the areas within Allegheny County which drain to the Monongahela River with the exception of those areas which lie within the Turtle Creek, Peters Creek and Youghiogheny River watersheds. Although these watersheds are tributary to the Monongahela River, they are specifically designated for separate investigation under Act 167.

POLITICAL FEATURES

With the exception of a very small portion at the southern extremity which extends into Washington County, the watershed is contained entirely within Allegheny County. A total of 34 municipalities are situated in whole or in part in this watershed. These municipalities, together with statistics describing the approximate area of each which lie within the watershed and the portion of the watershed encompassed by each are listed in Table III-1.

NATURAL FEATURES

TOPOGRAPHY

The Monongahela River basin lies completely within the Appalachian Plateaus. The portion of the basin which is subject to this planning effort lies in the Pittsburgh Plateaus Section of the Appalachian Plateaus. The Pittsburgh Plateaus consist in most places of rounded hills and ridges extending northward from Washington to Pittsburgh. Elevations range from approximately 1250 feet above mean sea level at the southern extremities of the watershed to the normal Monongahela River pool elevation of 710 feet above mean sea level at its confluence with the Allegheny River.

GEOLOGY

The geology of this watershed is predominated by rocks of the Pennsylvanian system. The Monongahela Formation of the Pennsylvania system consists of cyclic sequences of sandstone, shale, limestone and coal. The Conemaugh Formation consists of cyclic sequences of red and gray shales and siltstones with thin limestones and coal.

Scale
Feet
0
8000
16000

Monongahela River Stormwater Management Plan

Outline of Watershed

CHESTER ENVIRONMENTAL

Plate III -1

9/29/92

N

HSG B

HSG C

HSG D

Urban

Stripmine

Other

Water

Plate III-2

Allegheny County

Monongahela River Watershed
Stormwater Management Plan

Hydrologic Soil Groups

CHESTER ENVIRONMENTAL

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TABLE III-1
MUNICIPALITIES LYING WITHIN THE WATERSHED

Municipality	Area In Watershed (sq. mi.)	Percent of Watershed (percent)
Baldwin Borough	6.88	7.02
Braddock Hills Borough	0.78	0.80
Brentwood Borough	0.87	0.89
Clairton City	1.90	1.94
Dravosburg Borough	1.06	1.08
Duquesne City	2.02	2.06
East McKeesport Borough	0.08	0.08
Edgewood Borough	0.59	0.60
Elizabeth Borough	0.40	0.41
Elizabeth Township	4.58	4.68
Forward Township	22.94	23.41
Glassport Borough	1.50	1.53
Homestead Borough	0.63	0.65
Jefferson Borough	7.79	7.95
Liberty Borough	0.15	0.15
Lincoln Borough	3.29	3.36
McKeesport City	3.66	3.73
Mt. Oliver Borough	0.33	0.34
Munhall Borough	2.33	2.37
North Braddock Borough	0.97	0.99
North Versaillles Township	2.90	2.96
Penn Hills, Municipality of	0.03	0.03
Pittsburgh City	18.53	18.91
Port Vue Borough	0.49	0.50
Rankin Borough	0.49	0.50
Swissvale Borough	1.23	1.26
West Elizabeth Borough	0.26	0.26
West Homestead Borough	0.99	1.01
West Mifflin Borough	13.40	13.68
Whitaker Borough	0.32	0.33
Whitehall Borough	1.32	1.34
White Oak Borough	0.77	0.78
Wilkinsburg Borough	2.07	2.11

SOILS

The upland and valley wall soils are silty clays, but the flood plain materials are silty and gravelly sands, much of which have been covered with industrial debris. The predominant soil associations in the Monongahela River Watershed include the following:

- Gilpin-Upshur-Atkins
- Urban Land-Philo-Rainsboro
- Urban Land-Rainsboro-Allegheny
- Urban Land-Wharton-Gilpin
- Urban Land-Dormont-Culleoka
- Dormont-Guernsey-Culleoka
- Strip Mines-Guernsey-Dormont

The Soil Conservation Service (S.C.S.) has defined groups of soils having similar hydrologic properties which directly influence the volume and rate of stormwater runoff. These hydrologic soil groups are defined as follows.

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

As the soil descriptions imply, runoff potentials increase from a minimum for Group A soils to a maximum for Group D soils. For the purposes of classifying soil types for stormwater management, this investigation identified two additional classifications: water bodies and urban land. Water bodies represent areas covered by water, a condition which results in direct runoff of precipitation. Urban land consists of land which is so altered by earth moving or so obscured by buildings or other structures that the original soils cannot be identified. In some places, cuts have removed all or nearly all the natural soil horizons. In other places, fills have buried the original soils. Urban soils are generally assigned Group C hydrologic characteristic reflecting the characteristics of the predominant natural soils in the area.

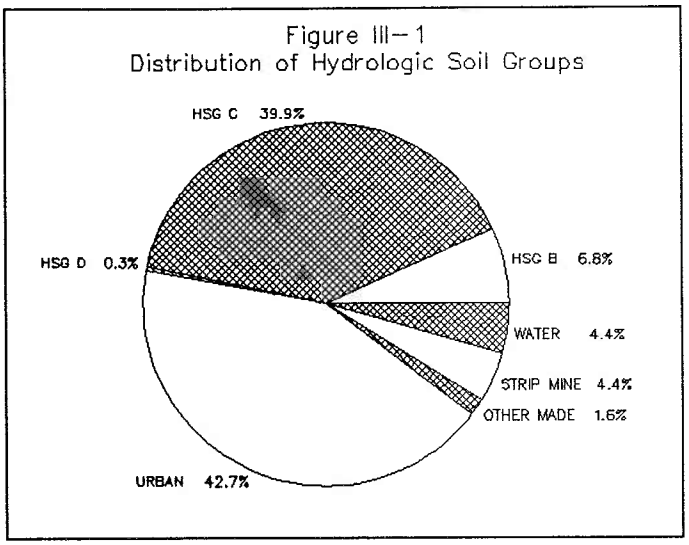
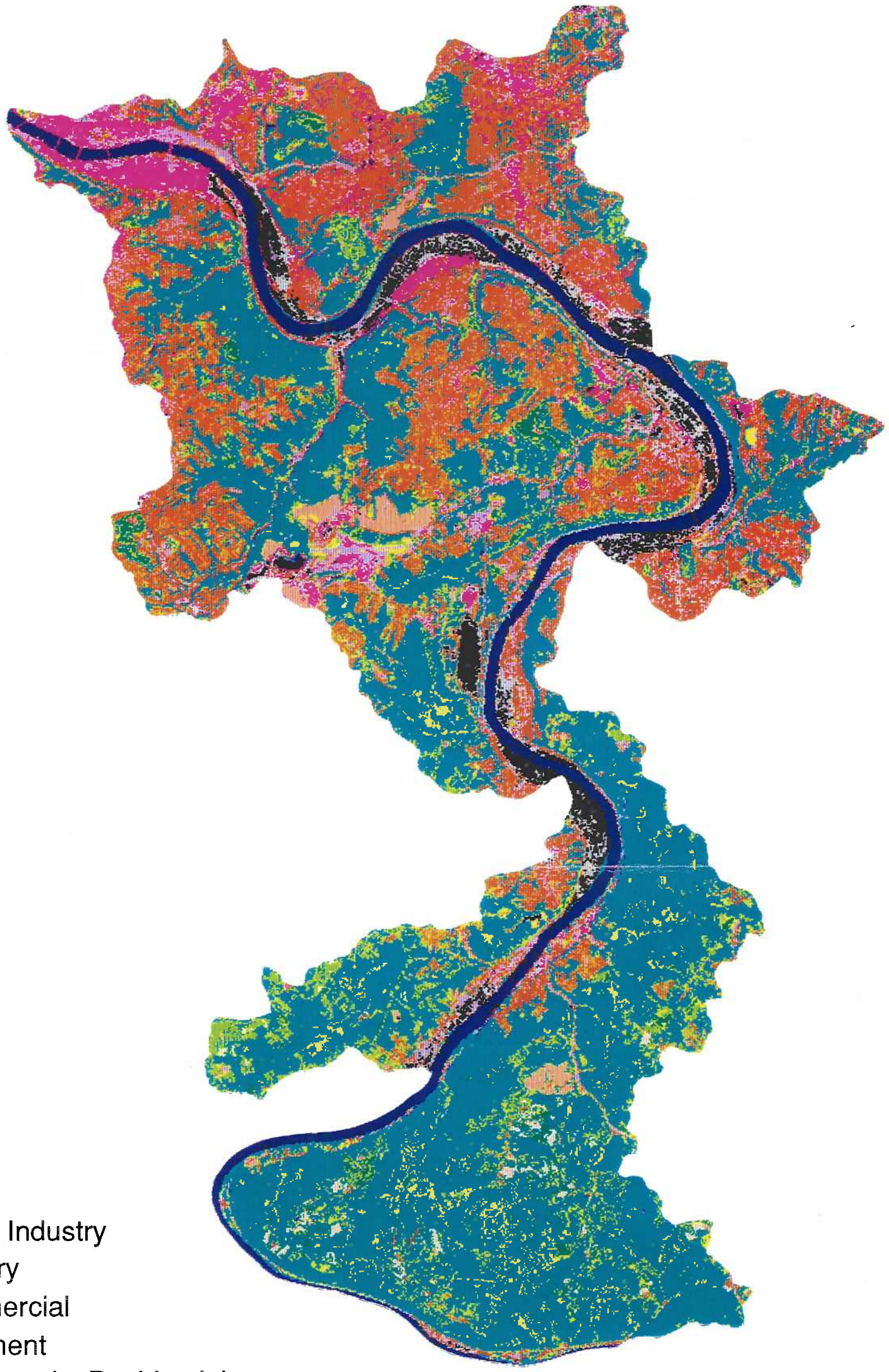


Figure III-1 presents a summary of soils located in the Monongahela River watershed. A map illustrating the distribution of soil groups throughout the watershed is provided in Plate III-2. The distribution of soil groups throughout the watershed was determined based upon soil series information mapped on the S.C.S. soil survey for Allegheny County. The aggregation of individual soil series into appropriate hydrologic soils groups was performed using S.C.S. Technical Release 55 information.

CLIMATE

The area is dominated by atmospheric flow patterns relevant to the Humid Continental type climate. Another flow pattern and primary source of heavy precipitation associated with cyclonic circulation is from the Gulf of Mexico northward through the area. As a result of the dominant westerly air flow into the area, the moist air flow from the Atlantic Ocean is a modifying rather than a controlling climatic factor. The Great Lakes have little or no influence on the climate in the watershed since the weather systems formed over the Great Lakes region migrate far to the north.

The normal succession of high and low pressure systems moving eastward across the United States produce weather changes in the area every few days in the winter and spring of the year. In summer and fall, the weather changes are less frequent due to the slowing down of the general atmospheric circulation during the warmer months. Low pressure cyclonic systems usually dominate the area with southerly winds, rising temperatures and some form of precipitation. The high pressure anticyclonic systems normally bring west to northwest winds, lowering temperatures and clearing skies to the area.



N

- Water
- Heavy Industry
- Industry
- Commercial
- Pavement
- High Density Residential
- Medium Density Residential
- Forest
- Forest with Grass
- Grassland
- Open Space, Parks, Golf Courses
- Cropland
- Fallow
- Poor Grass
- Strip Mine

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Plate III-5

Allegheny County

Monongahela River Watershed
Stormwater Management Plan

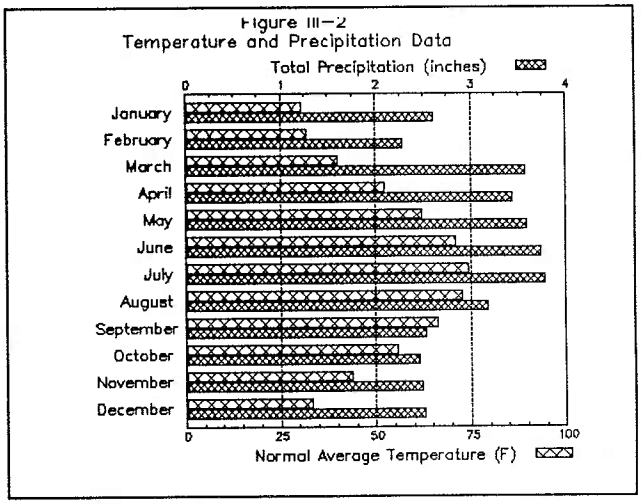
Current Land Cover

CHESTER
ENVIRONMENTAL

Hurricanes or tropical disturbances, as they move northward, follow a northeasterly path in the middle latitudes and produce heavy rainfalls and strong surface winds in the study area. Frequently causing floods, these tropical storms are observed during the hurricane season, June through November.

TEMPERATURE

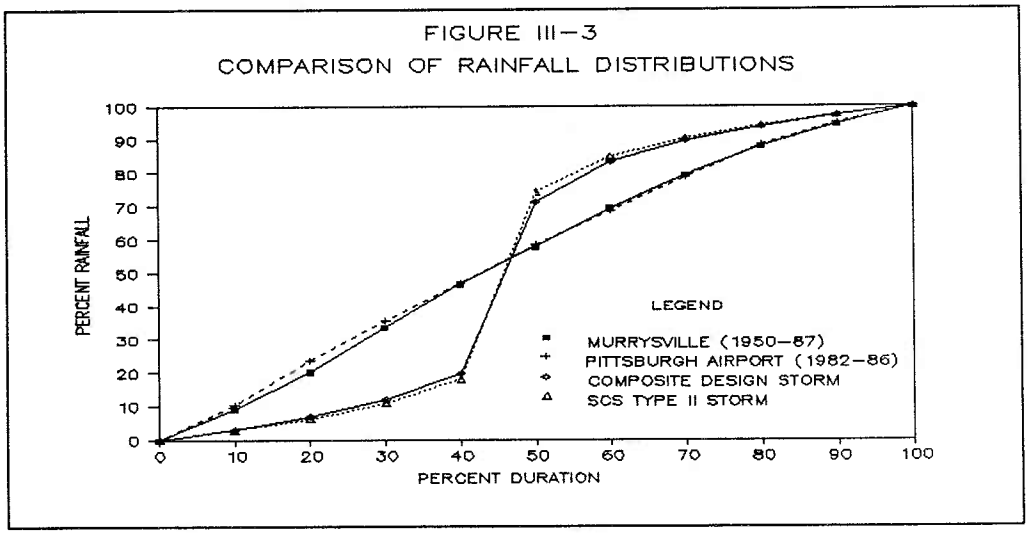
Temperature data are available from the first order Weather Bureau station at Pittsburgh. Climatic data are illustrated in Figure III-2. The average annual temperature is about 50 degrees Fahrenheit. The mean annual freeze-free period is about 155 days, but because of the topography of the area is variable. The summer mean temperature is about 70 degrees Fahrenheit and the winter mean is about 30 degrees Fahrenheit.



PRECIPITATION

Long term precipitation data is available from gauges located at Pittsburgh and Murrysville. Normal annual precipitation at the Pittsburgh station totals 46.22 inches. Maximum total precipitation occurs during the month of June (3.78 inches) while the minimum month in terms of precipitation is February (2.29 inches). The summer rains usually result from convectional storms of short duration and high intensity and are confined to relatively small areas. Precipitation in the fall, winter and early spring months is evenly spatially distributed and more moderate in intensity.

Alternative design storm distributions for the area are presented and compared in Figure III-3.



The SCS Type II distribution illustrated is a synthetic distribution developed by the United States Soil Conservation Service (SCS) to represent a pattern of rainfall arranged in a sequence which serves to maximize peak rates of runoff resulting from any given rainfall volume.

The Composite Design Storm distribution represents a similar pattern as recommended in the Pennsylvania Department of Transportation *Field Manual of Storm Intensity-Duration-Frequency Charts*. The historical distributions were produced through an analysis of rainfall data collected at the Pittsburgh and Murrysville observation stations.

As is indicated in Figure III-3, the differences between the historical and synthetic distributions are significant. The synthetic distributions (SCS Type II and Composite Design Storm) concentrate much of the precipitation near the middle of the storm event. The historical pattern, on the other hand, indicates a more uniform distribution of rainfall throughout the event.

HYDROLOGY

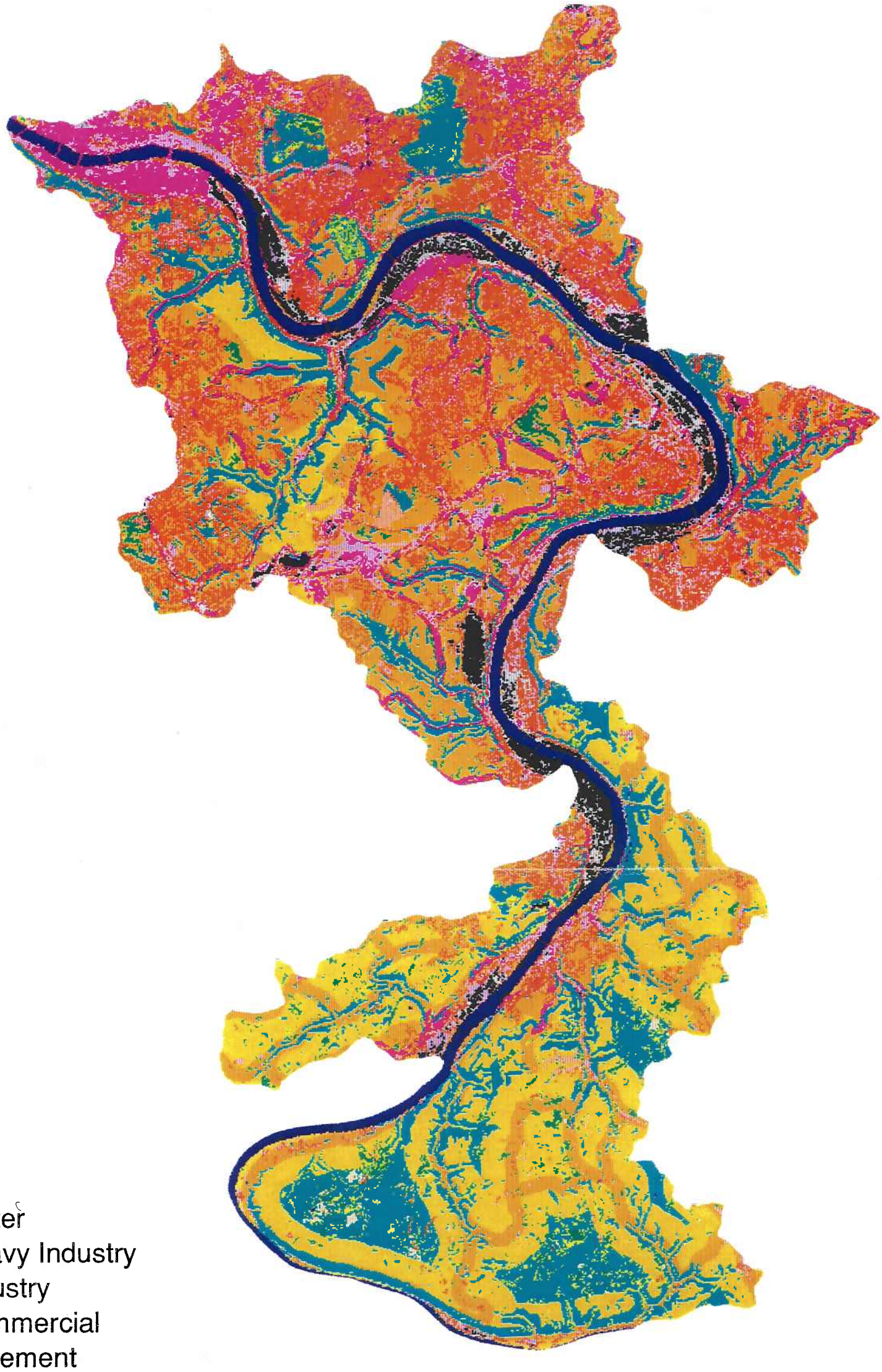
As indicated previously the portion of the Monongahela River Watershed investigated in this plan is limited to the approximately 98 square miles of the basin contained in Allegheny County, Pennsylvania and excluding the areas drained by the Youghiogheny River Turtle Creek and Peters Creek tributaries. The entire Monongahela River basin extends from the headwaters of the Tygart Valley River in West Virginia and spans and area of 7,384 square miles.

The Monongahela River Watershed included in this plan is elongated in shape with the long axis oriented in a north-south direction. While the Monongahela River flows essentially in a northerly direction, the tributaries flow predominantly in a west to east or east to west direction.

Significant tributaries to the Monongahela River Watershed studied herein are listed in Table III-2.

Stream Gauging Stations

According to the United States Geological Survey (U.S.G.S.) publication *Water Resources Data for Pennsylvania*, the only long term, currently operating gauges in the watershed are located on the Monongahela River at Braddock and Elizabeth. Both of these gauges have been in operation since the 1930's. According to available information, no stream gauging data is available for the Monongahela River tributaries included in this plan.



- Water
- Heavy Industry
- Industry
- Commercial
- Pavement
- High Density Residential
- Medium Density Residential
- Low Density Residential
- Forest
- Forest with Grass
- Grassland
- Open Space, Parks, Golf Courses
- Cropland
- Fallow
- Poor Grass
- Strip Mine

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Plate III-6

Allegheny County

Monongahela River Watershed
Stormwater Management Plan

Future Land Cover

CHESTER ENVIRONMENTAL

TABLE III-2
NAMED STREAMS

Stream	Drainage Area (sq. mi.)
Beckets Run	3.1
Becks Run	2.6
Bunola Run	1.0
Courain Run	0.8
Crooked Run	2.8
Curry Hollow Run	1.3
Fallen Timber Run	4.6
Homestead Run	2.8
Kelly Run	2.2
Lobbs Run	3.9
Mill Run	3.9
Ninemile Run	4.9
Panther Hollow	3.4
Smiths Run	0.2
Streets Run	10.7
Sunfish Run	1.5
Thompson Run	6.1
Coal Valley Run	2.9
West Run	1.5
Wylie Run	3.9

FLOOD FREQUENCY / DISCHARGE INFORMATION

Estimated flood frequency / discharge information for as presented in the various Flood Information Studies completed for municipalities in the watershed are presented in Table III-3: The data presented in Table III-3 were extracted from studies prepared for the City of Duquesene, West Elizabeth Borough, West Mifflin Borough, North Versailles Township, Jefferson Borough, Elizabeth Township and the City of McKeesport. The reader's attention is directed to Section IV of this report for a explanation of the concept of flood frequency - discharge data. Table II-4 contains estimates of 100 year return period peak discharges calculated from data contained in the "Floodway Data" tables included in various Flood Insurance Studies prepared for tributaries in the watershed.

TABLE III-3
REPORTED FLOOD FREQUENCY / DISCHARGE DATA

Location	Peak Discharge (cfs) 10-yr	50-yr	100-yr	500-yr
Monongahela River @ Mile 11.2	162,000	205,000	220,000	262,000
Monongahela River @ Mile 15.6	135,000	167,000	182,500	216,400
Crooked Run @ N. Versailles Border	560	980	1,170	1,710
Crooked Run @ Arcannia Street	470	810	970	1,420
Crooked Run @ Mouth	885	1,530	1,835	2,680
Crooked Run Between Hartman & Fawcett	690	1,190	1,430	2,085
Lobbs Run @ Mouth	760	1,320	1,610	2,410

TABLE III-4
ESTIMATES OF PEAK 100 FREQUENCY DISCHARGES COMPUTED FROM FLOOD INSURANCE STUDY DATA

Location	Municipality	Computed Discharge (CFS)
Crooked Run 673 feet above N. Versailles border	North Versailles	175
Crooked Run 2,033 feet above N. Versailles border	North Versailles	1020
Crooked Run 2,239 feet above N. Versailles border	North Versailles	963
Crooked Run 3,086 feet above N. Versailles border	North Versailles	961
Crooked Run 840 feet above Lincoln Way	McKeesport	1436
Crooked Run 1,205 feet above Lincoln Way	McKeesport	1500
Crooked Run 1,692 feet above Lincoln Way	McKeesport	1512
Wylie Run 1,235 feet above mouth	Lincoln Borough	998
Wylie Run 1,525 feet above mouth	Lincoln Borough	1001
Wylie Run 2,068 feet above mouth	Lincoln Borough	995
Wylie Run 2,448 feet above mouth	Lincoln Borough	1000
Wylie Run 3,138 feet above mouth	Lincoln Borough	959
Wylie Run 3,788 feet above mouth	Lincoln Borough	659
Wylie Run 4,645 feet above mouth	Elizabeth Township	655
Wylie Run 5,091 feet above mouth	Elizabeth Township	657
Wylie Run 5,602 feet above mouth	Elizabeth Township	660
Wylie Run 5,958 feet above mouth	Elizabeth Township	664
Wylie Run 6,690 feet above mouth	Elizabeth Township	662
Wylie Run 7,196 feet above mouth	Elizabeth Township	576
Wylie Run 7,655 feet above mouth	Elizabeth Township	510
Wylie Run 9,409 feet above mouth	Elizabeth Township	489
Wylie Run 9,937 feet above mouth	Elizabeth Township	410
Wylie Run 10,407 feet above mouth	Elizabeth Township	531
Wylie Run 10,947 feet above mouth	Elizabeth Township	316
Wylie Run 11,572 feet above mouth	Elizabeth Township	318
Happy Hollow Run 492 above mouth	Elizabeth Township	397
Happy Hollow Run 5,065 above mouth	Elizabeth Township	390
Happy Hollow Run 5,890 above mouth	Elizabeth Township	328
Fallen Timbers Run 2,914 feet above mouth	Elizabeth Township	816
Fallen Timbers Run 3,466 feet above mouth	Elizabeth Township	1096
Fallen Timbers Run 3,945 feet above mouth	Elizabeth Township	1098
Fallen Timbers Run 4,672 feet above mouth	Elizabeth Township	1100
Fallen Timbers Run 5,261 feet above mouth	Elizabeth Township	1102
Fallen Timbers Run 5,918 feet above mouth	Elizabeth Township	1102
Fallen Timbers Run 6,518 feet above mouth	Elizabeth Township	1093
Fallen Timbers Run 7,179 feet above mouth	Elizabeth Township	1689
Fallen Timbers Run 7,601 feet above mouth	Elizabeth Township	1039
Fallen Timbers Run 8,148 feet above mouth	Elizabeth Township	1092
Fallen Timbers Run 8,795 feet above mouth	Elizabeth Township	909
Fallen Timbers Run 9,600 feet above mouth	Elizabeth Township	912
Fallen Timbers Run 10,332 feet above mouth	Elizabeth Township	820
Fallen Timbers Run 10,855 feet above mouth	Elizabeth Township	820

FLOOD HAZARD / STORMWATER PROBLEM AREAS

DELINEATED FLOOD PRONE AREAS

Delineated flood prone areas as defined by the U.S.G.S. for the Federal Insurance Administration are illustrated on Plate III-3 (located in the map pocket appended to this report). The boundaries illustrated represent an approximation of the areas which, on average are likely to be inundated by flood waters at a frequency of once in 100 years.

REPORTED STORMWATER PROBLEM AREAS

The delineated flood prone areas established by flood insurance studies relate primarily to stream flooding during major storm events. As such they do not provide information concerning more minor flooding problems or stormwater problems separate from stream flooding such as street flooding, soil erosion or stormwater pollution instances.

Each of the municipalities in the watershed was contacted to solicit information relative to stormwater conditions which are perceived locally to be problems. In many cases, these problems may be somewhat localized, and related to local drainage limitations apart from stream flooding and may occur at a high frequency. Also, information relative to stormwater problems in addition to flooding (i.e., accelerated erosion, sedimentation and water pollution) was requested. To augment information provided by the municipalities, the supervisors of the three Allegheny County Maintenance Districts within the watershed were contacted and requested to provide information relative to any stormwater drainage problems with which they are aware.

Data obtained through these efforts were supplemented by a review of Flood Insurance Studies conducted in the watershed to produce the listing of identified stormwater problem areas summarized in Table III-5 and illustrated on Plate III-3 (located in the map pocket appended to this report). A total of 38 problem areas were reported in 19 of the municipalities in the watershed. Fourteen of the reported flooding problems are associated with flooding of the Monongahela River, a situation which occurs relatively infrequently and is caused largely be conditions external to this relatively small portion of the watershed. The distributions of identified problem types and suggested solutions are presented in Figure III-4.

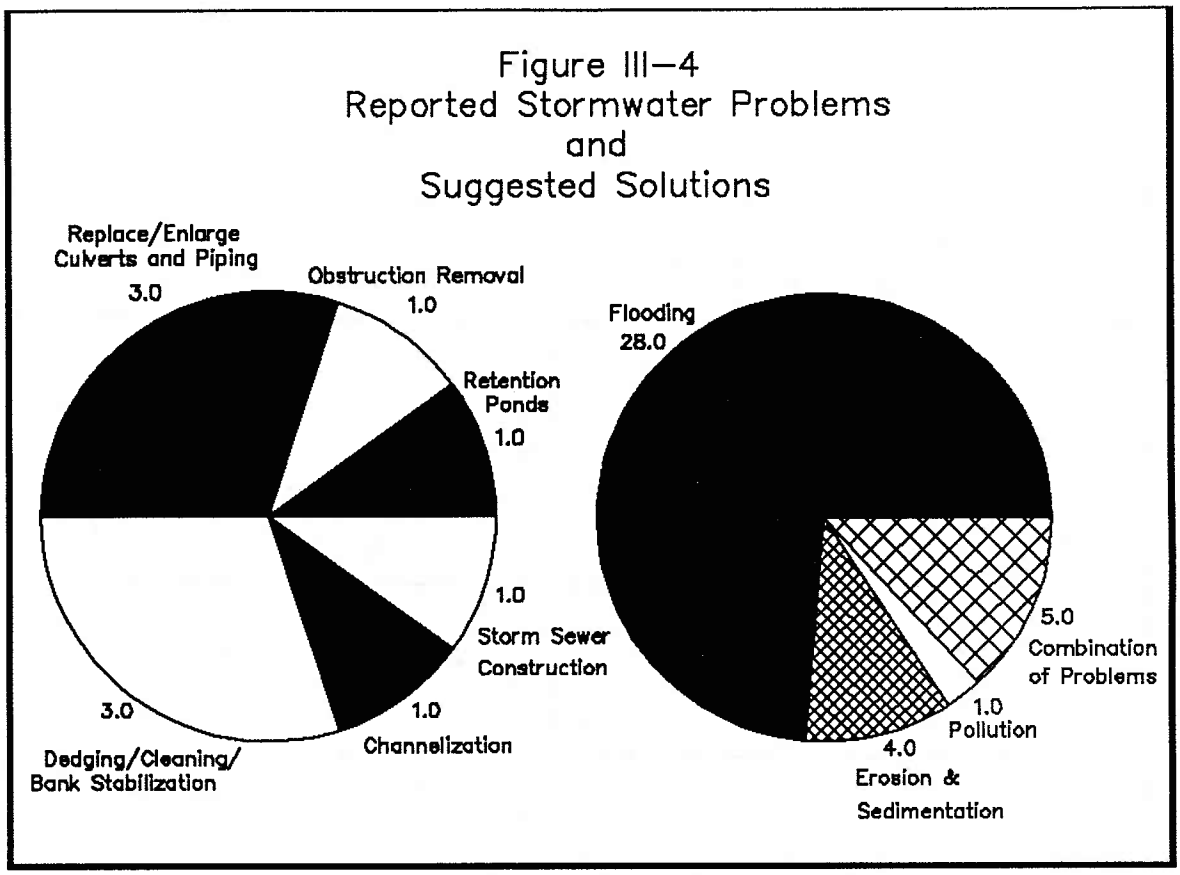
The identified flooding problems are in most cases stream flooding generally caused by stormwater runoff rates exceeding the channel and/or obstruction capacities. Erosion and sedimentation were the next most frequently reported stormwater runoff related problems. Water quality concerns related to sewer overflows and acid mine drainage were also expressed in several instances.

TABLE III--5
SUMMARY OF REPORTED STORMWATER PROBLEMS

Map Code	Municipality	Description	Stream/Location	Identified Causes	Frequency	Number of Properties Affected	Proposed Solution(s)	Information Source
A-1	Baldwin Borough	Flooding	Streets Run	Volume, obstruction	> once per year	11 or more	Storm sewer construction	Municipal Questionnaire
A-2	Baldwin Borough	Flooding	Streets Run	Volume, obstruction	> once per year	11 or more		Municipal Questionnaire
A-3	Baldwin Borough	Flooding	Streets Run	Volume	> once per year	11 or more		Municipal Questionnaire
A*	Baldwin Borough	Flooding	Monongahela River	Volume	N/A	N/A		Flood Insurance Study
A*	Baldwin Borough	Flooding	Becks Run	Monongahela River backwater	N/A	N/A		Flood Insurance Study
B*	Braddock Borough	Flooding	Monongahela River	Volume	N/A	N/A		Flood Insurance Study
C	Braddock Hills Borough							
D	Brentwood Borough							
E-1	City of Clairton	Accelerated erosion and	Between Elder Alley	Sediment and debris	> once per year	None	Frequent cleaning	Municipal Questionnaire
		erosion		accumulation at trash rack				
E-2	City of Clairton	Flooding	East of State Street near	Limited storm sewer	> once per year	None	Remove obstruction	Municipal Questionnaire
			Walnut Avenue	capacity / plugging				
E*	City of Clairton	Flooding	Monongahela River	Volume	N/A	N/A		Flood Insurance Study
F*	Dravosburg Borough	Flooding	Monongahela River	Volume	N/A	N/A		Flood Insurance Study
G-1	City of Duquesne	Pollution	Thompson Run	Mine drainage and	> once per year	N/A	STP upgrade	Municipal Questionnaire
				sewage discharges				
G-2	City of Duquesne	Flooding	Thompson Run	Debris clogging of culvert	N/A	N/A		Flood Insurance Study
H	East McKeesport Borough	None reported						Municipal Questionnaire
I	Edgewood Borough							
J*	Elizabeth Borough	Flooding	Monongahela River	Volume	N/A	N/A		Flood Insurance Study
K	Elizabeth Township	Flooding	Monongahela River	Volume	N/A	N/A		Flood Insurance Study
L-1	Forward Township	Flooding	Mill Run (Pangburn Hollow)	Volume and obstruction	> once per year	5		County Maintenance Department
M-1	Glassport Borough	Flooding	Detroit Hollow	Debris clogging of culvert	N/A	N/A		Flood Insurance Study
N	Homestead Borough	None reported						Municipal Questionnaire
O-1	Jefferson Borough	Flooding	Fifth Street	Volume, velocity	> once per year	2 to 10	Replace undersized pipes	Municipal Questionnaire
							and dredge channels	
O-2	Jefferson Borough	Flooding	Scotia Hollow	Volume, velocity	> once per year	11 or more	Replace undersized pipes	Municipal Questionnaire
							and dredge channels	
O-3	Jefferson Borough	Flooding	Calamity Hollow	Volume, velocity	> once per year	11 or more	Replace undersized pipes	Municipal Questionnaire
							and dredge channels	
O*	Jefferson Borough	Flooding	Monongahela River	Volume	N/A	N/A		Flood Insurance Study
P	Liberty Borough							
Q-1	Lincoln Borough	Accelerated erosion	Conrain Hill Run	Volume	> once per year	2 to 10	Bank stabilization	Municipal Questionnaire
Q*	Lincoln Borough							

TABLE III–5
SUMMARY OF REPORTED STORMWATER PROBLEMS

Map Code	Municipality	Description	Stream/Location	Identified Causes	Frequency	Number of Properties Affected	Proposed Solution(s)	Information Source
R*	City of McKeesport	Flooding	Monongahela River	Volume	N/A	N/A		Flood Insurance Study
S–1	Mt. Oliver Borough	Flooding	Becks Run @ Walter	Volume	N/A	N/A		Municipal Questionnaire
			Avenue					
T–1	Munhall Borough	Flooding, erosion, sediment.,	West Run	Volume, velocity and	N/A	6		Municipal Questionnaire
		water pollution		obstruction				
T–2	Munhall Borough	Flooding, erosion, sediment.,	Homestead Run	Volume, velocity and	N/A	> 11		Municipal Questionnaire
		,landslide water pollution		obstruction				
U	North Braddock Borough							
V–1	North Versailles Township	Accelerated erosion	Crooked Run	Volume and velocity	< once per year	2 to 10	Dredging and bank	Municipal Questionnaire
							stabilization	
V*	North Versailles Township	Flooding	Monongahela River	Volume	N/A	N/A		Flood Insurance Study
W	Municipality of Penn Hills							
X–1	City of Pittsburgh	Flooding, sedimentation,	Streets Run	Stream encroachment,	> once per year	11 or more	Channelization and	Municipal Questionnaire
		erosion, sanitary sewer		undersized obstructions			channel enlargement	
		overflows						
X–2	City of Pittsburgh	Flooding	Becks Run	Volume, obstruction	> once per year	2 to 10		Municipal Questionnaire
X–3	City of Pittsburgh	Erosion, sedimentation	Nine Mile Run	Volume, velocity,	> once per year	2 to 10	Cleaning creek & bank	Municipal Questionnaire
		and pollution		direction & obstruction			stabilization	
X–4	City of Pittsburgh	Erosion & sedimentation	West Run	Volume, velocity,	> once per year	2 to 10		Municipal Questionnaire
				direction & obstruction				
X–5	City of Pittsburgh	Flooding, pollution,	Four Mile Run	Volume	> once per year	11 or more	Retention ponds, relief	Municipal Questionnaire
		combined sewer overflow					sewer	
X*	City of Pittsburgh	Flooding	Monongahela River	Volume	N/A	N/A		Flood Insurance Study
Y	Port Vue Borough							
Z*	Rankin Borough	Flooding	Monongahela River	Volume	N/A	N/A		Flood Insurance Study
AA	Swissvale Borough							
BB	West Elizabeth Borough	Flooding	Monongahela River	Volume	N/A	N/A		Flood Insurance Study
CC	West Homestead Borough	Flooding	Monongahela River	Volume	N/A	N/A		Flood Insurance Study
DD*	West Mifflin Borough	Flooding	Thompson Run	N/A	N/A	N/A		Flood Insurance Study
DD*	West Mifflin Borough	Flooding	Monongahela River	Volume	N/A	N/A		Flood Insurance Study
EE	Whitaker Borough							
FF	Whitehall Borough	None reported						Municipal Questionnaire
GG	White Oak Borough							
HH	Wilkinsburg Borough							



Suggested solutions were offered for 10 of the reported problem areas. The suggested solutions include structural approaches such as constructing new or increasing the capacity of existing storm sewers, stream channelization and the construction of stormwater detention or ponding areas. Also included are such remedial actions as stream dredging for the removal of accumulated silt, the clearing of debris from trash racks and culvert and bridge openings and the removal of obstructions from the stream bed.

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

DEVELOPMENT IN FLOOD HAZARD AREAS

The State Water Plan has identified eleven damage centers in the Monongahela River watershed. The State Water Plan defines damage centers as communities where damages for one flood totalled $25,000 or more at a 1969 price level. The identified damage centers are listed in Table III-5.

TABLE III-5
IDENTIFIED FLOOD DAMAGE CENTERS

Stream / Municipality	Highest Flood Damages Recorded Before 1969 — Flood Date	Damages ($1,000)	1972 Agnes Damages ($1,000)
Pittsburgh Rt. bank Monongahela	3/36	19,610	1,119
Pittsburgh Left bank Monongahela	3/36	24,223	
Hays Monongahela	3/36	5,160	
Rankin Monongahela	3/36	4,420	
North Braddock Monongahela	3/36	6,378	92
West Mifflin Thompson Run and Lower Bull Run	8/56	83	
Dravosburg Monongahela	10/54	192	
McKeesport Monongahela	3/36	45,093	2,892
Elizabeth Monongahela	3/36		136
West Elizabeth Monongahela	3/63	279	188

No major new development is currently projected to occur in the identified flood hazard areas. However, land development upstream of these areas and within identified flood prone areas can be expected to occur unless adequately controlled. This points to the importance instituting adequate stormwater management and enforcing flood plain management ordinances throughout the watershed.

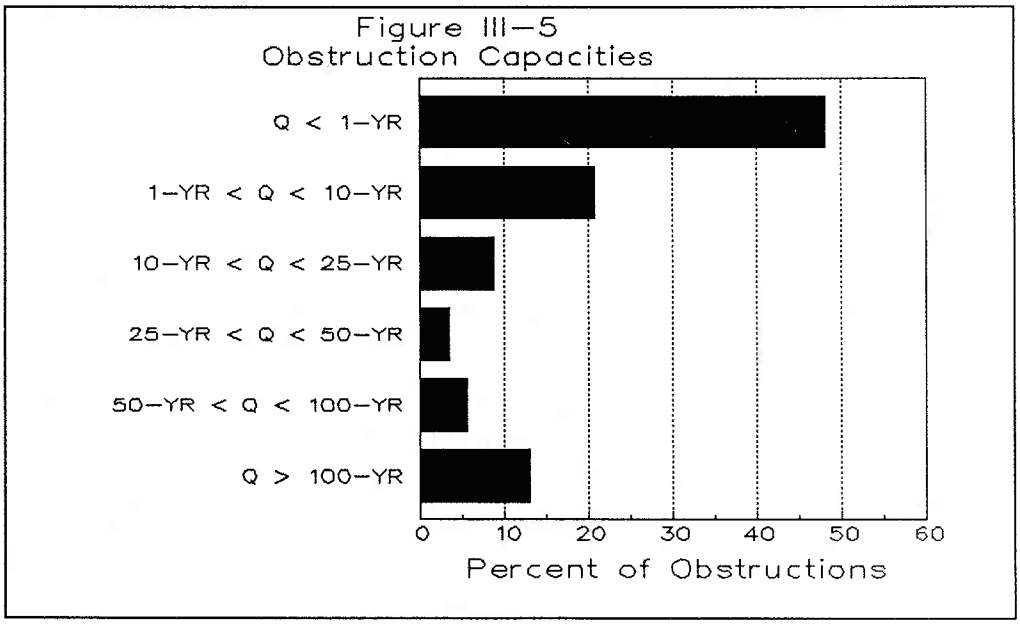
Effective stormwater management ordinances will prevent upstream development from aggravating existing flooding problems. Flood plain management ordinances and zoning ordinances, when effectively enforced can provide a means of managing development in flood prone areas so as to: 1) limit the development of land which is exposed to flood damage where appropriate; 2) guide development of proposed construction away from locations which are threatened by flood hazards; 3) reduce damage caused by floods. All of the municipalities in the watershed required under Act 166 to adopt flood plain management ordinances have done so. The adoption and enforcement of effective flood plain management ordinances is an important adjunct to stormwater management and should be afforded a high priority for implementation.

STREAM OBSTRUCTIONS

Stream obstructions are defined as structures or assembly of materials which may impede, retard or change flood flows. Typical obstructions include bridge crossings, culverts, piers, suspended pipelines, etc.. Information describing the dimensions, condition and flow capacity of approximately 429 separate stream obstructions was developed during the preparation of this plan. The approximate locations of these obstructions are illustrated in Plate III-4 (located in the map pocket appended to this report).

CAPACITIES

The capacities of the obstructions were calculated based upon field measurements and the application of procedures outlined in the U. S. Department of Transportation's publication *Hydraulic Design of Highway Culverts*. The calculated capacities represent full, but not surcharged conditions and, in most cases, inlet control conditions. Calculated obstruction capacities are presented in Table A-1, located in Appendix A. Capacities are presented in terms of adequacy as compared to estimated flood peaks at each location for various flood return frequencies. The flood peaks were estimated using the basin transfer method for estimating flood peaks based upon measured flood frequency data collected in a neighboring watershed. Preliminary estimates of peak discharges at various frequencies were developed by transferring Abers Creek discharge / frequency estimates to each of the subwatersheds in the Monongahela River basin. The Abers Creek data were developed through the statistical analysis of gauged records for a period of over thirty years. This method parallels the method employed during the preparation of local Flood Information Studies. Obstruction capacity data for the watershed are summarized in Figure III-5.



OBSTRUCTION CONDITIONS

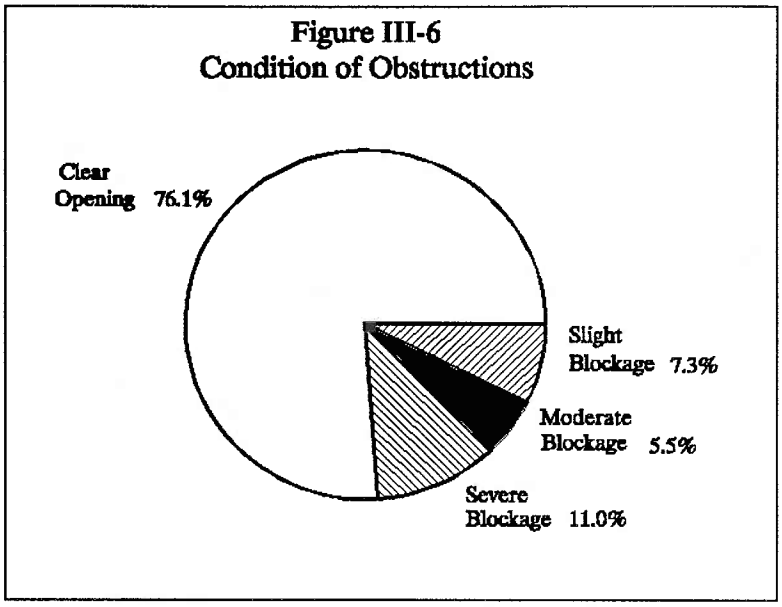


Figure III-6
Condition of Obstructions

The survey of stream obstructions also provided information characterizing their condition. The field data acquired indicate that sedimentation and/or accumulations of vegetation in the stream openings of the obstructions is evidenced in a relatively small but significant number of locations throughout the watershed. As is indicated in Figure III-6, the openings of roughly 24% of the obstructions surveyed contained observable amounts of sediment/debris. In roughly 16.5% of the cases, the degree of deposition can be classified as moderate to severe. The accumulation of debris in what should be the clear openings of culverts and bridges reduces the hydraulic capacity of the structures and increases the risk of flooding. The maintenance of clear openings under stream crossings, while not strictly speaking a stormwater management function, should be given a high priority by the responsible agencies in the watershed.

FLOOD CONTROL FACILITIES

EXISTING FLOOD PROTECTION FACILITIES

The State Water Plan identifies the following as having beneficial flood protection impacts within this watershed.

- Tygart Reservoir
- Youghiogheny River Lake

These two reservoirs lie outside of the limits of the watershed, but their impacts relative to flood protection are reported to extend into the portion of the Monongahela River watershed covered by this plan.

The Flood Information Study prepared for the City of Clairton identifies a floodwall located on the west bank of the Monongahela River from river mile 19.61 to 20.61. This flood wall was constructed in the early 1900's and added to in the 1950's.

The Municipal Questionnaire completed by the City of Pittsburgh identifies recently (1990) constructed storm sewers along West Run Road from Hamilton to Little as providing local flood protection.

PROPOSED FLOOD CONTROL FACILITIES

A flood control dam has been proposed for construction upstream of Weston, West Virginia, on the West Fork River. Another flood control dam has been proposed for construction on the Cheat River at Rowlesburg, West Virginia. If constructed, these two flood control facilities will serve to control flooding of the Monongahela River. However, these facilities will be located remote from the watershed and will have no effect on stormwater runoff generated within the portion of the watershed addressed by this Plan.

The City of Pittsburgh reports the following proposed local flood control projects:

- Boundary Street relief sewer and outfall project in the Four Mile Run watershed (project expected to be completed in 1992)
- Streets Run flood protection project (April 1990 Report by the PA Department of Environmental Resources recommends against the construction of flood protection based upon cost/benefit factors).
- Sanitary interceptor sewer improvements in the Streets Run watershed (in preliminary study phase)
- Culvert replacement in the Becks Run watershed (no action begun)

STORM SEWER SYSTEMS

EXISTING AND FUTURE STORM SEWER SYSTEMS

Most of the developed areas of the watershed are served by storm sewer systems, of either the combined or separate type. The locations of storm sewer systems essentially match the locations of concentrations of urban land use categories. Therefore, the location of these land use categories as displayed on the map of existing land use presented later in this section provides a good approximation of the location of existing storm sewer collection systems. In general, combined sewer systems predominate in the older developed areas. Essentially all of the City of Pittsburgh and the municipalities lying along the Monongahela River are served by combined sewer system. Separate storm sewers predominate in the more recently developed and currently developing areas of the watershed.

Future storm sewer system construction will occur as residential and commercial development progresses. The locations of future storm sewer systems will approximate the locations of anticipated future residential and commercial development as presented later in this section. The timing of new storm sewer construction will parallel that of new development in general.

FINANCING STORM SEWER CONSTRUCTION

Under current practice and conditions, most if not all major new storm sewer construction is performed by and paid for by private developers. Consequently, the construction of new storm sewers in the watershed will essentially be financed by

private land developers and paid for by the purchasers of the property. The costs incurred by municipalities in relation to such construction will be minimal.

STORMWATER CONTROL FACILITIES

EXISTING AND FUTURE STORMWATER CONTROL FACILITIES

The survey of Monongahela River watershed municipalities conducted during the preparation of this plan requested information relative to current and planned stormwater control facilities. The City of Pittsburgh was the only municipality which reported such facilities. This was a proposed parking detention system within the Four Mile Run watershed.

PRESENT AND FUTURE LAND USE

Current land use in the watershed is extremely diverse. Existing land use / land cover patterns are displayed on Plate III-5. This information was determined based upon the analysis of satellite imagery and high altitude photography obtained in 1988 and 1990.

Table III-7 contains estimates of current land use statistics within the Monongahela River watershed.

TABLE III-7
CURRENT LAND COVER / LAND USE STATISTICS

Land Cover Description	Percent of Watershed
Residential	24.2
Commerical/Industrial/Paved	15.2
Agricultural	3.3
Forest/Meadow	49.8
Unreclaimed Strip Mine	0.9
Other Open Space	2.0
Water	4.6

Land use ranges from the extremely dense commercial urban areas of the "Golden Triangle" area of the City of Pittsburgh to the essentially rural areas in Jefferson and Elizabeth Township. High density residential, commercial and industrial land use classes predominate in the northern areas of the watershed and in the areas immediately adjacent to the Monongahela River. The density of commercial and residential development generally decreases as one moves southward and away from the banks of the Monongahela River. In the upper reaches of the south-most portions of the watershed, open space and agricultural land uses predominate.

Table III-7 contains population densities for each of the municipalities in the watershed. The data presented therein is indicative of the wide variation in development density in the watershed.

TABLE III-7
POPULATION DENSITIES

Municipality	Population Density (Per./sq. mi.)
Baldwin Borough	3,779.8
Braddock Hills Borough	2,026.0
Brentwood Borough	7,730.7
Clairton City	3,448.6
Dravosburg Borough	2,377.0
Duquesne City	4,736.1
East McKeesport Borough	6,695.0
Edgewood Borough	5,968.3
Elizabeth Borough	4,025.0
Elizabeth Township	656.8
Forward Township	205.1
Glassport Borough	3,283.5
Homestead Borough	6,965.0
Jefferson Borough	574.3
Liberty Borough	1,960.0
Lincoln Borough	237.4
McKeesport City	5,203.2
Mt. Oliver Borough	13,866.7
Munhall Borough	5,720.9
North Braddock Borough	4,690.7
North Versaillles Township	1,518.8
Penn Hills, Municipality of	2,709.4
Pittsburgh City	6,652.5
Port Vue Borough	4,219.1
Rankin Borough	6,257.5
Swissvale Borough	8,864.2
West Elizabeth Borough	3,170.0
West Homestead Borough	2,772.2
West Mifflin Borough	1,665.1
Whitaker Borough	4,720.0
Whitehall Borough	4,379.1
White Oak Borough	1,307.6
Wilkinsburg Borough	9,165.2

Potential future land development patterns in the watershed were estimated by performing a series of exclusionary and proximity GIS analyses in order to identify "prime" potential development areas and estimate the type of development which may occur. Areas in the watershed which are currently developed and/or which lie on slopes greater than 25% were excluded from future land development. Of the remaining land areas, areas within approximately 2,000 feet of identified heavy and medium duty roads were identified as "prime" development areas. Future land cover in these areas was estimated by converting current land cover to either low density residential, medium density residential or commercial land coverages depending on the general nature of development in the area and the distance from the roadway.

Projected future land use / land cover patterns are indicated on Plate III-6. Projected future land cover statistics are presented in Table III-8.

TABLE III-8
PROJECTED FUTURE LAND COVER STATISTICS

Land Cover Description	Percent of Watershed
Residential	57.2
Commerical/Industrial/Paved	18.2
Agricultural	1.2
Forest/Meadow	16.6
Unreclaimed Strip Mine	0.2
Other Open Space	2.0
Water	4.6

MONONGAHELA RIVER WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION IV
WATERSHED TECHNICAL ANALYSIS - MODELING

INTRODUCTION

The requirement for assessing the watershed wide impact of the implementation of stormwater runoff controls demands the use of computer hydrologic modeling techniques to estimate stormwater runoff rates under various conditions. Digital computer modeling refers to the use of sets of mathematical expressions (algorithms) to reproduce key behavioral aspects of the natural system. This section contains a discussion of the modeling approached used in the preparation of the Monongahela River Watershed Stormwater Management Plan.

MODEL SELECTION

There are a number of hydrologic modeling techniques available for estimating stormwater runoff based upon ground cover and precipitation conditions. The Penn State Runoff Model (PSRM) was selected for use in the Monongahela River Watershed. PSRM was selected for use in this watershed for a number of reasons, including:

1. PSRM offers the ability to analyze the timing of flow combinations originating from various locations throughout a watershed. This capability is particularly important in the evaluation of the effects of various stormwater control techniques throughout a watershed.

2. PSRM is suitable for use for both urban and rural watersheds.

3. PSRM offers flexible data input and output modes.

4. PSRM is accepted for use throughout Pennsylvania for the preparation of watershed stormwater management plans under Act 167.

5. Personnel at the Allegheny County Department of Planning are familiar with the use of PSRM.

6. The utilization of PSRM will maintain consistency with past and on-going Act 167 planning in Allegheny County.

DATA COLLECTION AND PREPARATORY ANALYSIS

OVERVIEW

Input data requirements for PSRM include the following parameters:

1. Watershed Representation Data

   A. Tributary Area (Subbasin) Physical Features

      1. tributary land areas
      2. land slopes
      3. overland flow lengths

   B. Tributary Area (Subbasin) Hydrologic Features

      1. composite runoff curve numbers
      2. percentage imperviousness
      3. initial abstraction estimates

   C. Drainage (Reach) System Features

      1. conveyance system (streams and conduits) capacities
      2. roughness coefficients
      3. conveyance system travel times
      4. characteristics of flow detention facilities

   B. Rainfall Inputs

      1. rainfall volumes
      2. rainfall distribution

A discussion of the general methods used to develop the necessary input data set for the Monongahela River watershed follows.

SUBBASIN PHYSICAL FEATURES

PSRM develops runoff hydrographs for individual portions (subbasins) of a watershed which are then routed and combined in a manner corresponding to the network of streams that link the subbasins. Consequently, the initial task in the development of the modeling data base was the delineation of subbasins within the watershed. The designated Monongahela River watershed actually consists of a number of small to moderately sized streams which drain to the Monongahela River; areas along the banks of the river which drain directly to the Monongahela essentially through overland flow; and highly urbanized areas which are served by extensive and complex storm and combined sewer systems. Therefore the overall watershed was first divided into subwatersheds. These subwatersheds, in turn, were further divided into subbasins. Subwatersheds were delineated based upon topographic features so as to 1) define the major stream drainage basins ; and 2) provide coverage of the entire watershed. Delineated subwatersheds and selected characteristics are listed in Table IV-1 and delineated in Plate IV-1. Plate IV-1 is Appended to the rear of this report.

TABLE IV-1
DELINEATED SUBWATERSHEDS

Stream / Area	Tributary Area (Acres)	Developable Area (%)
MODELED SUBWATERSHEDS		
Becks Run	1,668	30
Beckets Run	1,981	73
Belle Bridge Stream	296	59
Bunola Run	551	87
Coal Valley Run	2,030	59
Courain Hill Stream	515	74
Crooked Run	1,798	35
Curry Hollow Run	856	44
Fallen Timber Run	2,956	69
Homestead Run	1,798	24
Kelly Run	1,426	83
Lobbs Run	2,468	79
Mill Run	2,463	71
River Hill Stream	410	77
River Mile 5.0 Stream	111	93
River Mile 9.7 Stream	640	42
River Mile 22.0 Stream	361	41
River Mile 23.5 Stream	587	48
Smiths Run	101	69
Sunfish Run	971	76
Streets Run	6,820	41
Thompson Run	3,870	43
West Run	994	29
Wylie Run	2,516	77
SUBWATERSHEDS NOT MODELED		
EXTENSIVELY URBANIZED AREAS		
Nine Mile Run	3,145	16
River Mile 10.0 Stream	828	12
Panther Hollow	2,152	6
Braddock area	141	12
Clairton area	864	20
Downtown Pittsburgh / Oakland area	1,251	7
Duquesne area	680	5
Edgewood / Swissvale area	982	13
Hazelwood / Glenwood area	1,333	20
Homestead area	652	2
McKeesport area	831	11
South Side Pittsburgh area	1,429	11
West Elizabeth area	160	20
West Mifflin (eastern area)	504	10
DIRECT RUNOFF AREAS	5,996	37

As is indicated in Table IV-1, 65% of the designated Monongahela River watershed was included in the detailed modeling effort. Approximately 25% of the watershed was not modeled because these areas are extremely highly urbanized (remaining developable area less than or equal to 20%). In these areas, the stormwater effects produced by the limited future development which can occur can be adequately managed by the institution of uniform control standards. Therefore, there was no need to complete the complex and expensive modeling of the extensive storm drainage facilities which serve these areas. Finally, approximately 10% of the watershed was not modeled because they drain directly to the Monongahela River through no discernable stream channel network. Consequently, appropriate runoff controls for those can be devised as uniform standards without the need for modeling.

Subbasin boundaries comprising the modeled subwatersheds were defined so as to as closely as practical produce hydrologically homogeneous areas as well as to adequately model hydrologically significant features such as tributaries, major storm sewers, and significant obstructions. A total of 340 subbasins were delineated.

United States Geological Survey (U.S.G.S.) 7.5 minute quadrangle topographic mapping supplemented with field investigations of obstructions was used as the basis for defining subwatersheds and subbasins. The subbasin boundaries were delineated on the U.S.G.S. base and digitized to facilitate subsequent analysis. Once digitized, the subbasin areas were calculated. Subbasin areas average 113 acres in size.

Stream locations were digitized and added to the data base. Representative overland flow widths for each subbasin were calculated based upon an analysis of the digitized stream locations and subbasin boundaries.

Digital Elevation Model (DEM) data obtained from U.S.G.S. served as the source of digital terrain data used to produce slope summaries for each subbasin. DEM quadrangles were mosaicked to fully cover the watershed. Slope in percent and aspect in degrees were calculated from the raw elevation data and were used to determine representative ground slopes for each of the subbasins.

SUBBASIN HYDROLOGIC CHARACTERISTICS

The principal subbasin specific hydrologic characteristics of interest in this analysis are the composite Soil Conservation Service (S.C.S.) runoff curve number and percentage of impervious area for each subbasin. Percent of impervious area is defined as the percentage of the total subbasin area covered by surfaces which are essentially impermeable to water. The runoff curve number is a indication of the amount of surface runoff which may be expected to be produced as a result of a storm event. This runoff potential is influenced by land cover and soil conditions. The determination of impervious percentages and curve numbers required the classification of land cover and soil types.

Land Cover / Land Use Classification

National High Altitude Program (NHAP) color infrared transparencies and Landsat thematic mapper multispectral digital data were used to provide the necessary land use and land cover information.

Impervious Area Statistics

Impervious area statistics for each subbasin were estimated based upon the land cover and land use through the relationships of impervious area components of various land use / land cover classes developed and published by the U.S. Soil Conservation Service.

Soils Group Classifications

The spatial distribution of soils (aggregated by S.C.S. hydrologic soil groups) was defined through the use of S.C.S. soils maps and reports for Allegheny and Washington counties. The various soil types were aggregated into the appropriate hydrologic soil groups based upon U.S. Soil Conservation Service (S.C.S.) procedures. The hydrologic soil group polygons were transferred from the S.C.S. plats to stable-base mylar, registered to the U.S.G.S. base and digitized. This procedure produced the data set used to create the hydrologic soil group map presented previously in Section III.

Calculation of Runoff Curve Numbers

The factors that determine runoff curve numbers (CN) are the hydrologic soil group and land cover type and condition. The S.C.S. has developed and published tables which provide runoff curve numbers for each intersection of hydrologic soil group and land cover type. Information extracted from the S.C.S. literature was used to assemble the CN matrix of land use / land cover characteristics versus hydrologic soil group displayed in Table IV-2.

Geographic Information system (GIS) methods were used to digitally combine the land use / land cover and hydrologic soil group themes to yield a set of associations between surface type and soils units. These associations were referenced to the S.C.S. information to attach the appropriate runoff curve number. Further processing within the GIS determined composite runoff curve numbers for each of the subbasins in the watershed.

Modeling Subbasin Data File Production

All of the subbasin information necessary for PSRM modeling was represented in the GIS system as digitized themes. Once these data were resident in the GIS, the necessary analyses were performed to develop the required PSRM input data set. This data set is common to all subwatersheds and subbasins in the watershed and is keyed to assigned subbasin identification numbers. The version of PSRM used in this modeling effort has the capability of reading the appropriate individual subbasin characteristics data directly from the common subbasin data file.

TABLE IV-2
LAND COVER / HYDROLOGIC SOIL GROUP
CURVE NUMBER MATRIX

Land Use / Land Cover	HSG B	HSG C	HSG D
Water	100	100	100
Heavy Industry	90	90	95
Industry	88	91	93
Commercial	92	94	95
Pavement	99	99	99
High Density Residential	75	83	87
Medium Density Residential	70	80	85
Forest	60	73	79
Mixed Forest and Meadow	65	76	82
Meadow	69	79	84
Golf Courses, Parks, etc.	69	79	84
Poor Condition Grass	79	86	89
Cropland	75	82	86
Strip Mines	99	99	99
Heavy Industry on Strip Mine	94	97	99
Industry on Strip Mine	94	97	99
Commercial on Strip Mine	94	96	97
High Den. Res. on Strip Mine	79	87	91
Med. Den.Res. on Strip Mine	76	86	91
Forest on Strip Mine	70	83	89
Mixed Forest on Strip Mine	80	91	97
Meadow on Strip Mine	86	96	99
Cropland on Strip Mine	87	94	98

STREAM REACH HYDRAULIC CHARACTERISTICS

Important input data requirements of the PSRM are estimates of the times of travel in each of the modeled stream reaches and the bankfull capacity of each reach.

Travel Time Estimates

Travel time is calculated as the length of the reach divided by the average velocity. Stream reaches were defined in conjunction with the delineation of watershed subbasins as described previously. The length of each reach was determined by direct measurement from the U.S.G.S. maps. Stream reach velocity estimates were based upon cross section information available from Flood Insurance Studies (FIS) completed within the watershed. This data was used in conjunction with empirical relationships between stream cross section measurements, discharge and mean velocity to produce velocity estimates for stream reaches for which no FIS information is available. Velocities for improved (i.e. channelized) stream reaches and major storm sewers and long culverts were calculated based upon reported and/or field measured dimensional and slope information.

Estimated velocities were divided by measured lengths to produce estimates of times of travel for each stream reach for input into PSRM.

Bankfull Capacity Estimates

The estimation of bankfull capacities in the natural stream reaches in the Monongahela River watershed was performed based upon information reported in the literature which essentially states that bankfull capacities in natural streams approximate the 2-year return frequency flood discharge rate (Leopold, 1953; Brush, 1961; Harvey, 1969; and Brown, 1979). The estimates of the 2-year flood for each stream reach were determined by transferring the Abers Creek discharge / frequency data to each of the subwatersheds in the basin. The Abers Creek data were developed through the statistical analysis of United States Geological Survey gauged streamflow data for a period of over 30 years. Discharges calculated using this procedure were used as initial bankfull capacity estimates for natural stream reaches.

Full flow capacities for improved stream reaches and major storm sewer pipes or culverts were calculated based upon slope and dimensional information.

Modeling Stream Reach Data File Production

The stream reach data required for PSRM modeling of the watershed was compiled into a single reach data file. This input file contains stream time of travel and capacity data keyed to each of the identified reaches modeled during this planning effort.

RAINFALL CHARACTERISTICS

Rainfall Intensity-Duration-Frequency

Rainfall depth-duration-frequency (DDF) values for the Monongahela River watershed are summarized in Table IV-3.

These data were calculated using the charts describing rainfall intensity-duration-frequency (IDF) data presented in the Pennsylvania Department of Transportation IDF Field Manual. This document divides the state of Pennsylvania into five regions of relatively uniform rainfall patterns. Intensity-duration-frequency and depth-duration-frequency (DDF) relationships for each of the five regions are presented in the form of design charts. The Monongahela River watershed lies both in Regions 2 and 3. Rainfall depth-duration-frequency values were calculated for the Monongahela River watershed by averaging the indicated values for Regions 2 and 3.

TABLE IV-3
RAINFALL DEPTH, DURATION AND FREQUENCY DATA

Return Period (Years)	Storm Duration (Hours) 3	6	12	24
2	1.49	1.77	2.10	2.50
5	1.84	2.19	2.61	3.10
10	2.14	2.55	3.03	3.60
25	2.62	3.11	3.70	4.40
50	2.97	3.54	4.20	5.00
100	3.39	4.03	4.79	5.70

Rainfall Distribution

The distribution of rainfall within the overall storm event relevant to the modeling effort. The U.S. Soil Conservation Service (SCS) has developed synthetic rainfall distribution patterns which include maximum rainfall intensities for the selected design frequency arranged in a sequence that is critical for producing peak runoff. SCS has developed four synthetic distributions from available National Weather Service data. The SCS Type II distribution represents design storm conditions appropriate for the Monongahela River watershed.

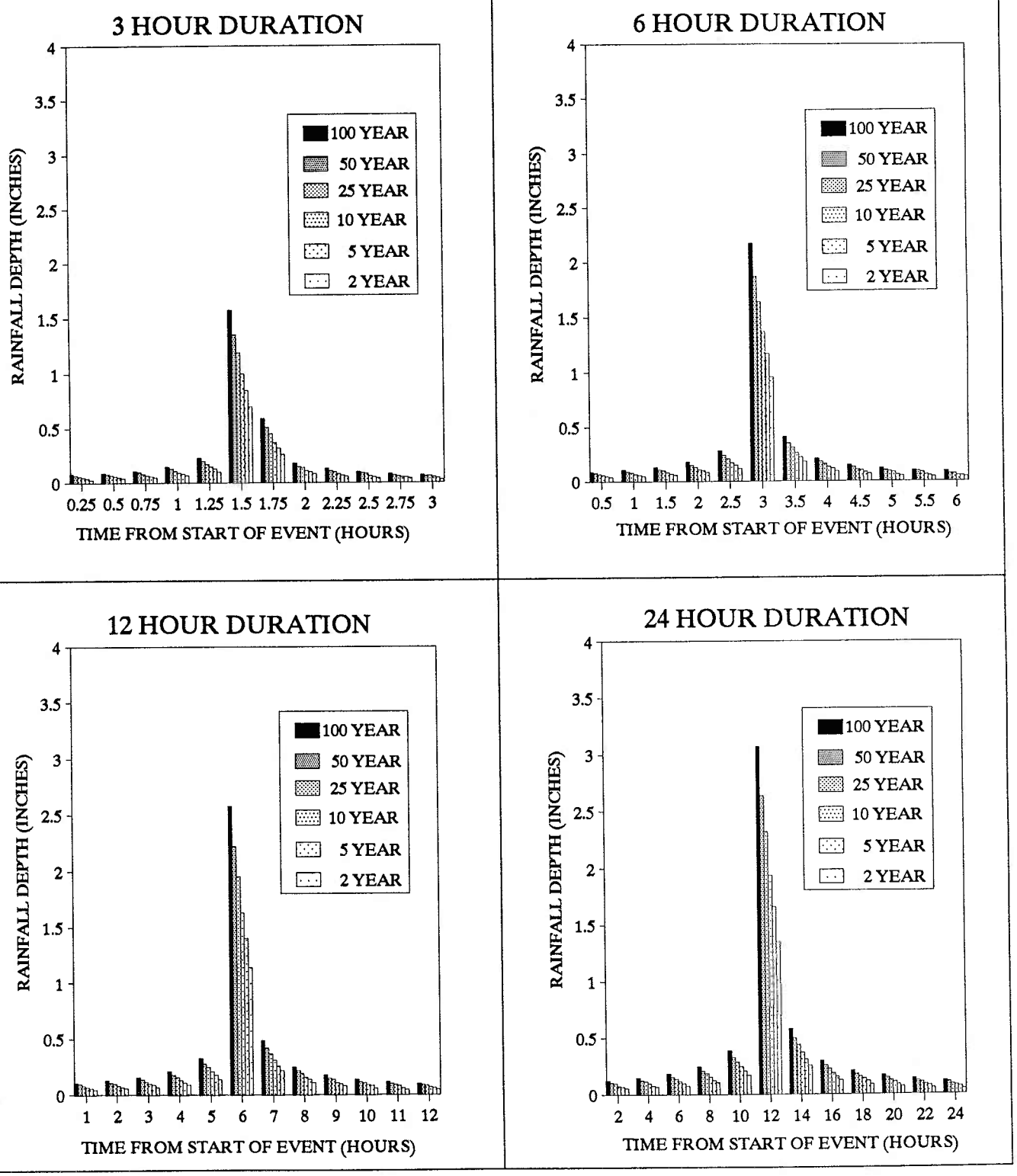
Other candidate storm distribution patterns for application in the Monongahela River watershed are the composite rainfall distribution and historic average patterns. The composite rainfall distribution attempts to represent conditions critical to peak runoff rates while the historical average pattern represents actual local average rainfall distribution patterns. The historical pattern for the Monongahela River watershed was produced through an analysis of rainfall records for the 1950 to 1987 period as measured at the USGS rainfall gaging station at Murrysville.

Since the SCS Type II storm distribution is supported by significant research activity, is widely used in stormwater runoff calculations throughout the area and its use is incorporated directly in the frequently employed SCS stormwater runoff computational procedures it was selected for use in the Monongahela River watershed model. Rainfall hyetographs for various durations and return frequencies constructed using the SCS Type II storm distributions are presented in Figure IV-2.

MODEL CALIBRATION / VERIFICATION

As was discussed in Section III, there are no continuously recording stream gages are in operation in the Monongahela River watershed. Attempts were made to gather simultaneous rainfall and streamflow information sufficient to calibrate / verify the model against observed, event specific data gathered within the watershed.

Figure IV-1
Monongahela River SCS Type II Storm Distributions



To this end, a network of stream gauges and rainfall records was installed and operated as part of this planning effort. Continuously recording stream gauges were installed on the following streams: 1) Becks Run, 2) Lobbs Run and 3) Curry Hollow Run. These gauges were placed in order measure stream flow depths which could be converted to discharge rates. A corresponding network of three recording ranges was installed to measure rainfall in each of the watersheds. The data collected in this manner was to have provided coincidental rainfall / streamflow measurements which was to have been used to calibrate the model.

The network of gauges was operated for a three month period from June 3, 1991 through September 6, 1991. This period coincided with a regional drought. While several rainfall events were captured, all of events were unsuitable for calibration purposes for several reasons: 1) the events were generally small in magnitude; 2) the events were of short duration; 3) the storms consisted of scattered thundershowers which very uneven spatial distributions; and 4) the drought conditions represented very atypical antecedent soil moisture conditions. Due to these factors, it was not feasible to use event specific rainfall events to calibrate the model.

As an alternative, the model was evaluated against flood frequency / discharge estimates developed for the modeled streams in the watershed. The first step in this process consisted of developing estimates of the flood peaks of various return frequencies for the major streams to be modeled. This was accomplished by using the basin transfer method to transfer the observed flood frequency / discharge relationships reported for the Abers Creek watershed to the streams in the designated Monongahela River watershed. It is important to note that Abers Creek lies only several miles from the study area and also drains to the Monongahela River through Turtle Creek. Consequently, the flood / frequency relationships exhibited by Abers Creek can be expected to be representative of the streams modeled under this plan. The basin transfer calculation was performed using the standard equation:

$$Q_1 = Q_2(A_1/A_2)^a$$

Where: Q = peak discharge
A = drainage area
a = exponent = 0.8

The value of the exponent (0.8) was selected based upon similar analyses reported in several Flood Insurance Studies completed in the watershed which used the same procedure. Flood peaks were estimated using this method for the mean annual, 5, 10, 25, 50 and 100 year return frequency events. Each of the major subwatersheds was then modeled using PSRM using rainfall events with the same return frequencies (i.e. mean annual, 5, 10, 25, 50 and 100 year storms). Four storm durations (3, 6, 12 and 24 hour storms) were modeled, creating a family of flood frequency duration curves for each of the watersheds. The rainfall events were distributed in accordance with the S.C.S. Type II Distribution. The model output is compared to the statistically derived flood frequency in the charts presented in Figures IV-2 through IV-5. As these charts indicate, the model results generally bracket the statistically derived estimates. This indicates that the model reasonably approximates actual conditions.

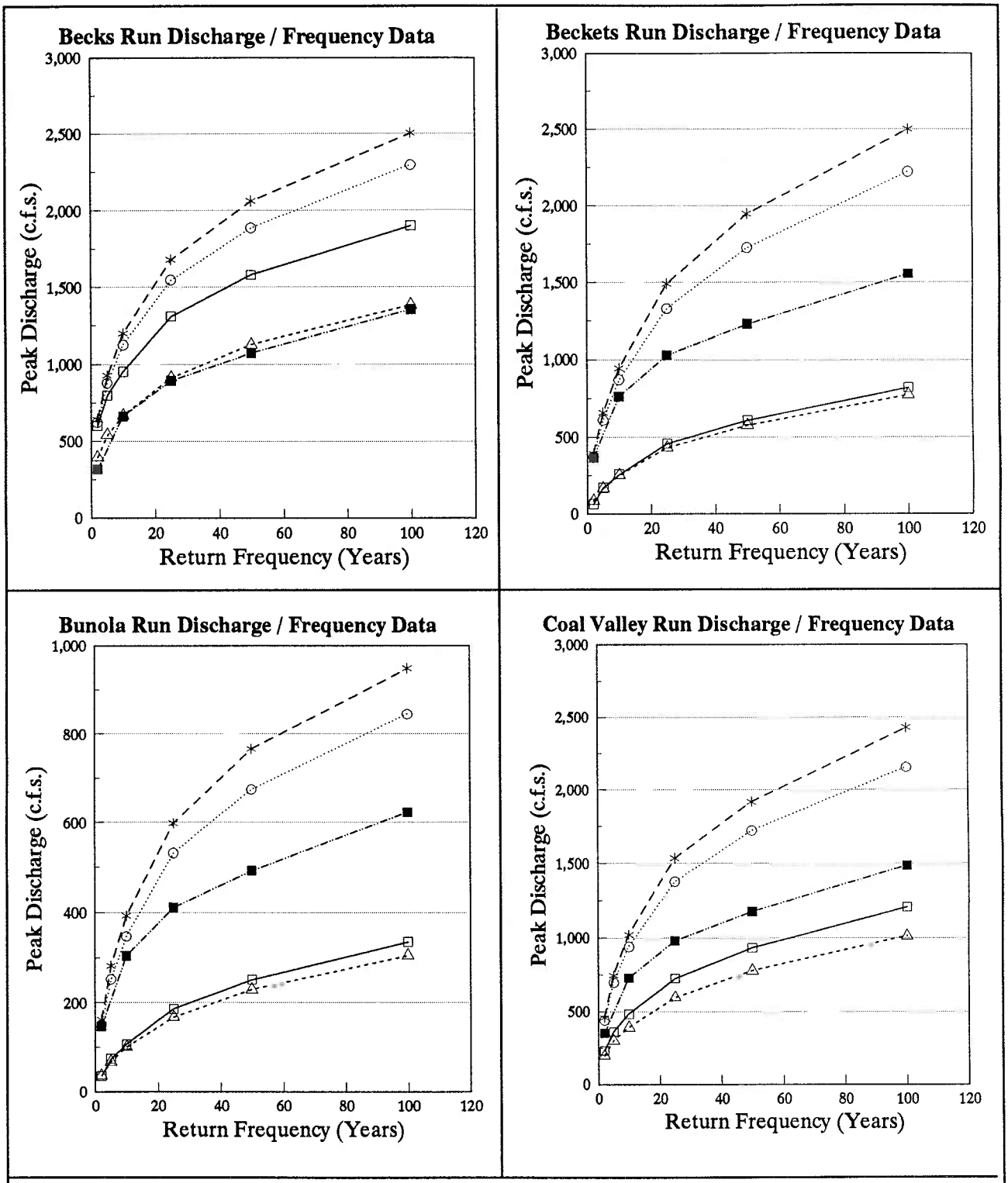

Becks Run Discharge / Frequency Data
Peak Discharge (c.f.s.)
Return Frequency (Years)
Beckets Run Discharge / Frequency Data
Peak Discharge (c.f.s.)
Return Frequency (Years)
Bunola Run Discharge / Frequency Data
Peak Discharge (c.f.s.)
Return Frequency (Years)
Coal Valley Run Discharge / Frequency Data
Peak Discharge (c.f.s.)
Return Frequency (Years)
3 - Hour Duration
6 - Hour Duration
12 - Hour Duration
24 - Hour Duration
Gauged Estimate

FIGURE IV-2

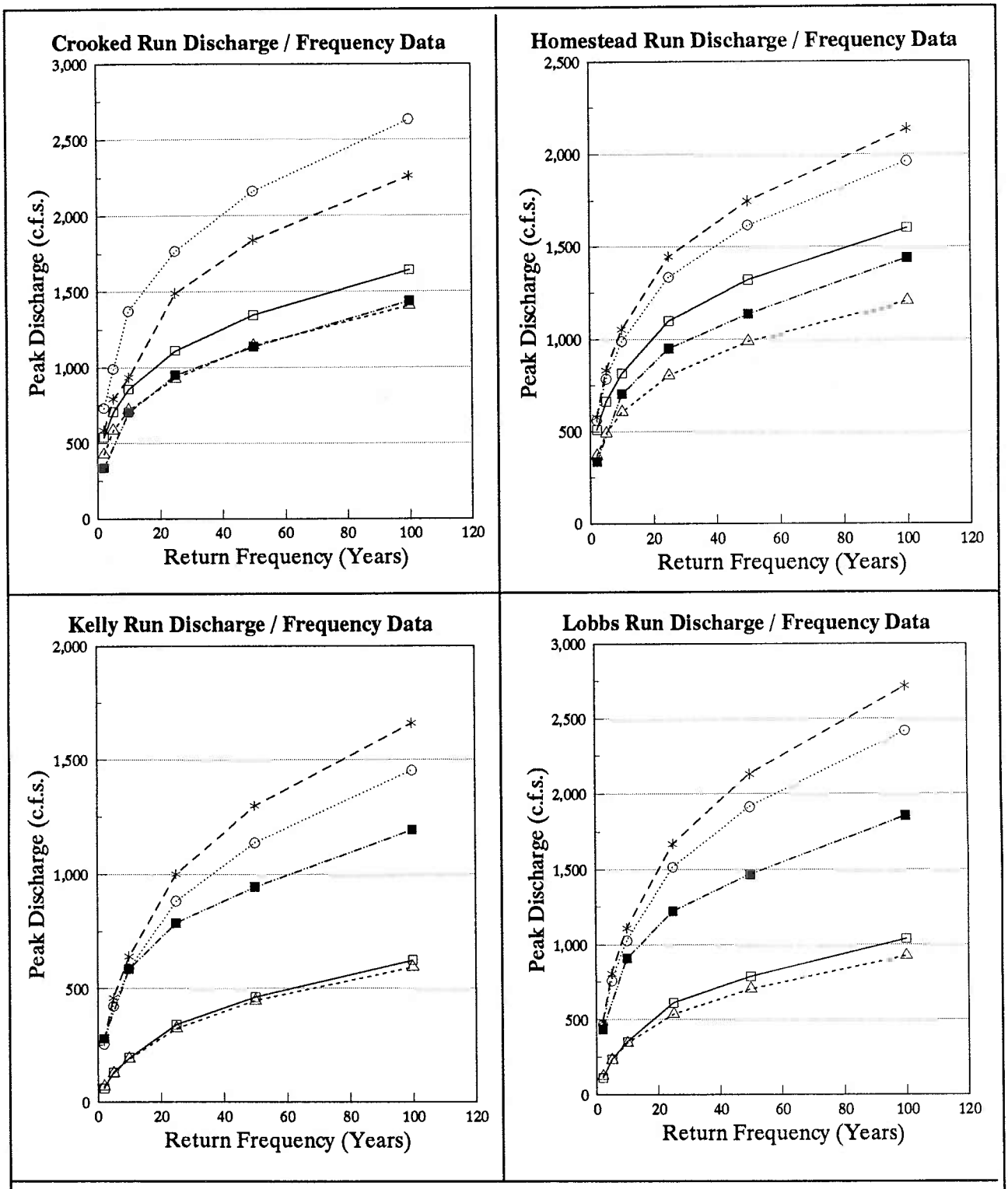

Crooked Run Discharge / Frequency Data
Peak Discharge (c.f.s.)
Return Frequency (Years)
Homestead Run Discharge / Frequency Data
Peak Discharge (c.f.s.)
Return Frequency (Years)
Kelly Run Discharge / Frequency Data
Peak Discharge (c.f.s.)
Return Frequency (Years)
Lobbs Run Discharge / Frequency Data
Peak Discharge (c.f.s.)
Return Frequency (Years)
3 - Hour Duration
6 - Hour Duration
12 - Hour Duration
24 - Hour Duration
Gauged Estimate

FIGURE IV-3

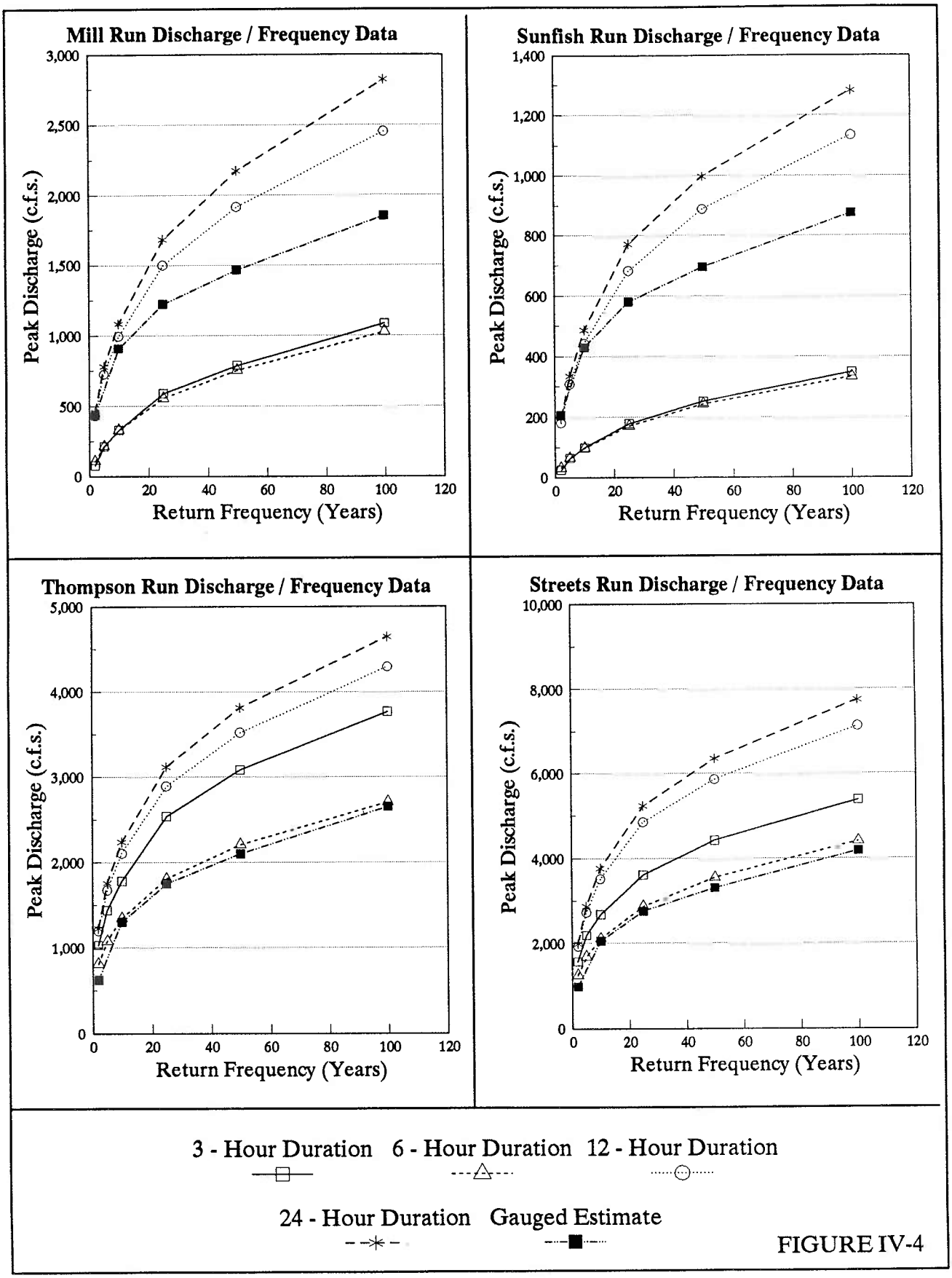
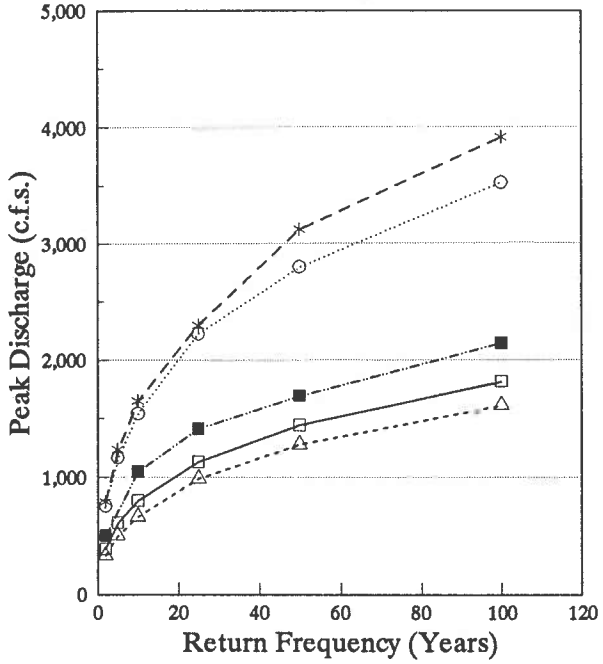
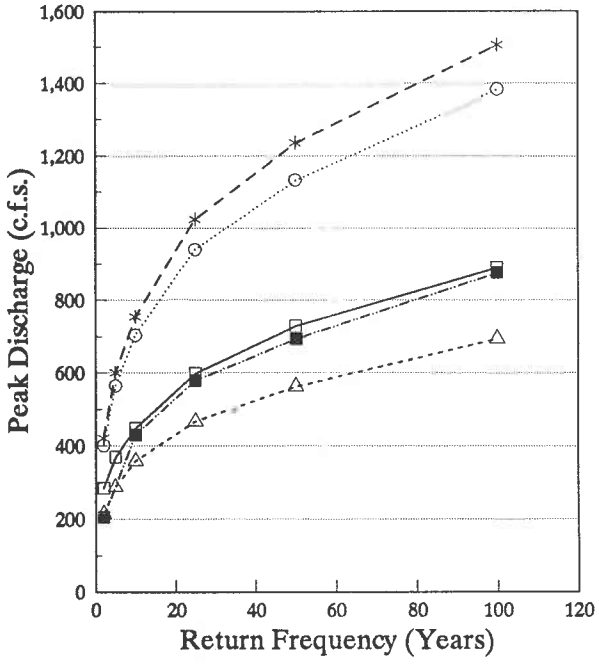
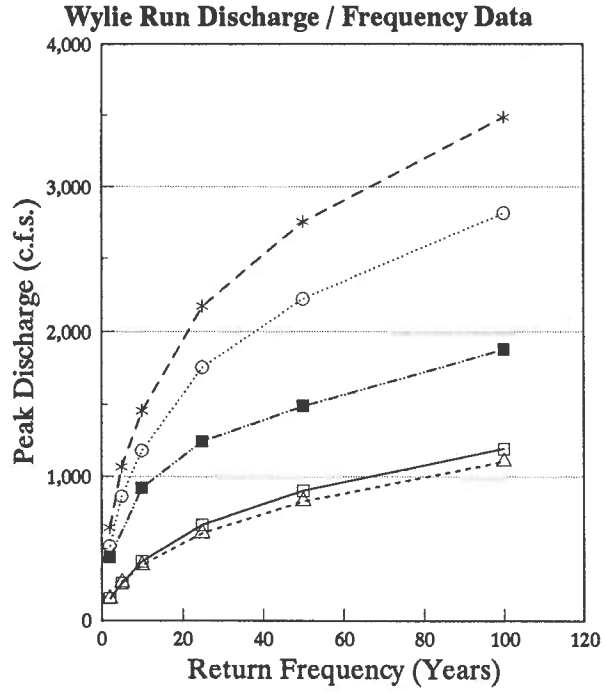

Mill Run Discharge / Frequency Data
Peak Discharge (c.f.s.)
3,000
2,500
2,000
1,500
1,000
500
0
0 20 40 60 80 100 120
Return Frequency (Years)
Sunfish Run Discharge / Frequency Data
Peak Discharge (c.f.s.)
1,400
1,200
1,000
800
600
400
200
0
0 20 40 60 80 100 120
Return Frequency (Years)
Thompson Run Discharge / Frequency Data
Peak Discharge (c.f.s.)
5,000
4,000
3,000
2,000
1,000
0
0 20 40 60 80 100 120
Return Frequency (Years)
Streets Run Discharge / Frequency Data
Peak Discharge (c.f.s.)
10,000
8,000
6,000
4,000
2,000
0
0 20 40 60 80 100 120
Return Frequency (Years)
3 - Hour Duration
6 - Hour Duration
12 - Hour Duration
24 - Hour Duration
Gauged Estimate

FIGURE IV-4







3 - Hour Duration 6 - Hour Duration 12 - Hour Duration

24 - Hour Duration Gauged Estimate

FIGURE IV-5

The data illustrated in Figures IV-2 through IV-5 further indicate that, in most cases, the return frequency of flood peaks resulting from storms storms ranging in duration from 3 hours to somewhat less than 12 hours most closely approximate the statistically derived flood frequency relationships. The storms ranging from 12 to 24 hours in duration produce modeled flood peaks which are significantly higher than the statistical estimates. The data appears to indicate that storms of longer durations (12 to 24 hours) which exhibit rainfall distributions as severe as the S.C.S. Type II distribution occur more rarely than the rainfall-duration-depth-frequency relationships would indicate. As a result, these longer duration storms represent very conservative estimates of peak discharges of given return frequencies. It is important that the modeled results not be compared directly and uncritically with flood frequency estimates produced using statistical methods. It is particularly true for the longer duration storms that the rainfall - runoff model using the S.C.S. Type II Distribution will produce "worst case", conservative peak flow estimates that almost invariably exceed the statistically derived estimates.

MODEL RESULTS

EXISTING CONDITIONS

Runoff and streamflow rates were estimated under current conditions using the PSRM for each of the subwatersheds selected for detailed modeling. The model was run for the mean annual, 5, 10, 25, 50 and 100 return frequency volumes associated with 3, 6, 12 and 24 hour duration storm events. In all, model output was developed for 24 storm conditions for each of the 24 subwatersheds included in the modeling program. The results of this modeling effort are summarized in Appendix B.

In reviewing the model results, the reader's attention is redirected to the previous discussion concerning the observed variance between the rainfall - runoff model peak discharge estimates presented herein and estimates derived by others by applying statistical analysis techniques to measured flood peaks. It is important to recognize that the streamflow estimates developed as part of this plan have been developed by modeling the runoff produced by rainfall volumes with a range of return frequencies distributed according to the SCS Type II Distribution. Since this distribution is designed to maximize runoff from any given rainfall volume, this procedure produces conservatively high runoff rate estimates suitable for the design of local controls. The estimates presented herein should not be used in the design of regional flood control facilities or flood plain management projects. Estimates based upon flood frequency analyses of local gauged watersheds are more appropriate for these purposes.

FUTURE CONDITIONS

The PSRM was used to estimate runoff and streamflow rates under projected future development conditions. This was accomplished by revising the S.C.S. runoff curve number and percent impervious estimates in the model subbasin database to reflect the projected future land use / land cover characteristics as presented in Section III. The model was then run under these conditions to produce estimates of future runoff and streamflow rates for the 24 hour, 50 year return frequency storm. Model output for each of the modeled subbasins is provided in Appendix B and summarized at the mouth of each subwatershed in Table IV-4.

TABLE IV-4
COMPARISON OF EXISTING AND FUTURE PEAK DISCHARGES
(24 HOUR, 50 YEAR FREQUENCY EVENT)

Stream / Area	Existing Conditions (cfs)	Future Conditions (cfs)
Becks Run	2,060	2,290
Beckets Run	1,950	2,300
Belle Bridge Stream	370	430
Bunola Run	770	730
Coal Valley Run	1,880	2,390
Courain Hill Stream	560	670
Crooked Run	1,840	2,300
Curry Hollow Run	1,170	1,410
Fallen Timber Run	3,120	3,380
Homestead Run	1,750	1,970
Kelly Run	1,300	1,310
Lobbs Run	2,130	2,540
Mill Run	2,170	2,510
Smiths Run	150	190
Sunfish Run	1,000	1,030
Streets Run	6,350	6,840
Thompson Run	3,820	4,510
West Run	1,240	1,380
Wylie Run	2,760	3,150

MONONGAHELA RIVER WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION V

DEVELOPMENT OF WATERSHED TECHNICAL STANDARDS AND CRITERIA

INTRODUCTION

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

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

CONTROL STORM CHARACTERISTICS CRITERIA

A key element in the development of this stormwater management study is the definition of the characteristics of the rainfall events against which the developed control standards must be applied. Specifically, the rainfall events which the stormwater control measures must adequately handle need to be defined. The objective of the analyses discussed in the following paragraphs was to describe characteristics of storm events which will serve as the basis for the evaluation and design of effective control measures in the Monongahela River watershed.

The critical rainfall event characteristics are as follows:

1. An identified duration or length of the particular rainfall event.

2. An identified rainfall intensity or distribution or pattern of precipitation falling over the duration of the event.

3. An identified frequency of occurrence or the expected time interval between occurrences of the given precipitation event.

4. An identified volume or total amount of rainfall that can be expected for the particular event.

STORM DISTRIBUTION

The selection of the appropriate distribution of rainfall within the overall storm event was discussed in Section IV. For the reasons specified therein, the Soil Conservation Service (SCS) Type II rainfall distribution was selected for application to the development of control standards and the design of actions to be taken to satisfy those standards.

STORM DURATION

Storm duration refers to the length of time over which the specified amount of precipitation falls. This factor is of concern because rainfall duration has a direct effect upon the resulting runoff volume and peak rate of discharge. The length of the rainfall period contributing to the peak runoff rate is related to the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest (time of concentration). In general, largest peak discharges result when the storm duration roughly equals the time of concentration in the watershed.

In small watersheds the critical storm duration may be measured in minutes, while in large watersheds or basins the time of concentration may be measured in days. In the Monongahela River watershed, the appropriate storm duration for use in the development and application of control standards was selected using the hydrologic model. The PSRM was used to estimated peak discharge rates throughout the watershed for the mean annual, 5, 10 25, 50 and 100 year return frequency storms of the following candidate durations: 3 hour, 6 hour, 12 hour and 24 hours. The model runs produced estimates of the peak discharges at 432 points throughout the watershed for each of the four candidate durations. Nearly uniformly, the 24 hour duration storm produced the highest peak discharges. These results support the selection of 24 hours as the design storm duration for use in watershed management.

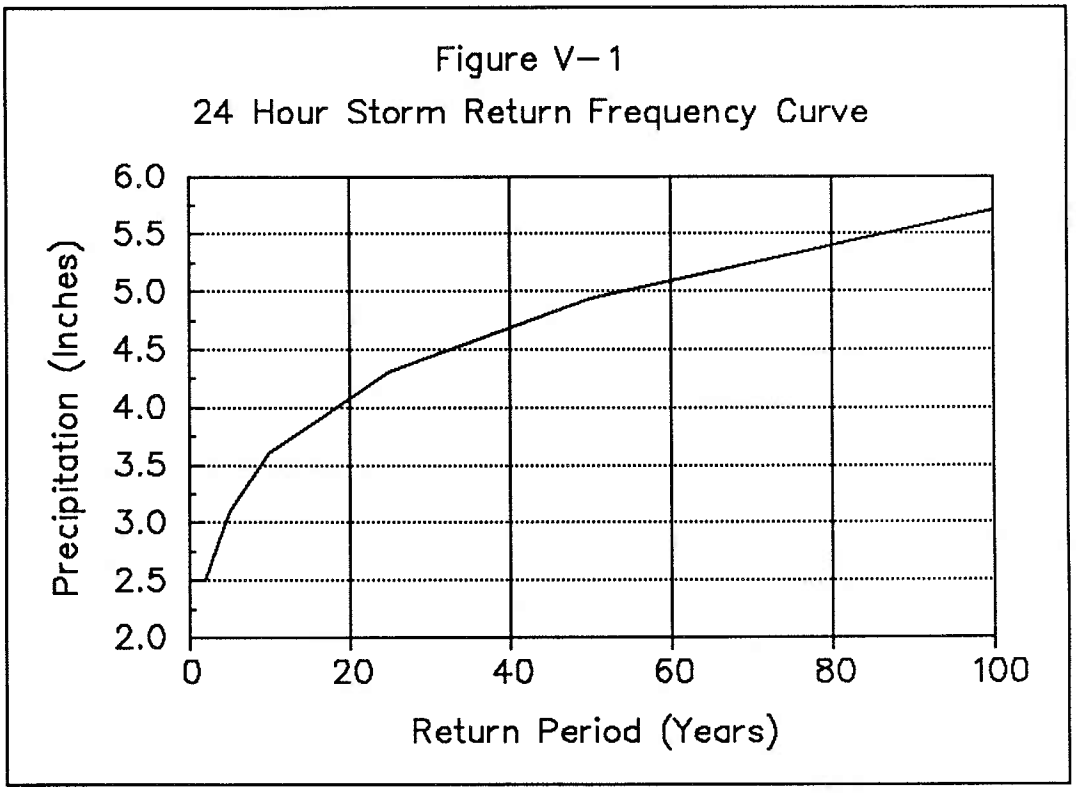
A supporting consideration in the selection of the storm duration for use in the Monongahela watershed is the fact that the popular Soil Conservation Service Technical Release 55 Urban Hydrology for Small Watersheds procedure for estimating runoff and peak discharges is based upon a 24-hour storm duration. This procedure is extensively used within the region and nationally in the production of stormwater control plans for proposed land development. Adoption of a storm duration criteria other than 24 hours would effectively preclude the use of this most popular computational procedure.

For the reasons discussed above, 24 hours has been selected as the appropriate storm duration criteria for application throughout the watershed. It is recognized that the use of shorter durations will be appropriate and permissible in the design of stormwater collection facilities. However, the selection and application of controls to the discharge of runoff from developing sites will be based upon the 24-hour storm duration criteria.

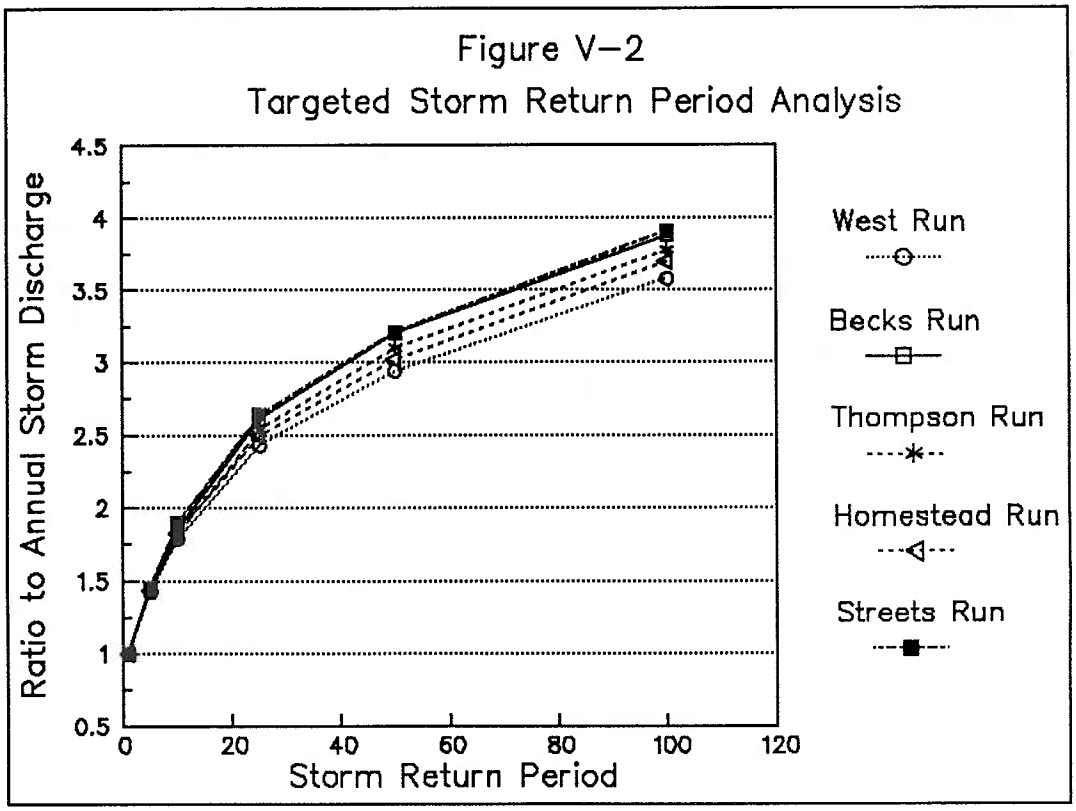
STORM RETURN FREQUENCIES AND PRECIPITATION VOLUMES

General

Storm return frequency refers to the average interval in years over which a storm event of a given precipitation volume can be expected to recur. For example, reference to a "10-year" storm with an associated 3.61 inch 24 hour duration storm volume indicates that a storm producing 3.61 inches of rainfall over a 24 hour period on the average can be expected to occur approximately every ten years. Another way to consider this storm is that, on the average, a storm producing 3.61 inches of rainfall over a 24 hour period has approximately a ten (10) percent chance of occurring in any given year. Storm duration and volumes for return frequencies ranging from 2-years to 100-years were presented previously in Section IV of this report (Table IV-2). This data is presented graphically below in Figure V-1.



As is indicated in Figure V-1, precipitation amounts increase with increasing return periods reflecting the obvious fact that the larger the rainfall event the more infrequent the occurrence. As one would expect, larger rainfall amounts produce larger stream discharges. This is illustrated in Figure V-2 for various streams in the watershed. The estimates of stream discharges reflected in Figure V-2 were produced using the Penn State Runoff Model developed for the Monongahela River watershed.



The Pennsylvania Department of Environmental Resources "Storm Water Management Guidelines" describe design frequencies as the peak rates of discharge for which the components of drainage systems are designed. Reoccurrence intervals used for design typically range from 2 to 100 years. Individual drainage system components are generally assigned design storm frequencies based upon an evaluation of such factors as the size of the area drained and the potential for damage produced as a result of inadequate drainage as characterized by the size of the affected area, the nature and characteristics of land use in the affected area (i.e., residential, commercial, industrial uses). Components of the initial drainage system such as storm sewers and inlet structures generally a designed for relatively high frequency events ranging upwards to the 10-year storms. Major drainage system components are generally designed for less frequent, larger storms such as the 25-year and 50-year events. Flood protection projects typically are designed to accommodate conditions produced by the 100-year storm events.

Design frequency criteria for the construction of conveyance facilities such as storm sewers, pipes, culverts, bridge openings and spillways are contained in a number regulations and design manuals, including: regulations produced relative to the Pennsylvania Dam Safety and Encroachments Act, and the Pennsylvania Flood Plain Management Act; Pennsylvania Department of Transportation design criteria; Pennsylvania Soil and Erosion Control Manual; and the Water Pollution Control Federation Manual of Practice No. 9: Design and Construction of Sanitary and Storm Sewers. These references provide ample guidance under the law and standard engineering practice to permit local municipalities to establish local

requirements for traditional stormwater facilities design commensurate with local conditions. There are, however, no state level criteria for stormwater discharges as they relate to total discharge volumes and rates from new land development. Moreover, unlike the generally site specific conduit construction criteria, site runoff criteria must be established based upon watershed wide considerations. Consequently, this watershed plan presents specific criteria relative to storm frequencies to be used in controlling total stormwater discharge volumes and rates from new site development.

Upper and Lower Storm Frequency Criteria Limits

For this study the design storm frequency criteria were selected to respond to watershed conditions and to meet the objective of Act 167 to minimize stormwater damage now and in the future. The following example serves to illustrate the design storm frequency criteria selection rationale. The following table contains pre-development and post-development peak rates of discharge for a hypothetical development.

Table V-1
Hypothetical Design Storm Discharge Rates

	Design Storm		
	2-Year	10-Year	100-Year
Pre-development	50 cfs	75 cfs	100 cfs
Post-development	100 cfs	150 cfs	200 cfs

Two conclusions may be drawn for the data presented in this table:

1. If the design storm frequency criteria require that only the 100-year event be used as a point of control, the post-development discharge for the 2- and 10-year storms will be greater that the pre-development rate and runoff from the development may cause downstream harm at the more frequent storm events.

2. If the criteria require that only the 2-year event be applied, damage may result from increased runoff during the less frequent storm conditions.

If the stormwater conveyance system from this hypothetical development site to the river were capable of accommodating flows generated under 100-year return frequency storm conditions controlling discharges under simply a 100-year storm frequency criteria would be acceptable. However, information obtained from local municipal questionnaires and data produced through an analysis of existing obstruction capacities identified a number of locations where flooding occurs as frequently as once per year. The municipal questionnaires identified 15 locations within the watershed at which flooding occurs on average at least once per year (Table III-5). Also, an analysis of the capacity of obstructions located throughout

the watershed identified 198 structures with capacities less than the estimated mean annual flood in the vicinity (Table A-1). Consequently, the mean annual (2-year) event has been selected as the lower limit design storm frequency criteria.

The 100-year frequency storm was selected for use in the watershed for the following several reasons.

1. The survey of obstructions identified 20 obstructions with capacities between the 50- and 100-year floods (Table A-1). A failure to control runoff under storms of these frequencies would exacerbate flooding conditions at these sites as well as those sites with even smaller capacities.

2. Control of the 100-year frequency runoff would serve to preserve the 100-year flood plain and floodway boundaries as defined in the flood insurance studies completed in the watershed. These boundaries provide the basis for on-going flood plain management in the area. Permitting increased runoff at the 100-year return frequency conditions would result in an expansion of the flood zones and substantially increase the potential for damage.

3. The use of a 100-year frequency for the upper limit of the criteria would afford a high degree of protection commensurate with the highly developed urbanized areas existing at the base of most of the watersheds.

4. The 100-year upper limit for the return frequency is consistent with previous stormwater management plans prepared for Allegheny County.

Intermediate Frequency Criteria

In setting the upper and lower limit for return frequency storms to be controlled, it is assumed that runoff produced from discharges occurring events occurring at all intermediate frequencies will also be controlled. In other words, the stormwater control facilities would regulate discharges such that the post-development discharges would match the pre-development discharges at the 3-year, 4-year, 5-year frequency storms and so on through the 100-year frequency event. Since it would clearly be impractical to design for such a multitude of conditions and cumbersome to review management plans produced on such a basis.

Intermediate return frequency events were selected as reasonable points at which to verify that the runoff control system performance will generally parallel pre-development conditions between the 2- and 100-year limits. The selected check points and the manner in which they approximate modeled actual runoff rates at various return frequencies are illustrated in Figure V-3.

The following storm frequency check points have been selected for inclusion in the stormwater management criteria:

1. 2-year frequency storm;
2. 10-year frequency storm;

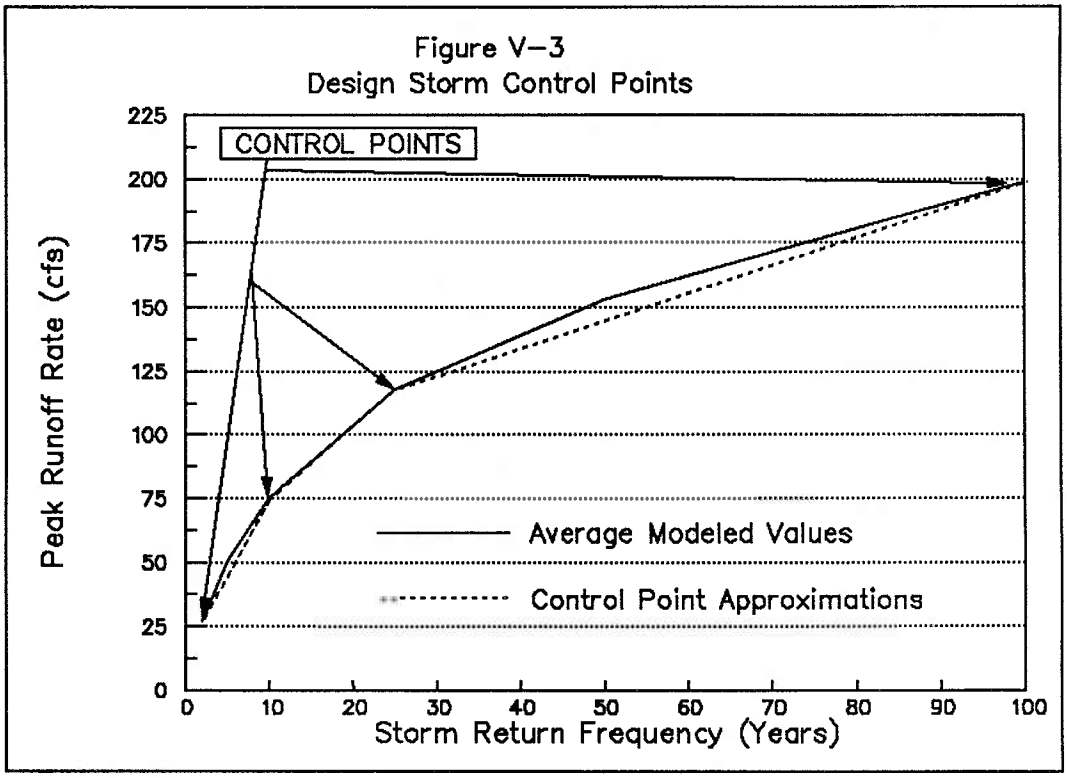
3. 25-year frequency storm; and
4. 100-year frequency storm.

The rationale for the selection of the upper and lower check points was described previously. The reasons for selecting the 10-year and 25-year frequency storm intermediate check points are as follows:

1. The use of these two intermediate points are effective in producing a curve of runoff rate verses storm return frequency which reasonably closely approximates the observed modeled relationship between the two variables (as illustrated in Figure V-4).

2. The 10-year and 25-year events are the most frequently referenced recommended design storm for a wide range of stormwater drainage facilities.

Figure V–3
Design Storm Control Points



Precipitation Volumes

Precipitation volumes to be used in the design and evaluation of stormwater control measures in the Monongahela River watershed are presented in Table V-2.

TABLE V-2 PRECIPITATION VOLUMES	
Return Period	Volume (Inches)
2 - Year	2.50
10 - Year	3.61
25 - Year	4.31
100 - Year	5.71

RUNOFF CONTROL STANDARDS

GENERAL APPROACH

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

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

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

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

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

(1) to assure that the maximum rate of storm water runoff is no greater after development than prior to development activities; or

(2) to manage the quantity, velocity and direction of resulting storm water runoff in a manner which otherwise adequately protects health and property from possible injury."

The most effective method means of satisfying the Act based upon the statements of legislative findings and definition of duty would be to control land development

activities such that both the total volume and rate of runoff from new development are identical to that which occurred before development i.e., post-development runoff volume and rates identical to pre-development conditions. If this could be accomplished, stormwater runoff from the new development would not produce any effect on downstream flows, eliminating any concern relative to the creation of downstream damage potentials. Unfortunately, however, most land development activities involve the conversion of land use from a type which exhibits a relatively low runoff potential to a higher runoff potential type. This factor produces a typical effect upon runoff as illustrated in Figure V-4. As is indicated in Figure V-4, land development typically produces increases in both total runoff volumes and peak rates of discharge.

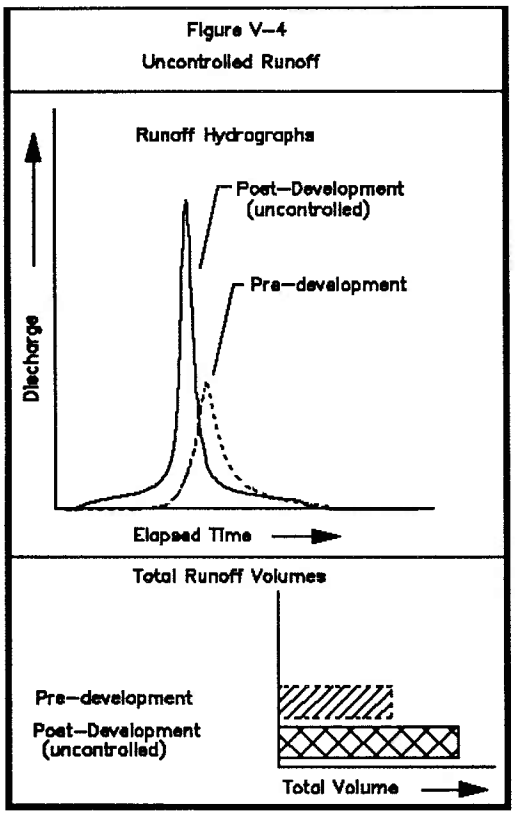


Figure V–4
Uncontrolled Runoff

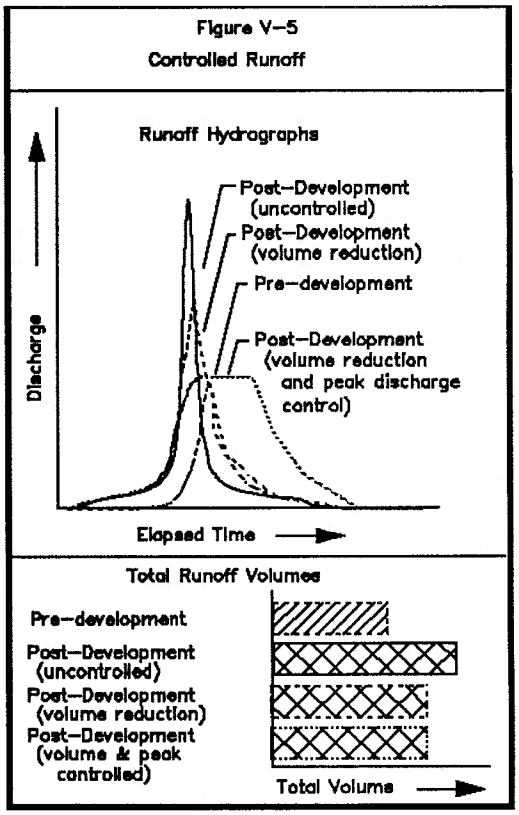


Figure V–5
Controlled Runoff

As is indicated in Figure V-5, measures can be taken to manage stormwater runoff by reducing the increase in total runoff volume and/or control peak rates of discharge. Techniques which may be used to minimize the increase in total runoff volume are described in Section VI of this report. These techniques generally consist of measures which minimize the extent of land cover changes from pervious to impervious areas and/or artificially induce infiltration to ground water. While these measures can be effective in reducing increases in runoff volumes, it is usually impractical to entirely avoid runoff volume increases attendant with most land development activities. Consequently, as indicated in Figure V-5, post-development hydrographs produced through the implementation of runoff volume reduction measures typically produce hydrographs with peak rates of discharge and total volumes falling between pre-development and uncontrolled post-development conditions.

Because it is impractical to entirely avoid increases in total runoff volume, the inevitability of some degree of runoff volume increases must be accepted and the primary emphasis of the stormwater control criteria must be placed upon the control of peak discharge rates. In order to minimize the potential for damage, the basic, minimum stormwater runoff control criteria to be applied in the watershed is that post-development peak discharges rates must not exceed pre-development peak discharge rates. Methods of controlling peak discharge rates from new development are presented in Section VI of this report. In general, they consist of measures which essentially retain and delay the controlled release of runoff so as not to exceed pre-development rates.

The typical results of the application of peak discharge control measures in addition to feasible runoff volume reduction provisions are illustrated in Figure V-5. As is indicated in Figure V-5, although the post-development total runoff volumes fall between pre-development and uncontrolled post-development volumes, the peak rate of discharge approximates the pre-development peak rate. This is accomplished by extending the time duration of time the peak rate of discharge occurs. Instead of an instantaneous peak as occurs in the pre-development condition, the peak discharge occurs over an extended period of time. This characteristic attenuation of peak discharge rates necessitates the development of additional standards designed to avoid the development of associated downstream problems. The derivation of these supplemental standards is discussed below.

RELEASE RATE PERCENTAGE CONCEPT

General Concept

It is through the development and application of release rate percentage based peak discharge standards that the stormwater management plan truly assumes a watershed wide status. The investigations which serve as the basis for the establishment of release rate percentage represent the principal means through which the watershed wide implications of control strategies are evaluated, considered and incorporated into specific control standards.

The general concepts behind the development and application of release rate percentage based stormwater management criteria are discussed below through the use of the hypothetical watershed illustrated in Figure V-6. Figure V-7 contains individual hydrographs for the total hydrograph for flows at the point of interest as well as the hydrographs for flows generated in each of the five (5) subbasins as they reach the point of interest.

As is illustrated in Figure V-7 and summarized in Table V-3, the peak discharge at the point of interest is sum of the discharges originating from each of the upstream subbasins as they coincidentally reach the point of interest.

The potential effects of land development occurring in Subbasin 3 upon the runoff hydrographs for Subbasin 3 and the entire hypothetical watershed are illustrated in Figures V-8 and V-9 and are tabulated in Table V-4. Figure V-9 illustrates the effects of the institution of stormwater controls which serve to limit post-development peak discharge rates to the pre-development discharge rate through flow detention. As is indicated by the hydrographs presented in Figure V-9, limiting

the peak discharge in this manner would serve to extend the period over which the pre-development discharge occurs. The result of this flow attenuation is described by the data presented in Table V-4. Following development and the institution of the specified controls, Subbasin 3 would contribute 500 cfs to the watershed peak at the point of interest rather than the 400 cfs contributed in the pre-development state. This would produce a 100 cfs increase in the watershed peak despite the control of Subbasin 3 peak discharges to pre-development levels.

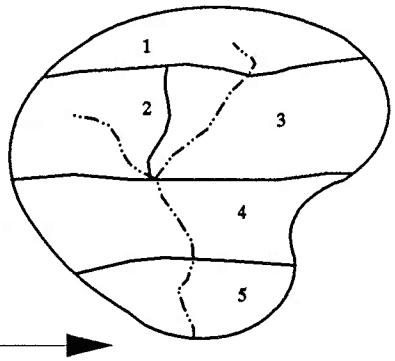
Table V-3
Example Hydrograph Combination
Pre-Development Conditions

	Peak Discharge at Subbasin Mouth		Discharge at Point of Interest During Watershed Peak	
Subbasin Number	Time (Minutes)	Discharge (cfs)	Time (Minutes)	Discharge (cfs)
1	20	200	70	0
2	50	650	70	650
3	40	500	70	400
4	50	500	70	300
5	30	300	70	150
Total	----	----	----	1,500

Table V-4
Example Watershed Impacts
Flow Attenuation

	Peak Runoff	Contribution to Watershed Peak	Watershed Peak
Pre-development	500	400	1,500
Post-development (Uncontrolled)	710	490	1,590
Post-development (100% Release Rate)	500	500	1,600
Post-development (Reduced Release Rate)	400	400	1,500

HYPOTHETICAL WATERSHED



Point of Interest →

FIGURE V-6

SUBBASIN HYDROGRAPH

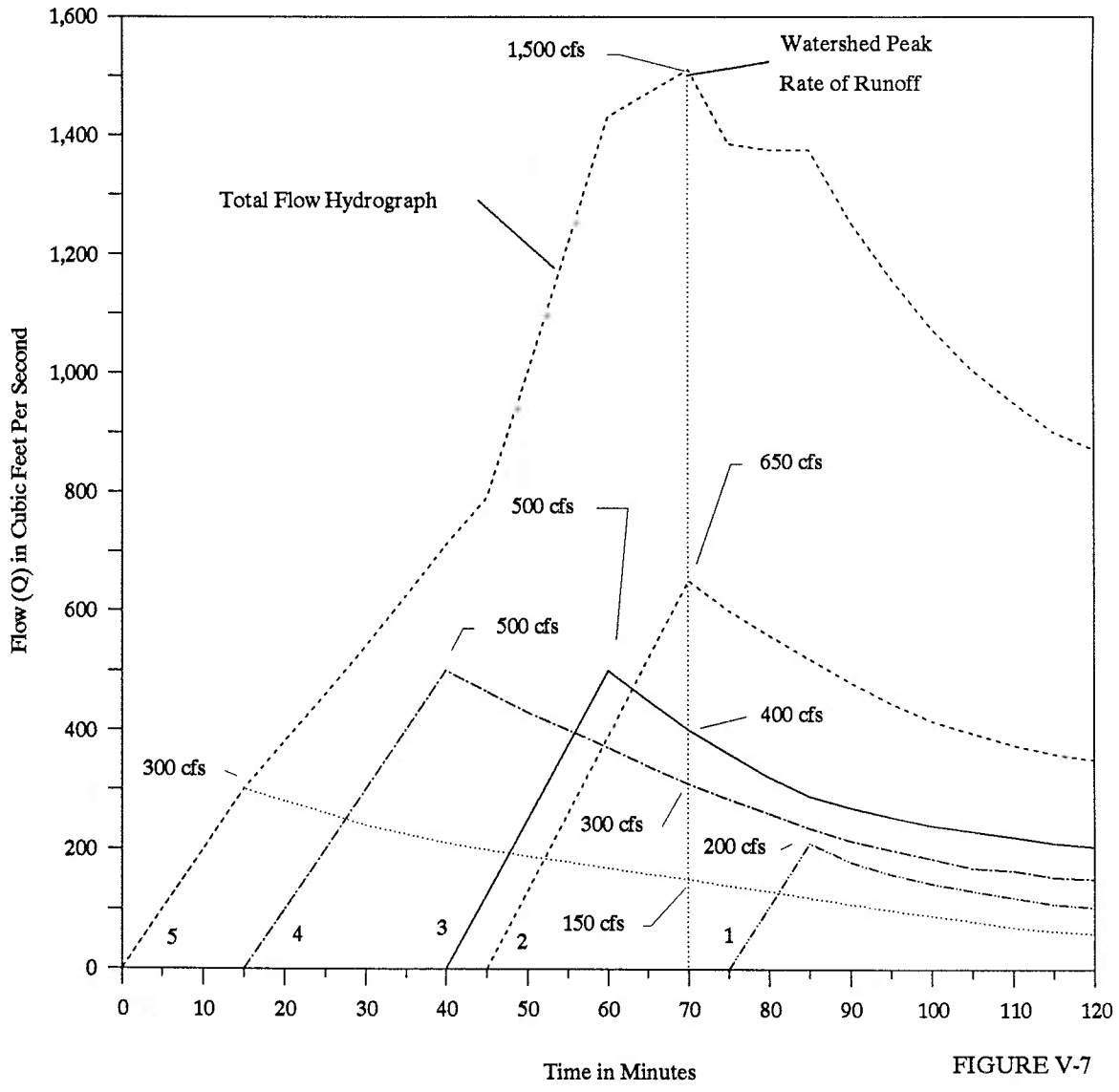


FIGURE V-7

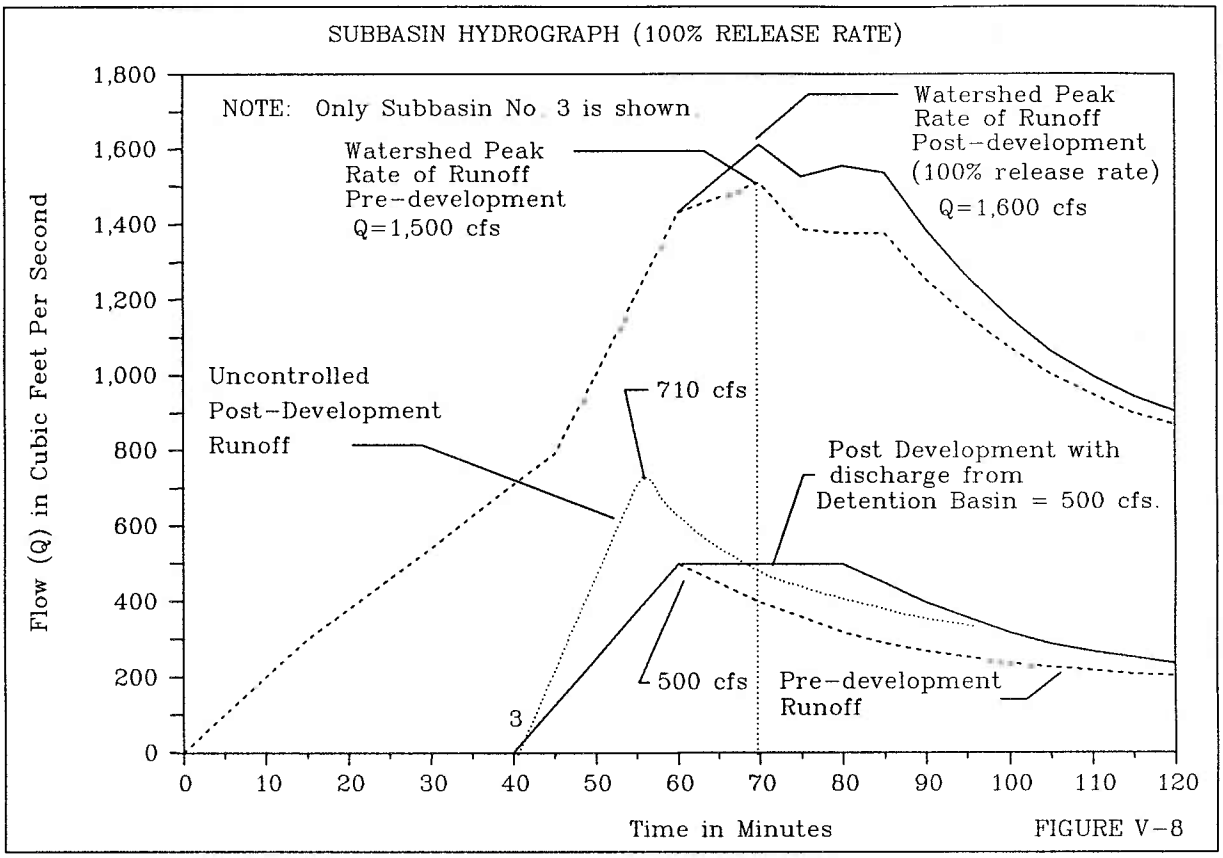


FIGURE V-8

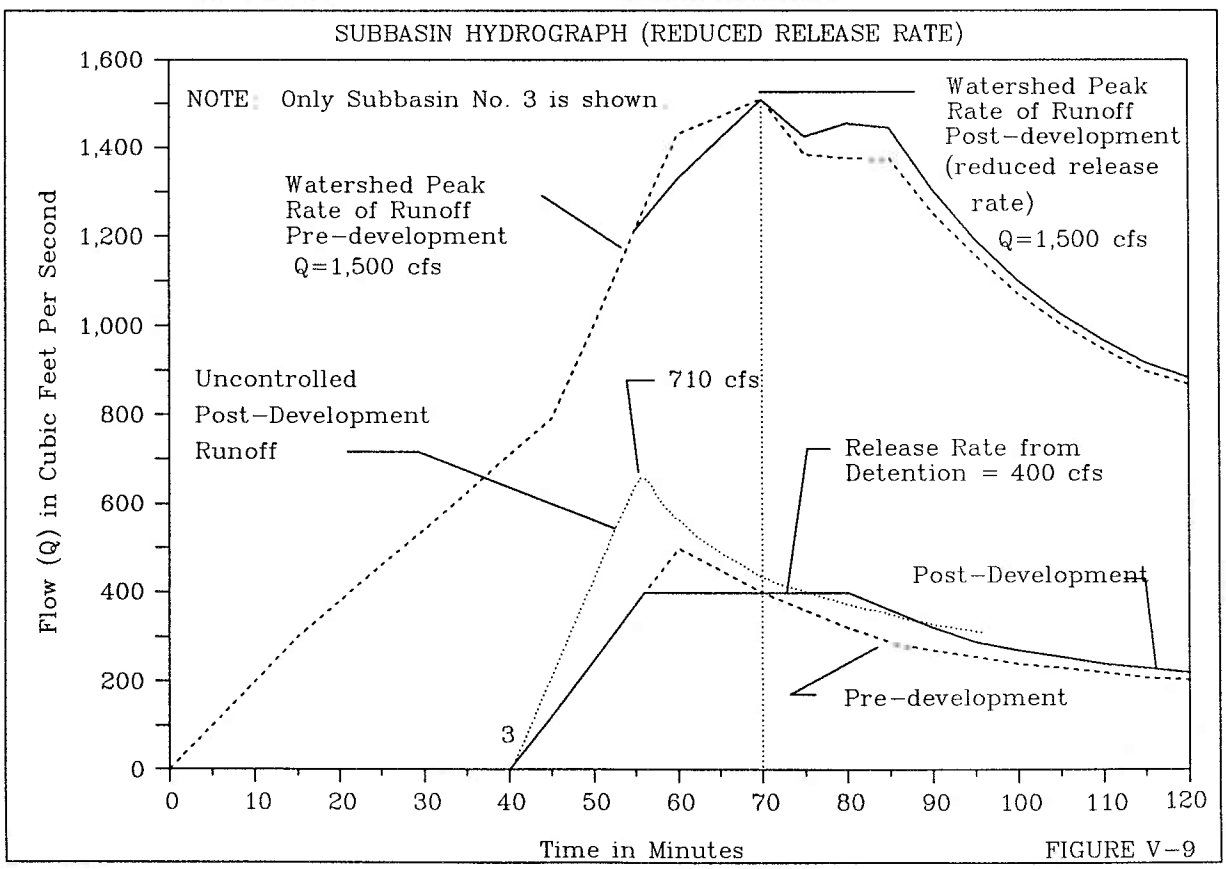


FIGURE V-9

This situation can be avoided if the post-development runoff rate is controlled so that the peak rate of runoff does not exceed the rate of flow contributed to the watershed peak.

The effects of controlling peak rates of runoff in the example situation are presented graphically in Figure V-10 and in tabular form in Table V-4. As is indicated, selection of the proper allowable post-development peak discharge rate in consideration of contribution to downstream flows can avoid unintentional increases in peak stream discharges as a consequence of efforts to limit runoff from the new development(s).

The methodology used to determine the allowable peak rate of post-development discharge in the previous example can be generalized as follows:

EQUATION 1
Pre-development Subbasin Peak Discharge Contribution to Watershed Peak - Pre-development Subbasin Peak Discharge = Assigned Release Rate Percentage

EQUATION 2
Pre-development Subbasin Peak Discharge X Assigned Release Rate Percentage = Allowable Post-development Peak Discharge

The application of these two equations to the determination of appropriate post-development peak discharge rates defines the release rate percentage concept of stormwater management. This concept was developed to be fully responsive to the intent and requirements of Pennsylvania Act 167. The release rate percentage concept provides performance standards for storm drainage control in a watershed. The significance of this approach lies in the fact that the concept provides an effective tool for comprehensive watershed stormwater management.

Determination of Release Rate Percentages

The previous paragraphs introduced the release rate percentage concept using a simplified example. The following discussion presents the general strategy that was used to apply this concept in the Monongahela River watershed.

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

For areas modeled, the general approach employed in the Monongahela River watershed was to establish release rate percentages for each subbasin by determining the peak rate of runoff from the subbasin and its contribution to peak discharges in downstream reaches. This was accomplished using the Penn State Runoff Model described in Section IV of this report. The specific steps in the approach are as follows:

1. Perform overall watershed modeling using the Penn State Runoff Model.

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

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

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

Areas not included in the modeling effort were assigned a release rate percentage of 100%. In these areas, which were previously identified in Chapter IV, the potential for future development is extremely limited and/or runoff drains essentially directly to the Monongahela River. Due to these circumstances, the stormwater management goals can be achieved through the application of a uniform standard requiring that post-development peaks shall not exceed the pre-development peak discharge rates (i.e., a release rate percentage of 100%).

Assigned Release Rate Percentages

Assigned release rate percentages for the Monongahela River watershed are tabulated in Table V-5 and illustrated in Plate V-1. Please note that in both Table V-5 and Plate V-1, the subbasins have been aggregated into "Release Rate Percentage Areas".

Application of the Assigned Release Rate Percentages

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

TABLE V–5
MONONGAHELA RIVER WATERSHED
ASSIGNED RELEASE RATE PERCENTAGES

Release Rate Area	Assigned Release Rate Percentage		Release Rate Area	Assigned Release Rate Percentage		Release Rate Area	Assigned Release Rate Percentage
1	100		32	70		63	80
2	100		33	70		64	60
3	60		34	50		65	80
4	60		35	70		66	90
5	100		36	100		67	50
6	60		37	60		68	70
7	50		38	50		69	70
8	80		39	80		70	60
9	90		40	100		71	100
10	70		41	60		72	60
11	60		42	70		73	50
12	50		43	100		74	90
13	100		44	50		75	80
14	80		45	80		76	70
15	70		46	80		77	80
16	100		47	90		78	100
17	50		48	60		79	90
18	70		49	80		80	50
19	70		50	100		81	70
20	100		51	50		82	50
21	50		52	60		83	70
22	60		53	70		84	80
23	80		54	60		85	50
24	70		55	50		86	70
25	70		56	80		87	60
26	70		57	100		88	60
27	80		58	60		89	70
28	60		59	80		90	60
29	50		60	70		91	50
30	60		61	90		92	80
31	70		62	60		93	60

Note: Release Rate Percentage Areas refer to those delineated in Plate V–1.

To utilize the release rate for a particular site in one of the delineated release rate percentage areas, the developer should follow the following general sequence of actions.

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

2. Apply on-site stormwater management techniques to increase infiltration and reduce impervious surfaces. Recompute the post-development runoff rate for the 2, 10, 25 and 100 year storms; and if the resulting post-development rate is less than or equal to the pre-development rate, the requirements of this plan have been met. Otherwise, stormwater detention or retention will be required and the developer should proceed to Step 3.

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

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

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

The topic of regional storage is further discussed in Section VI of this report.

PERMISSIBLE RUNOFF COMPUTATION TECHNIQUES

GENERAL

A number of techniques and methods have been developed and are used to estimate rates and volumes of runoff from land. Runoff computation techniques permissible for use in developing runoff control plans pursuant to the requirements of this Plan have been identified. It is recommended that municipalities require land developers to limit the computation techniques employed to one or more of those listed. The

list of permissible techniques includes a cross section of the most commonly used computation methods entailing a range of approaches, levels of effort and required access to computer facilities. The list affords developers the opportunity to select from a suite of techniques. At the same time, the number of techniques which the local reviewing engineer must be familiar with is kept to a manageable number. In addition, the use of inapplicable, unproven or inaccurate techniques is prohibited.

PERMISSIBLE RUNOFF COMPUTATION TECHNIQUES

The recommended permissible runoff computation techniques are as follows.

1. Soil Conservation Service Urban Hydrology Method (TR-55)
2. Soil Conservation Service Model (TR-20)
3. U. S. Army Corps of Engineers Flood Hydrograph Package (HEC-1)
4. Penn State Runoff Model
5. Modified Rational Method

Engineers involved in the preparation of stormwater control plans and reviewers of such plans should review the pertinent information relative to the use and applicability of each of these methods. It is important that the assumptions implicit and explicit in each of the techniques be understood and that the techniques are properly applied. Particular attention should be paid to the use of the Modified Rational Method. Experience in applying the Modified Rational Method and comparing the results to other stormwater detention facilities sizing techniques suggests that a significant under estimation of storage requirements may occur. Consequently, the Modified Rational Method should be used guardedly and generally restricted to preliminary sizing of detention facilities.

HYDROLOGICALLY SENSITIVE AREAS

As an aid to ongoing stormwater management in the watershed, efforts were made to identify subbasins within the Monongahela River watershed which are particularly sensitive to the effects of land development activities. This was accomplished by evaluating the "hydrologic sensitivity" of each subbasin based upon the consideration of (3) parameters descriptive of hydrological conditions in the subbasins.

The subbasins were ranked under each of the parameters or factors by assigning a scoring equivalent to the ranking (with increasing ranking or scoring indicative of increased hydrologic sensitivity). The rankings for each subbasin under each factor were totaled to produce an overall "hydrological sensitivity scoring" and the subbasins were ranked based upon this overall scoring. Roughly 25% of the subbasins with the highest overall ranking were assigned a "high" hydrologic sensitivity rating. Roughly 25% of the subbasins with the lowest overall ranking were assigned a "low" hydrologic sensitivity rating and the middle 60% of the subbasins were assigned a "moderate" rating.

The four parameters included in this analysis are as follows:

1. Slope: hydrologic sensitivity increases as representative land slope increases.

2. Current composite runoff curve number: since land development typically increases composite runoff curve numbers subbasins with currently low runoff will be most affected by development activities. Therefore, hydrologic sensitivity is inversely proportional to current composite runoff curve number.

3. Assigned release rate percentage: Hydrologic sensitivity is inversely proportional to assigned release rate percentage.

4. Proximity (upstream) to reported stormwater problems areas.

The results of the hydrologic sensitivity analysis and rating are presented in Table V-6. Note that the subbasin designations contained in Table V-6 refer to those displayed on Plate IV-1 introduced in Section IV of this report. The distribution of relative hydrologic sensitivity designations is illustrated on Plate V-2.

No special actions beyond the satisfaction of the various management criteria defined in this Plan necessarily need be applied in the "high" hydrologic sensitivity areas. Similarly, classification as a subbasin as a "low" hydrologic sensitivity area does not remove or reduce the required stormwater management requirements in force therein. Instead, the designation of a subbasin as a "high" hydrologic sensitivity area should alert developers and municipalities to take special care in the design of control plans and exercise special vigilance in the review of those plans. Future Plan updates should reevaluate these designations for changes in the conditions which affect hydrologic sensitivity.

Table V–6
Hydrologic Sensitivity

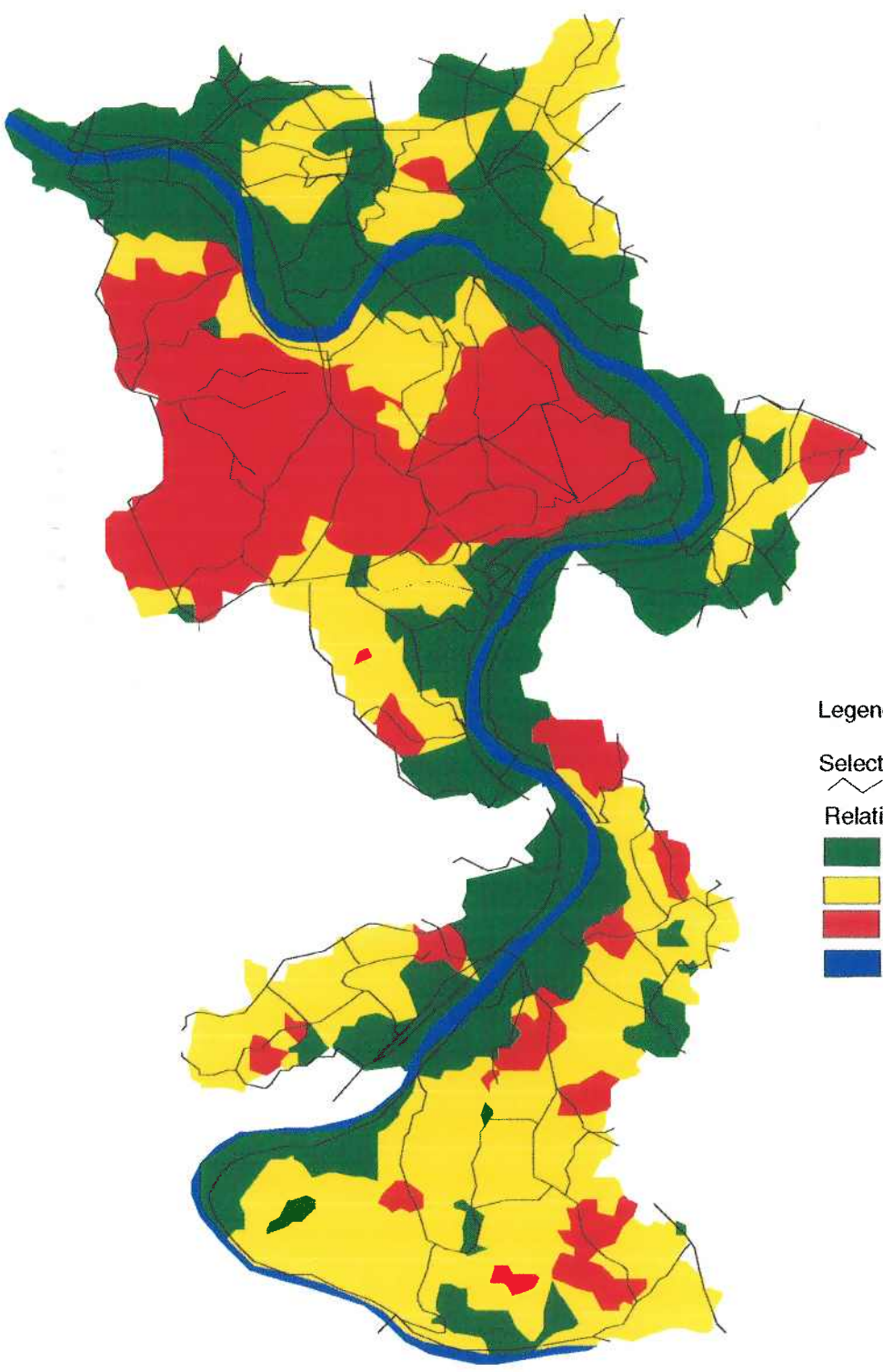
SUBBASIN	HYDROLOGIC SENSITIVITY	SUBBASIN	HYDROLOGIC SENSITIVITY	SUBBASIN	HYDROLOGIC SENSITIVITY
1	MODERATE	44	MODERATE	87	MODERATE
2	MODERATE	45	MODERATE	88	MODERATE
3	MODERATE	46	MODERATE	89	MODERATE
4	MODERATE	47	MODERATE	90	LOW
5	MODERATE	48	MODERATE	91	LOW
6	LOW	49	MODERATE	92	LOW
7	MODERATE	50	MODERATE	93	LOW
8	HIGH	51	LOW	94	LOW
9	MODERATE	52	LOW	95	LOW
10	MODERATE	53	LOW	96	LOW
11	MODERATE	54	MODERATE	97	MODERATE
12	MODERATE	55	MODERATE	98	MODERATE
13	HIGH	56	MODERATE	99	MODERATE
14	MODERATE	57	LOW	100	MODERATE
15	HIGH	58	LOW	101	MODERATE
16	MODERATE	59	LOW	102	MODERATE
17	MODERATE	60	LOW	103	MODERATE
18	MODERATE	61	LOW	104	MODERATE
19	MODERATE	62	LOW	105	MODERATE
20	HIGH	63	LOW	106	MODERATE
21	MODERATE	64	MODERATE	107	MODERATE
22	MODERATE	65	LOW	108	MODERATE
23	MODERATE	66	MODERATE	109	MODERATE
24	MODERATE	67	MODERATE	110	MODERATE
25	MODERATE	68	MODERATE	111	MODERATE
26	MODERATE	69	LOW	112	MODERATE
27	HIGH	70	MODERATE	113	MODERATE
28	MODERATE	71	MODERATE	114	MODERATE
29	MODERATE	72	MODERATE	115	MODERATE
30	MODERATE	73	MODERATE	116	MODERATE
31	LOW	74	HIGH	117	MODERATE
32	LOW	75	MODERATE	118	MODERATE
33	LOW	76	MODERATE	119	HIGH
34	MODERATE	77	MODERATE	120	MODERATE
35	LOW	78	MODERATE	121	MODERATE
36	MODERATE	79	MODERATE	122	MODERATE
37	MODERATE	80	MODERATE	123	HIGH
38	LOW	81	LOW	124	HIGH
39	MODERATE	82	MODERATE	125	MODERATE
40	MODERATE	83	MODERATE	126	LOW
41	MODERATE	84	MODERATE	127	LOW
42	MODERATE	85	HIGH	128	LOW
43	MODERATE	86	MODERATE	129	LOW

Table V–6
Hydrologic Sensitivity

SUBBASIN	HYDROLOGIC SENSITIVITY	SUBBASIN	HYDROLOGIC SENSITIVITY	SUBBASIN	HYDROLOGIC SENSITIVITY
130	LOW	173	MODERATE	216	MODERATE
131	LOW	174	MODERATE	217	LOW
132	LOW	175	MODERATE	218	MODERATE
133	LOW	176	MODERATE	219	MODERATE
134	MODERATE	177	MODERATE	220	HIGH
135	LOW	178	MODERATE	221	LOW
136	MODERATE	179	MODERATE	222	LOW
137	MODERATE	180	MODERATE	223	MODERATE
138	MODERATE	181	MODERATE	224	MODERATE
139	MODERATE	182	MODERATE	225	MODERATE
140	MODERATE	183	MODERATE	226	HIGH
141	HIGH	184	MODERATE	227	MODERATE
142	MODERATE	185	MODERATE	228	LOW
143	MODERATE	186	MODERATE	229	LOW
144	MODERATE	187	LOW	230	LOW
145	MODERATE	188	LOW	231	LOW
146	MODERATE	189	LOW	232	LOW
147	MODERATE	190	HIGH	233	LOW
148	MODERATE	191	MODERATE	234	MODERATE
149	MODERATE	192	LOW	235	MODERATE
150	MODERATE	193	LOW	236	LOW
151	MODERATE	194	LOW	237	LOW
152	HIGH	195	LOW	238	LOW
153	LOW	196	LOW	239	LOW
154	LOW	197	MODERATE	240	HIGH
155	LOW	198	MODERATE	241	HIGH
156	MODERATE	199	MODERATE	242	HIGH
157	MODERATE	200	MODERATE	243	HIGH
158	MODERATE	201	HIGH	244	HIGH
159	MODERATE	202	HIGH	245	HIGH
160	MODERATE	203	HIGH	246	HIGH
161	MODERATE	204	HIGH	247	HIGH
162	MODERATE	205	HIGH	248	HIGH
163	HIGH	206	MODERATE	249	HIGH
164	MODERATE	207	N/A (RIVER)	250	HIGH
165	MODERATE	208	MODERATE	251	HIGH
166	MODERATE	209	MODERATE	252	HIGH
167	HIGH	210	MODERATE	253	HIGH
168	MODERATE	211	MODERATE	254	HIGH
169	MODERATE	212	MODERATE	255	HIGH
170	MODERATE	213	HIGH	256	HIGH
171	MODERATE	214	MODERATE	257	HIGH
172	MODERATE	215	MODERATE	258	HIGH

Table V–6
Hydrologic Sensitivity

SUBBASIN	HYDROLOGIC SENSITIVITY	SUBBASIN	HYDROLOGIC SENSITIVITY	SUBBASIN	HYDROLOGIC SENSITIVITY
259	HIGH	302	HIGH	346	MODERATE
260	HIGH	303	HIGH	347	MODERATE
261	LOW	304	HIGH	348	LOW
262	LOW	305	HIGH	349	MODERATE
263	LOW	306	HIGH	350	LOW
264	LOW	307	HIGH	351	LOW
265	LOW	308	HIGH	352	MODERATE
266	LOW	309	HIGH	353	HIGH
267	LOW	310	HIGH	354	MODERATE
268	LOW	311	HIGH	355	LOW
269	HIGH	312	MODERATE	356	MODERATE
270	HIGH	313	HIGH	357	MODERATE
271	HIGH	314	HIGH	358	LOW
272	HIGH	315	HIGH	359	LOW
273	HIGH	316	HIGH	360	LOW
274	HIGH	317	HIGH	361	LOW
275	HIGH	318	MODERATE	362	HIGH
276	MODERATE	319	MODERATE	363	HIGH
277	LOW	320	MODERATE	364	MODERATE
278	LOW	321	MODERATE	365	MODERATE
279	MODERATE	322	HIGH	366	LOW
280	HIGH	323	MODERATE	367	MODERATE
281	HIGH	324	MODERATE	368	LOW
282	HIGH	325	MODERATE	369	LOW
283	HIGH	326	MODERATE	370	LOW
284	HIGH	327	MODERATE	371	LOW
285	HIGH	328	LOW	372	MODERATE
286	HIGH	329	LOW	373	MODERATE
287	MODERATE	330	LOW	374	LOW
288	HIGH	331	HIGH	375	LOW
289	HIGH	332	HIGH	376	MODERATE
290	HIGH	333	MODERATE	377	LOW
291	HIGH	334	HIGH	378	LOW
292	HIGH	335	HIGH	379	MODERATE
293	HIGH	336	MODERATE	380	MODERATE
294	HIGH	337	MODERATE	381	MODERATE
295	HIGH	338	HIGH	382	HIGH
296	MODERATE	339	LOW	383	MODERATE
297	HIGH	340	LOW	384	MODERATE
298	HIGH	341	LOW	385	MODERATE
299	HIGH	342	MODERATE	386	MODERATE
300	HIGH	343	LOW	387	LOW
301	HIGH	344	MODERATE	388	LOW
		345	LOW	389	LOW



N

Legend

Selected Roads

Relative Hydrologic Sensitivity

- Low Sensitivity
- Moderate Sensitivity
- High Sensitivity
- Monongahela River

Monongahela River Watershed

Relative Hydrologic Sensitivity

CHESTER ENVIRONMENTAL

Plate V-2

2/mrrhs
2/10/93

MONONGAHELA RIVER WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION VI
STORMWATER MANAGEMENT TECHNIQUES

INTRODUCTION

One of the key features of the Stormwater Management Act 167 is its mandate to implement comprehensive stormwater runoff control practices. The Act requires stormwater planning at the watershed level in such a manner that adverse impacts of storm runoff are prevented, both at a particular site and at every potential flood prone location downstream from the watershed. Therefore, any stormwater management technique must consider runoff impacts on the watershed.

Studies in recent years have identified a number of methods of reducing the impact of development on storm peaks. Many management practices indicate the ingenuity of the planning, engineering and regulatory agencies. In particular, the publications of Soil Conservation Service (SCS) of Department of Agriculture (USDA), U.S. Environmental Protection Agency (EPA) and American Public Works Association (APWA) are quite comprehensive and aid in expanding some of the management practices reported in this section.

The present-day emphasis on detention or reduction of urban runoff within the contributing source area represents a remarkable shift in runoff control strategy that has occurred only just recently [Kibler and Aron, 1980]. This trend toward on-site runoff abatement includes control measures that either reduce the runoff directly at the source or delay the arrival of runoff contributions at some critical points downstream. Attesting to the strength of this trend is the large and growing number of publications describing various on-site control measures. Notable contributions in this regard include those by Poertner [1974, 78] on stormwater detention practices; Becker et al. [1973] on rooftop storage; Aron et al. [1976] on general runoff abatement measures including infiltration trench design; Montgomery County Soil Conservation District on storage detention ponds; ASCE, The Urban Land Institute, and the National Association of Homebuilders [1976] on residential runoff abatement measures; and Field [1978] and Field and Lager [1975] for comprehensive reviews of structural and nonstructural measures.

Methods applicable to almost all watersheds are based on the principles of velocity reduction, infiltration enhancement, detention and retention storage, etc. However, site-specific conditions in a given watershed may lead to the development of innovative control measures. All the methods are designed to control sediment, pollution and stormwater within the watershed. Although the design of stormwater control facilities is usually completed by engineers and landscape architects, key policy questions should first be answered by local officials. Preferences of local residents concerning level of protection, aesthetics, maintenance responsibilities, and cost allocation should be assessed by local officials, not professionals. After

community stormwater management policies have been established, detailed design or design review of particular controls and measures can be carried out [Clinton River Watershed Council, 1984]. Where practical, control measures should be designed to exploit the beneficial uses of the stormwater such as recreational and aesthetic benefits and recharge of underground aquifers. In many cases this can be the decisive factor in approval of a new land development. The intent of this chapter is to review the existing storm water management techniques and make recommendations on their applicability, from many different perspectives such as suitability for the study watershed, cost, effectiveness, advantages, disadvantages and maintenance etc.

CONCEPT OF STORMWATER MANAGEMENT

Early stormwater management efforts concentrated on transporting the runoff as quickly as possible from a storm location, by routing it through storm sever systems. As the urban development increased in the watershed, such a flood control effort resulted in the worst flooding conditions downstream, due to increased total flow, peak flow rate, stream velocity and flow depth. Land development causes an increase in the rate of runoff from the site, resulting in an increased peak flow rate. Changing a natural channel to a concrete-lined ditch or a storm sewer system increases the velocity and reduces the travel time to downstream locations. A reduction in the travel time may make the peak flow rate from one watershed, to contribute or in the worst case to coincide with the peak flow rate of some other watershed(s). This again results in an increased peak flow rate. Detaining the storm water and releasing the maximum rate over a longer period of time may also induce the same adverse effect.

It is now recognized due to above mentioned problems that, the most logical and effective approach to control the storm runoff is to maintain the natural runoff flow characteristics. This can be accomplished in general by maximizing natural infiltration processes, reducing impervious surfaces, preserving floodplains, and controlling storm runoff in the watershed. There are numerous, technically acceptable techniques which have varying degrees of applicability in the study area, depending on the site and watershed characteristics. Some of the most widely used ones will be described here, along with a brief discussion of their key features, advantages and disadvantages, and typical costs. It will be up to each individual developer to select the techniques that are most appropriate to the project and site. It is most likely that in most situations, a combination of on-site controls will be the most appropriate and least costly stormwater management system. Nevertheless, some alternatives must be carefully analyzed. For example, when several detention basins are used, their interaction must be considered, since a combination of the timing of their releases could aggravate downstream flooding rather than alleviating it. Also, the efficiency and costs of many of management alternatives vary from one location to another. Many of the alternatives, such as on site storage basins, erosion control, and flow reduction alternatives, may be feasible only for areas of new development [Kibler, 1982].

To determine the most appropriate set of techniques for a particular site, several factors should be evaluated:

1. Soil characteristics (i.e. soil permeability, erodibility)
2. Topography
3. Subsurface conditions
4. Drainage patterns (i.e. proximity to stream flooding problems)
5. Proposed land uses
6. Costs
7. General advantages and disadvantages of each technique.

STORMWATER RUNOFF PROBLEMS

FLOODING

During high intensity, or long duration storms the existing infiltration capacity of soils may be exceeded and surface storage filled to capacity. Once this happens, runoff occurs in the form of overland and channel flow. During some high runoff and relatively infrequent storm events, if the existing watercourses have insufficient capacity to convey surface flows, they get flooded. Natural floodplains provide some benefits by serving as reservoirs, natural recharge basins, collectors of pollutants, wildlife habitats etc. As floodplain or upstream areas are developed, this natural beneficial phenomenon, becomes a disaster due to its increased frequency and magnitude. Thus, new developments increase the flood problems and damage downstream as compared to predevelopment.

There are many ways to reduce the impact of new development on flooding. Some general concepts to consider in determining which solutions are applicable to a study area are listed below:

1. Limit development of floodplains and prohibit development in floodways
2. Increase infiltration
3. Reduce runoff rates
4. Store precipitation and runoff where it falls and release it slowly
5. Keep water confined in adequate pipes or channels

6. Protect areas subject to flood damages

7. Build flood control measures

8 Limit erosion and sediment transport

EROSION AND SEDIMENTATION

When raindrops hit bare soil, the cumulative effect is the splashing of the hundreds of tons of soil into the air. Some particles are washed into streams or downstream areas unless the velocity is very low or the soil is protected by some means. This phenomenon is called erosion. The runoff from new land developments can result in erosion both on-site and off-site. Once soil erosion begins, the soil particles transported by runoff and water currents begin to settle down in downstream drainage ways, which is called sedimentation. Sedimentation may result in blockages of natural watercourses, plugging of culverts and storm sewers, smothering of vegetation, filling of reservoirs, etc. The sedimentation occurs at increased rates during and following land development because graded areas are left in an unprotected state. Data collected by Brandt [1972] shows that erosion rates on land undergoing development can be 2,000 times the erosion rate of forested lands. General concepts to be followed for minimizing erosion and sedimentation include the following:

1. Protect the soil surface to withstand effects of rainfall and runoff

2. Limit soil erosion through site management practices

3. Store rainfall and runoff where it originates and release it slowly

4. Catch sediment before it enters natural drainage channels

POLLUTANT TRANSPORT

Runoff from developed areas contains more pollutants than from natural watersheds. These pollutants include heavy metals, BOD, and high concentration of suspended solids. Heavy metals and BOD generally increase as the area is developed and reach a plateau when the development has stabilized. Suspended solids increase during first two years following the disturbance of land for development. The impacts of these pollutants depend on the existing quality and use of the receiving waters. If the newly developed area drains into a supply reservoir, an increase in the amount of pollutants could be very significant. In other cases, the impacts may be difficult to determine and are often long-term, subtle, and persuasive rather than immediate.

ON-SITE STORM WATER MANAGEMENT

Many methods are available to alleviate the impact of urbanization on runoff. Maryland Interim Watershed Management Policy [APWA, 1981] states, "When engineering a site for stormwater management, two overall concepts must be considered: 1) the perviousness of the system should be maintained or enhanced, and 2) the rate of runoff should be slowed. Land development methods which tend to reduce the volume of runoff are preferred over methods which tend to increase the volume of runoff." Many of the steps taken to reduce flooding also have significant effects in reducing erosion, sedimentation and stream pollution and may reduce the need for capital-intensive storm sewer systems.

All things considered, the most advantageous means of controlling stormwater runoff from new developments is by minimizing the amount of increased runoff volumes produced. If it were possible to complete the new development in a manner such that there would be no change in either the volume or peak rate of discharge after development, there would be essentially no stormwater related impacts. While it is recognized that, in most cases, it may not be possible to accomplish the goal of making both post-development runoff volumes and peak rates of runoff match pre-development conditions, reasonable efforts should be made to minimize increases in total runoff volumes prior to the design of supplemental controls designed to control peak discharge rates.

It is recommended that land developers be encouraged to take reasonable and applicable steps to incorporate features into their developments which will serve to minimize increases in stormwater runoff volumes.

RUNOFF VOLUME REDUCTION MEASURES

Following are brief descriptions of measures which may be taken to limit increases in total runoff volumes resulting from new developments. The applicability of these measures is highly site specific and dependent upon the nature of the development. However, it is recognized that the potential application of these techniques be seriously considered early in the design of land development activities.

Limit the Amount of Land Disturbed

The added volume of runoff produced as a result of the development of "virgin" land is directly related to the amount of land cover changed from its natural state to a more impervious condition (usually paved). Consequently, increases in runoff volumes can be minimized to the extent that land cover disturbances can be minimized. Individuals involved in land development activities, should, therefore, be encouraged to optimize their development activities from the standpoint of accomplishing the basic objectives of the development while minimizing the amount of paved areas used and natural areas disturbed.

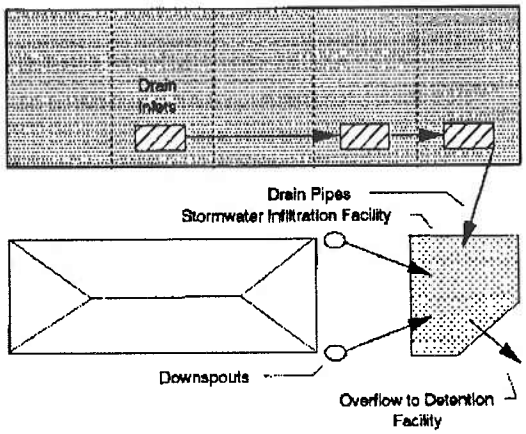
Utilize Terraces, Contoured Landscapes, Runoff Spreaders, Diversions and Grassed or Rock-Lined Waterways

These measures increase the time of concentration by increasing length of overland flow, and thus lowering the flood peak. They will provide the additional benefit of reducing total runoff by infiltration if the site has well-drained soils. Runoff spreaders spread runoff or direct it into a system of terraces. Terraces are more suitable for reducing erosion from agricultural and non-urban areas and conserving soil moisture. They reduce effective slope length and runoff concentration. About 90% of the soil that is moved is deposited in the terrace channels. In contouring, crop rows follow field contours to prevent erosion and runoff. It can reduce average soil loss by 50% on moderate slopes and less on steep slopes. It must be supported by terraces on long slopes. There are no soil or climatic limitations on practicing contouring, but it is not feasible on very irregular topography. Grassed waterways or swales stabilize vegetation on drainage channels. For velocities of up to 8 ft/sec runoff is reduced by grass channels, if correctly graded and stabilized. Detailed design information for this category of alternatives can be obtained from the Soil Conservation Service's Engineering Field Manual for Conservation Practices.

Use of Infiltration Devices

Infiltration devices are used to reduce flood peaks by releasing all or part of the stored runoff into the groundwater. The infiltrated water may appear a short distance downstream as surface water at a later time. However, the runoff hydrograph at the outlet point should be much lower and drawn out in time than that from runoff delay techniques [Aron, 1975]. An example application of infiltration storage techniques is provided in Figure VI-1.

Figure VI-1
Example Application of Roof
and Parking Lot Infiltration Facility



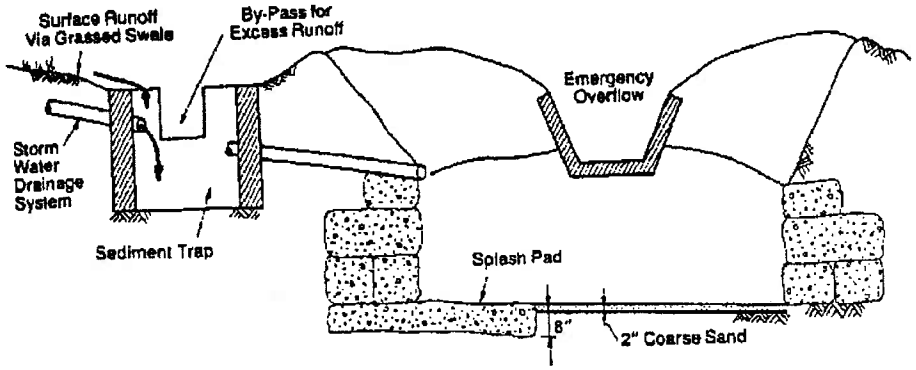
Soils comprised of sands and/or silty sands have high infiltration capacities, and therefore are well suited for infiltration storage. Soils comprised of fine silts and clays have low infiltration capacities and therefore, are not suitable for constructing infiltration devices over them. Deep soil sampling should be performed to assess the feasibility of water loading the various geological strata for purposes of stormwater disposal. Percolation tests, pumping tests, and soil sampling should provide useful data about the depth, size, and location where subsurface storage is practical. In the Monongahela River Watershed many of the soils have properties which can limit the applicability of infiltration storage. Therefore, this alternative should be used with caution. If this method is proposed as the primary means to reduce runoff for large development sites or for sites located in landslide-prone soil locations, a soil engineer's report should be obtained. Generally, infiltration systems should not be used where there is a reasonable probability the runoff may be contaminated (e.g. industrial sites, commercial parking lots, etc.).

The following techniques for stormwater control based on the principle of infiltration storage.

Seepage or Recharge Basins

Figure VI-2 shows a typical design of a seepage or recharge basin. In this method, runoff is collected in various storm drainage systems and then passed into large excavations called seepage or recharge basins designed to allow a large percentage of annual rainfall to recharge an underlying aquifer. In addition to reducing runoff volumes, this method offers to put the stormwater to beneficial use by allowing a large percentage of runoff to recharge an aquifer.

Figure VI-2
Seepage or Recharge Basin



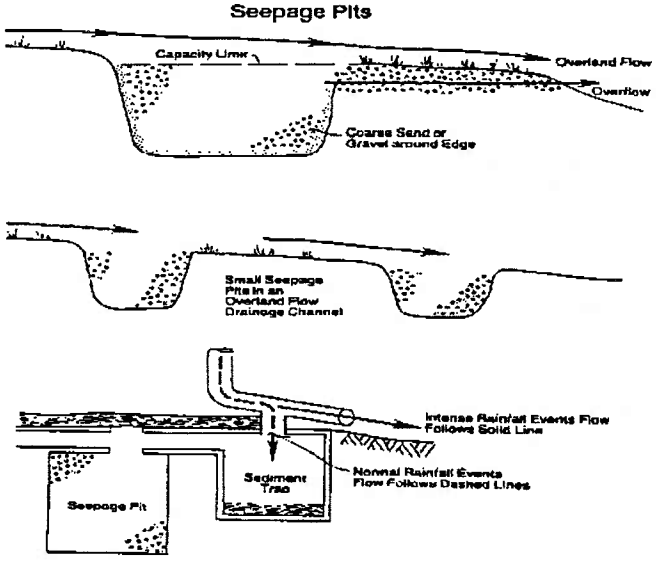
Generally, the basins must be located in aquifer recharge areas, but they may be used whenever the water table is more than 48" below the ground surface. If they are used as the only means of stormwater control, their size must be able to store the area's maximum design rainfall from all paved areas. However, they are economically more feasible if designed to recharge a certain percentage of the annual rainfall and control flood peaks by overflowing early during intense rainfall events. When using seepage basins there is a need to consider the impacts of the type and quality of runoff being infiltrated; e.g., water quality impacts on groundwater, possibility of the pit being sealed by the salts in the water. In order to maintain good infiltration rates, the bottom of the basin should be kept silt free by using a sediment trap. In addition, an emergency overflow structure is required to bypass excess runoff.

Seepage Pits or Dry Wells

Seepage pits are small excavations designed to overflow during intense storms, but reduce flood peaks by infiltration storage. They can be effectively used at the sites where soil permeability is over 0.15 ft/day and water table is more than 48" below the bottom of the pit.

There are two important design considerations associated with seepage pits: (1) the minimum size (which depends on porosity of the soil and design storm) should be sufficient to maintain predevelopment infiltration rate; (2) side area should be at least two times larger than the bottom area. Figure VI-3 shows three seepage pit designs each with an alternative overflow mechanism.

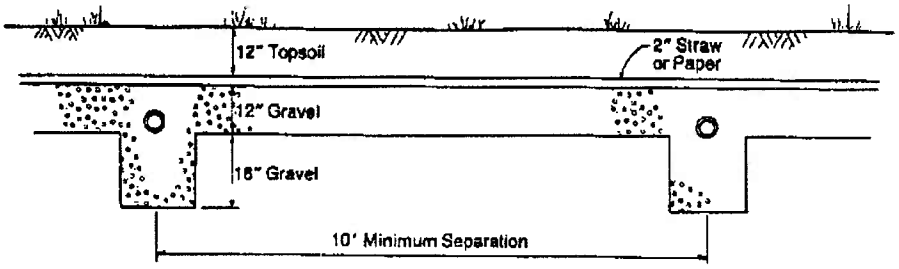
Figure VI-3
Seepage Pits



Seepage Beds or Ditches

Seepage beds dispose of runoff by infiltration it into the soil through a system of perforated pipes laid in ditches. The runoff should be allowed to pass through a sediment trap as shown in Figure 1, with a bypass structure to drain runoff from extreme rainfall events. They are not suitable for sites with water tables less than 48" deep and extremely low permeability. A typical design of a seepage bed is shown in Figure VI-4.

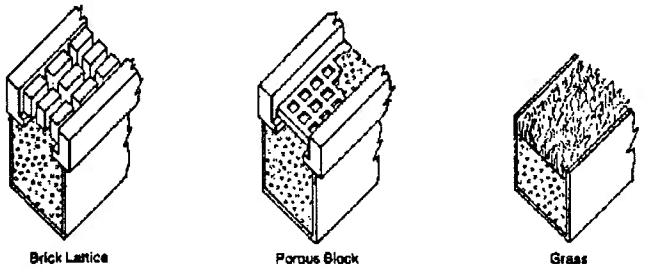
Figure VI-4
Seepage Bed



Dutch Drains

Dutch drains are employed in residential developments. They are simply ditches either filled entirely with gravel or covered with top soil and seeded. Very wide drains are usually covered with brick lattice or porous block as shown in Figure VI-5. The drains may either be located directly under the roof eaves along the length of a building, or runoff can be routed from downspouts to the dutch drain.

Figure VI-5
Dutch Drains



If dutch drains are the only means of stormwater disposal in a development, they should be able to drain area's design rainfall alone, and therefore their size will be

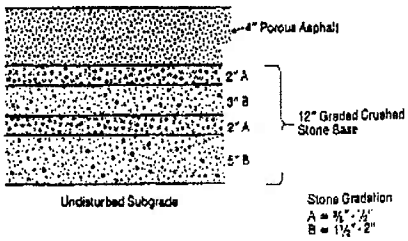
quite large. More often two to four feet drains are combined with other control alternatives for partial stormwater management using dutch drains.

Porous Pavement

Porous pavement is a special asphalt mixture designed to pass water at a high rate to a specially prepared subbase. The special subbase is thicker than a normal gravel subbase and is composed of coarse graded stone supplying large void spaces to store infiltrated runoff. Figure VI-6 shows a typical porous pavement cross-section. The base aggregate is designed to have about 40% voids ratio.

Regardless of design traffic number (DTN), a minimum surface thickness of 4" should be provided. Also, the combined surface and base thickness should not be less than anticipated frost penetration. Porous pavements have shown very positive results in regard to permeabilities, wear resistance and freezing - thawing effects. However, the main problem with porous pavements is that of pore clogging by muddy tires.

Figure VI-6
Typical Cross Section of Porous Pavement



PEAK DISCHARGE CONTROL DEVICES

Peak discharge control devices are those which control peak discharges rates by either lengthening the runoff path of the storm water or storing it and releasing it at a controlled rate. The runoff delay may vary between 15 to 30 minutes for very small areas to several hours for drainage basins of larger extent. A common goal of delay devices is, however, the disposal of all stored water before a second storm might hit. The stored water must be allowed to release at a flow rate that is designed not to cause harm.

Delay of runoff is accomplished by two basic principles of detention and retention. Detention is defined as detaining a large portion of the runoff from a storm, for a time period approximately equal to the natural runoff duration. Retention, on the other hand, is defined as holding of runoff for some time period longer than the natural runoff period. There are following alternatives available based on the principle of runoff delay.

There are a number of on-site locations for temporary storage of precipitation and runoff are generally considered:

1. Storage in ponds and lakes

2. Rooftop storage
3. Underground storage
4. Parking lot storage
5. Blue-green storage
6. Multiple use storage areas

In planning on-site storage methods, one should consider existing physical, social and economic limitations of the area. What may be a good solution at one site, may be inappropriate at another.

Detention and Retention Basins

Detention and retention basins take a variety of forms. Some are wet (filled with water all of the time) and some are dry (filled with water only during storms).

Some are designed as a continuation of a stream or river (on-stream basins) while others are separate from the river (off-site basins). Off-stream basins are usually connected to the water course by pipes or swales. Figure VI-7 shows the storage concept and the difference between the operation of detention and retention basins.

Dry Ponds

As the name implies, dry ponds are designed to be normally dry with the ability store a portion of the stormwater during a storm event and then release the stored volume slowly and safely.

Typically they are used in areas where runoff volume has been increased and it is desirable to reduce the runoff rate.

Retention basins are used when extreme limits on downstream flow rate or velocity are required. The outflow rate will be relatively low and extended over a longer period of time as compared to the outflow period of detention basin. This requires large amounts of storage for detaining stormwater for periods greater than 24 hours. Figure VI-8 shows a typical detention basin design. One detention basin can be designed to control the stormwater from 2, 10, 25 and 100-year design storm events, by constructing multi-stage outlet structures. The outlet flow discharge rate from the basin will depend on the return period of the design storm.

The outflow schedule of a pond can be extremely important as far as flood control efficiency is concerned. Some ponds could fill up with the early flush of the storm runoff and be ineffective by the time the flood peak arrives. To overcome this problem, a reservoir bypass option is employed. It allows an undisturbed sewer flow of 50 to 60 percent of capacity, beyond which the excess flow would be diverted into the reservoir.

Figure VI-7
Storage Concept for
Detention and Retention Basins

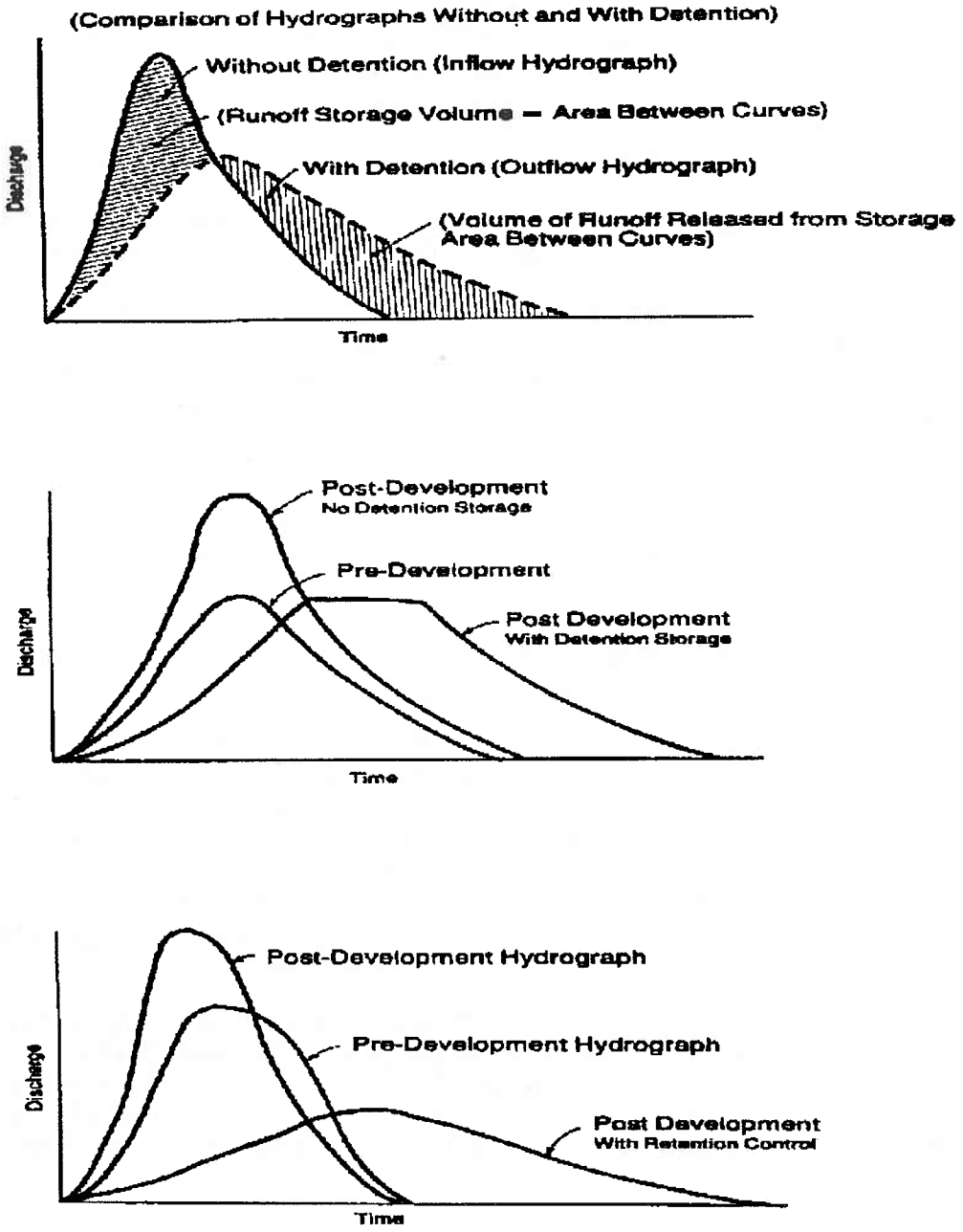
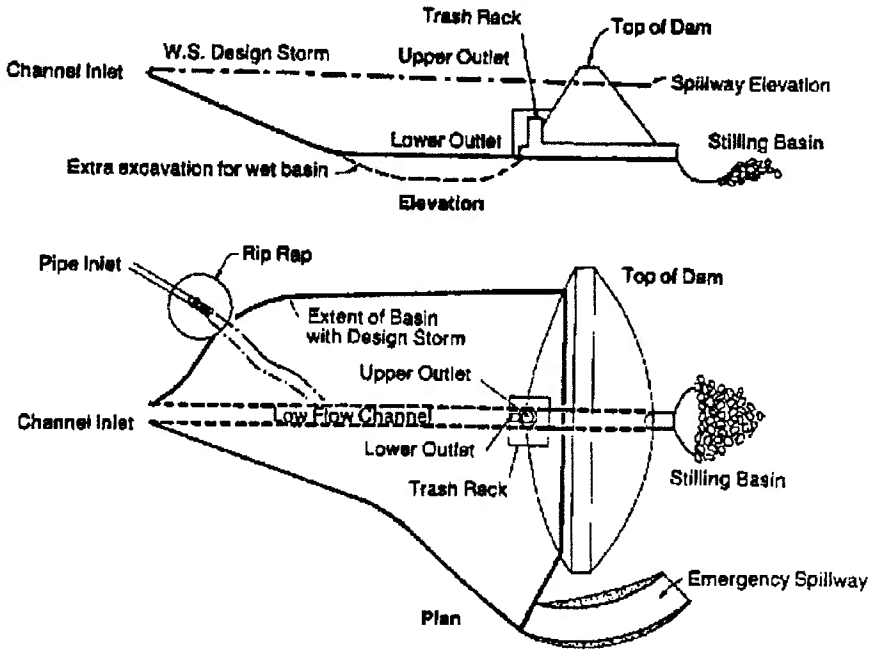


Figure VI-8
Typical Detention Basin Design



As shown in Figure 9 the detention basin is built right around the storm sewer. It allows the normal low to moderate flow to continue undiminished. As the discharge approaches full flow conditions (or any desired percentage thereof) water can spill through the holes in the top. If the bypass is only 50 percent or less, a half pipe or channel can be substituted for the full pipe. The reservoir will then be filled and not release any water until the water level in the reservoir is higher that in the pipe, at which time one-way flap gates will open and the reservoir will be gradually emptied for the next storm.

Rooftop Retention

Rooftop retention utilizes the built-in structural capabilities of rooftops to store a certain amount of rainfall that falls on them. In many cases, existing roof structures require little modification to function as retention structures. On flat rooftops, drains must be designed with proper outlet capacities to control release rates to the design level. Overflow mechanisms should be provided to preclude danger from overloading.

Special considerations of roof water tightness may be necessary when water is to be detained for longer time periods or where frequent freezing and thawing are prevalent. Figure VI-9 illustrates several types of rooftop retention devices. On sloping roofs, the retention can be achieved by providing findams. Findams are actually about 4" high gravel ridges at 15 to 30 ft spacing as shown in Figure VI-10. Individual wedge-shaped ponds would build up behind these "minidikes". Through laboratory studies it was found that a series of five dikes of 1/4 inch gravel placed on roofs of 1% slope will cut the peak runoff rate by 50% and extend the runoff time by about 30 minutes [Aron, 1975]. Finer gravel would naturally delay the runoff further. The effectiveness of the rooftop storage is a function of the actual area affected by such storage. It is most effective when used as an integral part of a larger stormwater runoff control plan. Additional maintenance should be anticipated on roofs subject to leaf accumulation.

Figure VI-9
Rooftop Retention Devices

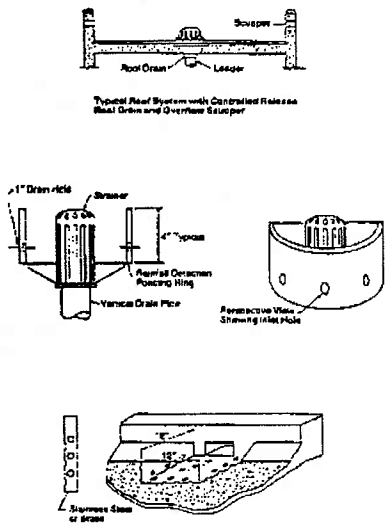
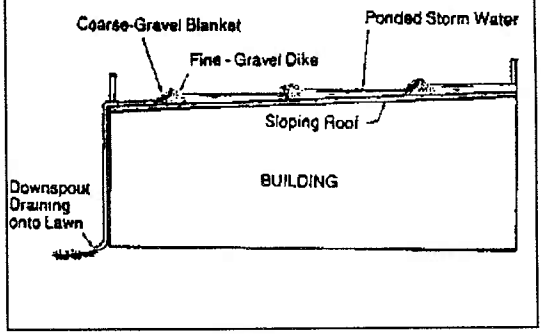


Figure VI-10
Roof Ponding With Gravel Dikes



Wet Ponds

Permanent or wet ponds are detention/retention structures filled with water all the time with adequate detention capacity to store the design floods above normal ponds level. Overflow spillways must be provided to bypass or discharge flows into floodways on the peripheries of the ponds so that safe water-storage elevations are not exceeded nor banks breached.

For extremely large ponds, adequate design precautions should be taken to minimize possible shoreline erosion due to ice, wind and wave action. Sediment accumulation and water pollution due to roadside accumulations of salts, copper, and asbestos from brake linings, grease, oil, and heavy metals, are the disadvantages associated with wet ponds. Such deleterious material should be screened out from the drainage system by interception and disposition before it reaches stormwater storage ponds. In some locations municipal, state or federal safety standards

regarding the depth and volume of water will have to be met. These ponds are unquestionably more aesthetically appealing than a typical dry detention basin. In addition, they can be designed to provide some recreational benefits. North Park Lake is an example of a permanent pool. Figure 10 shows some suitable locations in a site plan for a residential development [Becker et al., 1973].

The main difficulty with wet ponds lies in the frequent unavailability of land. Dry ponds can be made rather inconspicuous as an integral part of the landscaping or as lawn areas for office buildings. For example, depressed front lawn areas can be designed to detain runoff from intense storms and to serve as building's green space in dry season. They can be used heavily by people at lunch time. The outlet pipes allow the ponds to drain in 12 to 24 hours, and a certain amount of water undoubtedly filters into the ground [Aron, 1975].

Underground Detention/Retention Tanks

This alternative involves the underground construction of a holding tank or large size pipe as a means of providing controlled runoff from the site. In areas where land is expensive or surface topography is not suitable, these tanks can serve the same function as basins, but they conserve the land area. Outflow control devices may consist of small gravity pipes, or weirs. In some applications pumping may be required to discharge the stored runoff. This method is very expensive because of high material construction costs and possible pumping requirements.

Parking Lot Detention

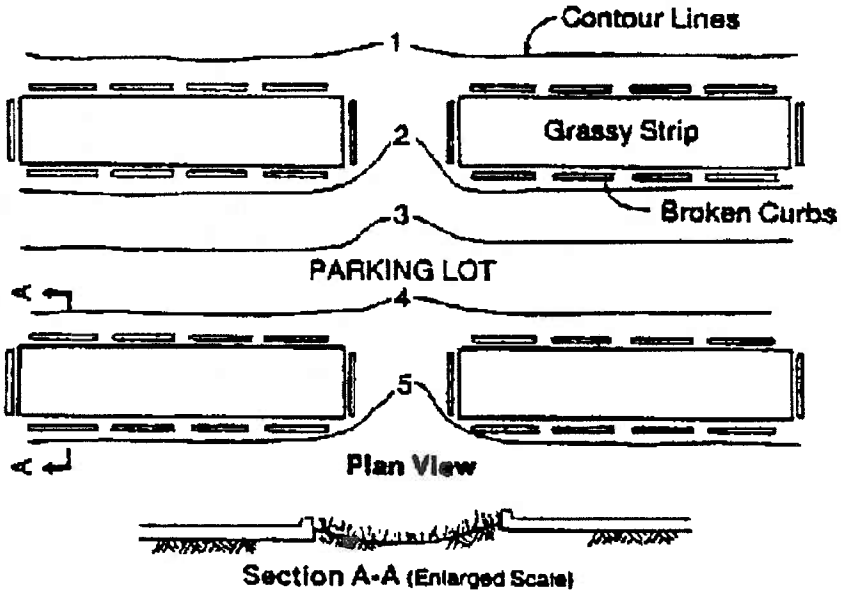
Parking lots cover a major portion of commercial developments and are, therefore, large contributors of stormwater runoff. Stormwater runoff can be detained on parking lot sites by shallow basins or swales. If properly designed, this measure can be quite effective; however, it is also quite a nuisance to shoppers trying to get into and out of their cars. Initial construction costs implementing these measures are only a small percentage above the construction cost of conventional parking lots. Arrangements of areas in a parking lot to accept ponding should be planned so that pedestrians are inconvenienced as little as possible. A 7" design depth is not unreasonable for parking locations in the remote areas of lots [APWA, 1981]. The facility should be designed to drain completely and avoid formation of ice.

Design considerations should recognize the possible use of porous asphalt, provided the subgrade has an adequate infiltration capability. Expansive and/or collapsing type soils may preclude this solution. An alternative to impervious paving of parking areas is the substitution of grassy strips. The ground surface of the planting strip is depressed and driving lanes are graded to direct the storm runoff into the depressions.

The strips should be filled with pervious soil to allow a maximum of infiltration, and planted with a Fescue-type grass which is both resistant to occasional swamping and dry soil conditions.

An efficient arrangement of planting strips is shown in Figure VI-11. The strips are oriented perpendicular to the parking lot slope and surrounded by broken curbs to protect them from being overrun by cars.

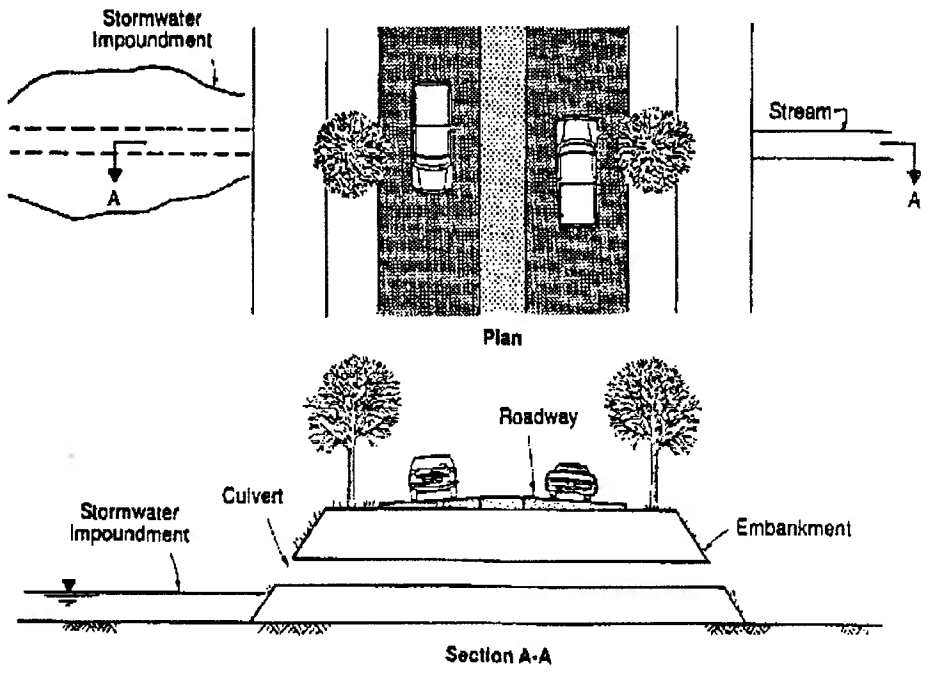
Figure VI-11
Parking Lot Detention on Swales



Blue-Green Storage

Incorporation of stormwater storage in urban drainage ways traversing roadways is a version of detention ponding that has been identified as the blue green concept. Topographical characteristics of many land areas adjacent to roadway embankments make them very much adaptable for use as detention facilities. This can be achieved by designing the culverts to pond where appropriate, as shown in Figure VI-12. Many drainage structures can be designed to operate in this fashion. Roadway embankments at control points should be stabilized and protected to minimize erosional effects of retained water.

Figure VI-12
Road Embankment Stormwater Detention



Detention within Pedestrian Plazas and Malls

On-site detention in heavily congested areas can be incorporated effectively in the design of pedestrian plazas, malls, and other similar type developments. The ponding requirement can be accomplished at selected locations with very shallow

depths (1 to 3 in) to avoid public inconvenience. Frequent maintenance and suitable discharge control devices designed to satisfy the architectural objectives of the land development are necessary in developments of this type.

Multiple Use Impoundment Areas

These areas utilize sites having primary functions other than runoff control. In new developments, such multiple use should be incorporated into the primary design. For example, open space and grassed areas provided in the land development to enhance the aesthetic appeal can also be used as stormwater detention facilities. This can be accomplished by providing stormwater release controls such as weirs, orifices, small diameter pipes and gates etc.

A hard-surface basketball or tennis court can be designed to drain adjacent grassed or paved areas. The stormwater would collect in grass swales around the edge of the court, seep through a gravel drain to retain the sediment load, and discharge onto a porous asphalt surface. Some type of emergency drain should be provided. Positive drainage toward the control devices is essential to avoid the swampy conditions, weed growth and increased maintenance costs. For optimum operation of control structures it is also essential to screen out the floating debris from the inlet stormwater.

RELATIVE ADVANTAGES AND DISADVANTAGES

Table VI-1 gives a brief summary of principal urban runoff abatement practices and relative advantages and disadvantages. As was expressed previously, the runoff volume reduction measures which simultaneously reduce runoff peaks offer significant advantages from the perspective of both local and watershed wide effects. However, since there are limitations inherent in the volume reduction techniques, it is likely that an overall stormwater control plan will include a combination of applicable volume reduction features and peak discharge control features (i.e. detention and/or retention facilities).

Selection of the best combination of techniques to be used in a particular instance should be made by the developer in consultation, or at least with the concurrence, of the municipal reviewer.

EROSION AND SEDIMENTATION CONTROL MEASURES

The ability of storm water runoff to transport material is a function of flow velocity and the erosion resistance of the material. As stormwater runoff flow rates increase, the flow velocity increases and more eroded material is transported. As the water travels down the watershed, channel gradients reduce flow velocity and sediment begins to be deposited in streams and storm sewers. This process, known as sedimentation, continues as the flow rate and flow velocity reduces. New developments further increase the sedimentation problem by removing natural vegetation and making the bare ground susceptible to erosion.

TABLE VI-1

ADVANTAGES AND DISADVANTAGES OF ON-SITE CONTROL METHODS

METHOD	ADVANTAGES	DISADVANTAGES
REDUCTION OF RUNOFF / INFILTRATION STORAGE		
Dutch Drains	– Reduces the total volume of runoff. – Reduces the peak runoff discharge rate. – Enhances the groundwater supply. – Provides additional water for vegetation in the area. – Reduces the size of down-slope stormwater control facilities.	– Looses efficiency if intensive storms follow in rapid succession. – Subject to clogging by sediment. – Limited to application for small sources of run-off only, i.e., roof drains, small parking lots, tennis courts. – Maintenance is difficult when the facility becomes clogged. – Limited application in poor infiltration soils.
Porous Pavement	– Reduces the total volume of runoff. – Reduces the peak runoff discharge rates. – Enhances the groundwater supply. – Provides additional water for vegetation in the area. – Reduces the size of down-slope stormwater control facilities. – Less costly than conven-tional pavements for most applications. – Safety features – superior skid resistance and visi-bility of pavement markings. – Provides pavement drainage without contouring.	– More prone to water stripping than conven-tional mixtures. – Subject to clogging by sediment. – Water freezing within the pores takes longer to thaw and limits infiltration. – Motor oil drippings and gasoline spillage may pollute groundwater. – Limited application in poor infiltration soils. – recent studies suggest that porous pavement's advantage will reduce with time.

TABLE VI-1

ADVANTAGES AND DISADVANTAGES OF ON-SITE CONTROL METHODS

METHOD	ADVANTAGES	DISADVANTAGES
	- Prevents puddling on the surface.	
Seepage/Recharge Basins	- Reduces the total volume of runoff. - Reduces the peak runoff discharge rates. - Enhances the groundwater supply. - Construction borrow pits often can be converted to a large seepage basin to serve multiple areas.	- Must be fenced and regularly maintained. - If porosity is greatly reduced, it may be necessary to bore seepage holes or pits in the base. - No filtering supplied by the topsoil. - Usefulness limited in poor infiltrations soils.
Seepage Pits	- Reduces the total volume of runoff. - Reduces the peak runoff discharge rates. - Enhances the groundwater supply. - Provides additional water for vegetation in the area. - Reduces the size of down-slope stormwater control facilities.	- Looses efficiency if intensive storms follow in rapid succession. - Subject to clogging by sediment. - Maintenance is difficult when the facility becomes clogged. - Limited utility in poor soils.
Seepage Beds/Ditches	- Reduces the total volume of runoff. - Reduces the peak runoff discharge rates. - Enhances groundwater supply. - Reduces the size of down-slope stormwater control facilities. - Distributes stormwater over a larger area than other infiltration	- More expensive than other infiltration techniques. - Replacement of entire system if clogging by sediment should occur. - Maintenance of sediment traps must be frequent and consequently more expensive.

TABLE VI-1

ADVANTAGES AND DISADVANTAGES OF ON-SITE CONTROL METHODS

METHOD	ADVANTAGES	DISADVANTAGES
	techniques. – May be placed under paved areas if the bearing capacity of the paved area is not affected. – Safer than seepage or recharge basins.	
Terraces, Diversions, Runoff Spreaders, Grassed Waterways, and Contoured Land-scapes	– Increases the overland flow time, increasing the time of concentration and allowing for increased infiltration. – Vegetative swales are less expensive than curb and gutter systems.	– On poorly drained soils, these techniques may leave ground waterlogged for extended periods after storms. – vegetative channels may require more maintenance than curb and gutter systems. – Roadside swales become less feasible as the number of driveway entrances requiring culverts increase.
DELAY OF RUNOFF		
Rooftop Retention	– No additional land requirements. – Not unsightly or a safety hazard. – May be adapted to existing structures.	– Leaks may cause damage to buildings and contents. – Stored runoff will greatly increase the load imposed on structural support. This increased construc-tion expense may be greater than the savings resulting from reducing the size of downslope stormwater management facilities.

TABLE VI-1

ADVANTAGES AND DISADVANTAGES OF ON-SITE CONTROL METHODS

METHOD	ADVANTAGES	DISADVANTAGES
Parking Lot Detention	– Adaptable to both existing and proposed parking facilities. – Parking lot storage is usually easy to incorporate into parking lot design and construction.	– May cause an inconvenience to people. – Ponding areas are prone to icing, requiring more frequent maintenance.
Multiple Use	– Serves more than one purpose. Employing areas of grass, a certain amount of stormwater will infiltrate and improve the quantity of water recharged by natural filtering processes. – If porous pavement is used on basketball or tennis courts, additional infiltration will be provided.	– Difficult to maintain the porosity of multi-use areas.
Detention/Retention Basins	– Offers design flexibility for adapting to a variety of uses. – Construction of ponds is relatively simple. – May allow significant reduction in the size of downslope stormwater management facilities. – May have some recreational and aesthetic benefits if runoff is not carrying heavy sediment loads.	– Facilities that empty out completely can have an unsightly nature and be a detriment to the developments. – Difficulty in establishing a regular maintenance program. – In a residential development, it may be difficult to determine whose responsibility it is to pay for the maintenance program. – Consumes land area which could be used for other purposes.

TABLE VI-1

ADVANTAGES AND DISADVANTAGES OF ON-SITE CONTROL METHODS

METHOD	ADVANTAGES	DISADVANTAGES
Permanent Ponds	– Will provide both a reduction in peak runoff rates and a source of recreation in any residential area. – Only minor modifications may be required to adapt an existing pond for use as a permanent stormwater management facility. – Wildlife habitat and wetlands may be preserved	– Stormwater runoff having a high sediment or pollutant load should not be controlled in existing ponds because of its adverse impact on the natural conditions.
Underground Retention/ Detention Tanks	– Minimal interference with traffic or people. – Can be used in existing as well as newly developed areas. – Potential for using storm-water for nonpotable uses.	– Subsurface excavation could be extremely expensive depending upon the type and amount of rock encountered. – Access for maintenance may be difficult if proper design features are not provided.

The following principles should be practiced for urban soil erosion and sedimentation control.

1. Keep disturbed areas small: Areas vulnerable to erosion should be disturbed the minimum amount possible. As much natural cover as possible should be retained and protected. The construction plan should be phased whenever possible in small units and in sequence such that only the area being developed is exposed. All other areas should have a good cover of vegetation or mulch.

2. Stabilize and Protect Disturbed Areas: Mechanical and/or structural methods and vegetative methods are available for stabilizing disturbed areas. These methods include seeding, mulching, sodding, retaining walls, terracing, use of chemical stabilizers, and others.

3. Keep Runoff Velocities Low: Removal of existing vegetative cover and the resulting increase in impermeable surface during development increase both the volume and velocity of runoff. Short slopes, low gradients and the preservation of natural vegetation cover help to keep stormwater velocities low and thus limit soil erosion.

4. Protect Disturbed Areas from Runoff: Protective measures that can be utilized to prevent water from entering and running over disturbed areas are diversions, waterways, structures etc.

5. Retain Sediment within the Site Area: Sediment can be retained by two methods: filtering runoff as it flows, and detaining sediment laden runoff for a period of time large enough to allow the soil particle settle. Sediment basins, vegetative filter strips, terraces and sediment barriers may be used to retain sediment. However one should not rely solely upon vegetation filter strips, since sediment may rapidly render such areas useless by killing the vegetation.

6. In-stream Control: After precipitation and runoff has concentrated, an outlet channel is needed for safe release of the water off the site. This outlet channel needs to be protected from erosion. A wide, shallow grassed water way can be a very good method. Channels with steeper gradients need structural protection along with, or instead of vegetative measures. Typical structural measures include: earth dams with a full flow pipe through the fill, weirs, flood gates, and check dams. In designing such facilities, it is important to consider the effects of the dam or embankment on upstream properties. The design must include safety features in the form of spillways and bypasses to prevent overtopping which can cause embankment failure.

The details on the design and implementation of practices described above and many others can be obtained from the Soil Conservation Service and the County Conservation District.

STORMWATER POLLUTION CONTROL MEASURES

The net result of runoff control problems is the potential degradation in quality of receiving waters. Flooding, erosion and sedimentation cause streams, ponds and lakes to fill with debris, pollutants and sediment. The principal water quality of impact of stormwater runoff from land development activities in the Monongahela River Watershed is related to erosion and sedimentation. The proper application of proven soil erosion and sedimentation control requirements currently enforced coupled with the stormwater quantity requirements recommended by this plan can serve minimize the stormwater related impacts of land development on receiving water quality.

The use of sediment basins can have a significant impact on water quality. A theoretical study performed by The Northeastern Illinois Planning Commission found that approximately 40% of the biological oxygen demand (BOD) could be removed through detention facilities, without the use of chemical coagulants. A report of U.S. Environmental Protection Agency (1977) states that, by sedimentation storage alone, suspended soils in urban stormwater could be reduced by 20 to 60 percent and BOD by 30 percent. This report stated that settleable solids could be reduced by 90 to 95 percent. The Soil Conservation Service encourages 10 hours or more of detention, with longer times urged to protect downstream water quality.

The control of nonpoint receiving water pollution is of growing concern in many areas. However there is relatively sparse field data with which to evaluate the pollution reduction from stormwater detention. Chapter 12 of the Special Report No. 49 of APWA (1981) reviews the empirical work which has been undertaken and which may serve as a basis for evaluating pollution abatement.

This plan does not impose any additional water quality requirements other than routine erosion and sedimentation control requirements.

SOIL CHARACTERISTICS VERSUS STORMWATER MANAGEMENT ALTERNATIVES

It was mentioned earlier that the soil characteristics at the development site, such as soil permeability, water capacity, frost penetration etc. play an important role in the selection of stormwater management alternatives. This section gives specific soil information for the Monongahela River Watershed and discusses the soil characteristics and their impact on alternative stormwater management techniques.

Soil information for Allegheny County can be obtained from the publications, "Soil Survey of Allegheny County, Pennsylvania". These publications are prepared by

Soil Conservation Service of U.S. Department of Agriculture. The survey for each county has a general soil map showing in color, the soil associations in the county. A soil association is a landscape that has a distinct pattern of soils in defined proportions. The soil association map should not be used to determine the soil type, for selecting stormwater water management alternatives. The reason is that, a general soil map is intended to be a general guide in evaluating large areas such as a watershed, or in county-wide planning for community development. It is not a suitable map for selecting a site for locating a stormwater detention or retention facility. For example, this map can be used to establish a generalized idea, that Gilpin soils constitute a major soil type in the Monongahela River Watershed. Also, the survey tells that these soils have bedrock at a depth of 1.0 to 2.0 feet, thus having severely limited application for infiltration storage. Thus, a general rule can be established that infiltration storage alternative should not be approved in the Gilpin soils unless the presence of bedrocks at low depths has been ruled out by on site engineering tests.

Table VI-2 presents some relevant properties of the Monongahela River Watershed soils significant to the use of various stormwater management techniques. Table VI-3 indicates the suitability of the soils for stormwater management alternatives.

OPERATION AND MAINTENANCE CONSIDERATIONS

Most stormwater control facilities or systems must be monitored and maintained regularly following construction to assure effective operation, long life and compatibility with the local setting. Table VI-4 contains a summary of key operation and maintenance considerations for the stormwater management alternatives discussed previously.

As is indicated in Table VI-4, there is range of operation / maintenance items which must be performed depending upon the type of stormwater management techniques employed. It is recommended that the enumeration of specific recommended operation and maintenance activities be required to be outlined by the design engineer at the time applications for permit approval are made. This set of recommended operation and maintenance activities should then be used as the basis of an on-going operation and maintenance plan. Also, provisions should be made in the appropriate ordinances or regulations to provide for effective mechanisms through which the completion of critical maintenance can be assured.

TABLE VI–2
MONONGAHELA RIVER WATERSHED
RELEVANT SOIL PROPERTIES

Soil Name	Depth To Water Table (Feet)	Depth To Bedrock (Feet)	Permeability (Inches/Hour)
Allegheny	> 6	> 5	0.6 – 6.0
Atkins	0 – 0.5	> 5	0.6 – 6.0
Brinkerton	0 – 0.5	> 5	0.06 – 6.0
Cavode	0.5 – 1.5	> 3.5	0.06 – 2.0
Clarksburg	1.5 – 3.0	> 5	0.06 – 6.0
Clymer	> 6	3.5 – 6.0	2.0 – 6.0
Culleoka	> 6	1.5 – 3.5	0.6 – 6.0
Dormont	> 6	> 4	0.06 – 2.0
Ernest	1.5 – 3.0	> 5	0.06 – 6.0
Gilpin	> 6	1.5 – 3.5	0.6 – 6.0
Guernsey	1.0 – 2.0	1.5 – 3.5	0.6 – 6.0
Hazelton	> 6	3.5 – 6.0	2.0 – 6.0
Huntington	> 4	> 5	0.6 – 6.0
Library	0.5 – 1.5	3.5 – 6.0	0.06 – 6.0
Lindside	1.5 – 3.0	> 5	0.06 – 6.0
Newark	0.0 – 1.0	> 5	0.6 – 2.0
Philo	1.5 – 3.0	> 5	0.6 – 6.0
Rainsboro	1.5 – 3.0	> 5	0.06 – 2.0
Rayne	> 6	3.5 – 5.0	0.6 – 6.0
Upshur	> 3	4.0 – 6.0	0.06 – .6
Weikert	> 6	1.0 – 1.5	2.0 – 6.0
Wharton	1.5 – 3.0	> 4	0.06 – 2.0

TABLE VI–3
MONONGAHELA RIVER WATERSHED
SUITABILITY OF SOILS FOR STORMWATER
MANAGEMENT ALTERNATIVES

Soil Name	Ponds	Embankments	Grassed Waterways, Terraces & Diversions
Allegheny	Pervious gravel in underlying material.	Medium to low shear strength; compressibility and permeability.	No unfavorable features.
Atkins	High water table; pervious layers in underlying material; hazard of flooding.	Medium to low shear strength; compressibility and permeability; high water table.	High water table.
Brinkerton	Pervious gravel in underlying material in places.	Medium to low shear strength; compressibility and permeability.	High water table; slowly permeable fragipan at a depth of 20 to 30 inches.
Cavode	Low seepage losses.	Highly plastic; low to medium shear strength; medium to high compressibility; low permeability.	Seasonal high water table; slow permeability in subsoil.
Clarksburg	Pervious layers in underlying material in places.	Medium to low shear strength; medium compressibility; low to medium permeability.	Seasonal high water table; slowly permeable fragipan at a depth of 20 to 30 inches.
Clymer	Pervious soil and underlying material.	High to medium shear strength; low to medium compressibility; medium to low permeability.	No unfavorable features.
Culleoka	Weathereed and fractured bedrock at a depth of 1.5 to 3.0 feet.	Bedrock at a depth of 1.5 to 3.0 feet; medium to high shear strength; medium to low compressibility and permeability.	Bedrock at a depth of 1.5 to 3.5 feet.
Dormont	Low sepage losses.	Steep slopes prone to landslide; medium to low shear strength; medium compressibility; low to medium permeability.	Seasonal high water table; slow permeability in subsoil.
Ernest	Pervious layers in underlying material in places.	Medium to low shear strength; medium compressibility; low to medium permeability.	Seasonal high water table; slow permeability in fragipan at a depth of 20 to 30 inches.

TABLE VI–3
MONONGAHELA RIVER WATERSHED
SUITABILITY OF SOILS FOR STORMWATER
MANAGEMENT ALTERNATIVES

Soil Name	Ponds	Embankments	Grassed Waterways, Terraces & Diversions
Gilpin	Bedrock at a depth of 1.5 to 3.5 feet.	Bedrock at a depth of 1.5 to 3.5 feet; medium to high shear strength; medium to low compressibility and permeability.	Bedrock at a depth of 1.5 to 3.5 feet.
Guernsey	Low seepage losses.	Highly plastic; step slopes; prone to landslide; medium to low shear strength; medium to high compressibility; low permeability.	Seasonal high water table; slow permeability in subsoil.
Hazelton	Pervious soil in underlying material.	High to medium shear strength; low to medium compressibility; medium to low permeability.	No unfavorable features.
Huntington	Pervious layers in underlying material; hazard of flooding.	High to medium shear strength, compressibility and permeability.	No unfavorable features.
Library	Low seepage losses.	Highly plastic; steep slopes prone to landslide; low to medium shear strength; medium to high compressibility; low permeability.	Seasonal high water table; slow permeability in subsoil; clayey subsoil.
Lindside	Pervious layers in underlying material; hazard of flooding.	Medium to low shear strength, compressibility, and permeability.	Seasonal high water table; hazard of flooding.
Newark	High water table, pervious layers in underlying material; hazard of flooding.	Medium to low shear strength, compressibility and permeability; high water table.	High water table; hazard of flooding.
Philo	Pervious layers in underlying material; hazard of flooding.	Medium to low shear strength, compressibility and permeability.	Seasonal high water table; hazard of flooding.
Rainsboro	Perfious layers in underlying material.	Medium to low shear strength; medium compressibility; medium to low permeability.	Seasonal high water table; slow permeability in fragipan at a depth of 20 to 30 inches.

TABLE VI–3
MONONGAHELA RIVER WATERSHED
SUITABILITY OF SOILS FOR STORMWATER
MANAGEMENT ALTERNATIVES

Soil Name	Ponds	Embankments	Grassed Waterways, Terraces & Diversions
Rayne	Pervious bedrock at depth of 3.5 to 5 feet.	Medium to low shear strength, compressibility and permeability.	No unfavorable features.
Upshur	Low seepage losses; landslide prone.	Highly plastic; landslide prone; low shear strength; medium to high compressibility; low permeability.	Slow permeability in subsoil; landslide prone; seep spots and springs.
Weikert	Pervious bedrock at a depth of 1 to 1.5 feet.	Bedrock at a depth of 1 to 1.5 feet.	Bedrock at a depth of 1 to 1.5 feet.
Wharton	Low seepage losses.	Highly plastic; medium to low shear strength; medium to high compressibility; low to medium permeability.	Seasonal high water table; slow permeability in substratum; clayey subsoil.

Table VI-4
Operation and Maintenance Considerations

	Dredging	Debris / Sedimentation Removal	Weed Control	Insect Control	Mechanical Maintenance	Mowing	Cleaning	Bottom Retilling	Repair	Inspection
Detention/Retention Basins		●	●	●		●			●	●
Detention/Retention Tanks				●	●		●		●	●
Ponds	●	●	●	●					●	●
Parking Lot Detention							●		●	●
Roof-top Retention							●		●	●
Open Space Detention		●				●				●
Road Embankment Detention		●	●	●			●		●	●
Seepage Basins		●	●	●		●		●		●
Infiltration Beds *		●					●			●
Porous Pavement							●		●	●
Open Channels		●	●			●				●
Pipe Systems		●					●		●	●

* Includes dutch drains, seepage pits and seepage beds.

PUBLIC ACCEPTANCE OF ON-SITE DETENTION

On-site detention, also has the disadvantage of not having wide spread public acceptance. This is mostly because the individuals have to spend extra dollars to satisfy the runoff control regulations. Also, they are concerned about the safety of their children also, which are usually attracted toward the ponds. Therefore, it is highly recommended to employ multi-purpose use of detention facilities. In the minds of a community, the multi-purpose use of such a detention facility greatly improves the perception that such a facility is a justifiable expense by the public or by the private developer [APWA, 1981]. Detention ponds are excellent examples of multi-purpose adaptability. When conceived and designed artistically, they can support different kind of activities throughout the year, such as, water sports and fishing. During winter months, shallow detention ponds with a permanent pool of water provide opportunities for ice skating in some parts of the country.

A detention basin that is dry between runoff events can be used for field sports such as football, soccer, baseball, and various passive recreational pursuits such as badminton, model airplane operation, shuffleboard, croquet, and picnicking. Some detention basins may double as tennis or baseball courts. It might be difficult to convince some developers that the benefits derived from recreation outweighs the cost of the land plus construction costs. However, should the recreation area be redesigned as a multi-purpose recreational/detention basin, the cost would look insignificant compared to the cost of upgrading a storm drainage system or the amount of potential flood damages.

Detention facilities may also contribute to the protection and preservation of wildlife habitats and other natural resources. One example is a 602 ha (244 ac) tract in Chester County, Pennsylvania, where 315 homes were to be constructed. Approximately 84 ha (34 ac) of open space were provided containing two detention ponds designed to store runoff from the 100-year rainstorm. One year following the completion of the detention ponds, wildlife was observed returning to its former habitat. Geese have nested and fish have returned to the streams and newly constructed channels. The dual purpose utilization of stormwater detention facilities as wetlands represents a potential useful means of coping with the increasingly stringent wetland protection requirements and associated wetland replacement activities.

Although multiple uses are a better alternative for securing the community acceptance, maintenance costs for such facilities may be higher. Therefore, when considering multiple uses, it is important to look at all the associated costs and intangible benefits, to determine if it is practical to proceed with the multiple use concept.

SAFETY CONSIDERATIONS

A survey conducted by APWA in 1980, based on 325 respondents, revealed that there have been two drownings reported at the detention facilities. It is therefore, very essential to take precautions in design and selection of storm water

management alternatives, to minimize hazards. Embankment slopes, railings, fencing and other features are obvious considerations. The importance of designing and constructing outflow structures and dams with safety considerations in mind should never be ignored. In general, the approaches that can be used to promote safety are [APWA, 1981]:

1. Keep people off the detention facility site
2. Provide escape aids
3. Make the onset of the hazards gradual
4. Eliminate the hazards

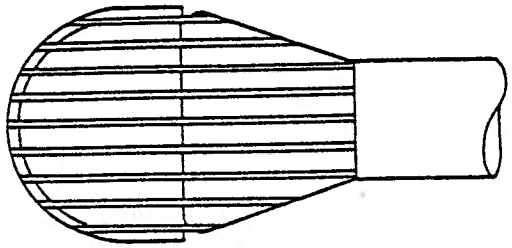
The designers and reviewers of stormwater control facilities, particularly those using detention / retention facilities should pay particular attention to incorporating appropriate safety features in the design of the facilities.

Special attention must be given to the design of outflow structures to satisfy the safety considerations. Water currents constitute a distinct hazard to persons who enter a detention pond or basin during periods when stormwater is being discharged. The force of the currents may push a person into an outflow structure or may hold a victim under the water where a bottom discharge is used. Several features designed to either eliminate or reduce such hazards are illustrated in Figures VI-13 and VI-14.

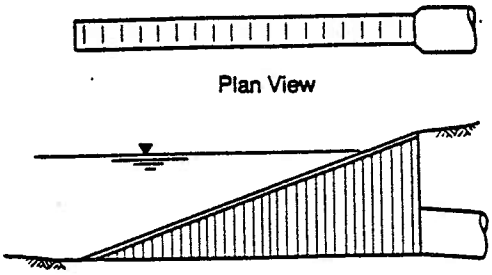
Figure VI-13 illustrates two versions of designs for non-submerged outlets: 1) curvilinear trash/safety racks for standard flared end sections and 2) narrow flume outlets. Both of these designs represent methods which tend to reduce the potential for persons to be drawn into or trapped against the outlet devices.

Figure VI-14 presents suggested safety features for submerged outlets: 1) outflow velocities and hence the associated hazards can be reduced through the use of a porous dam type of outlet facility; and 2) the illustrated safety rack for submerged outlets reduces the entrapment potential and provides a means of egress from the basin. As is also illustrated in Figure VI-14, drowning hazards can also be reduced by using a floating inlet for a basin outlet structure. The floating inlet reduces the drowning hazard by eliminating the water force which could trap a person at the outflow structure.

FIGURE IV-13
SUGGESTED SAFETY FEATURES FOR NON-SUBMERGED OUTLETS

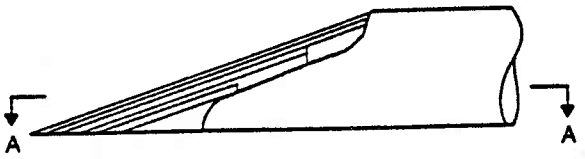


Plan View

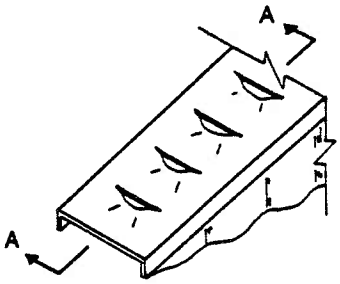


Plan View

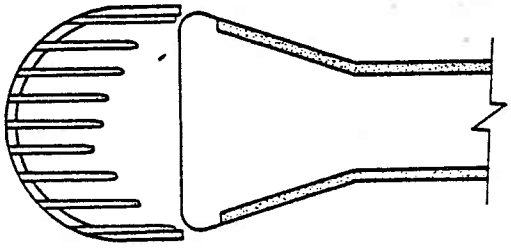
Elevation



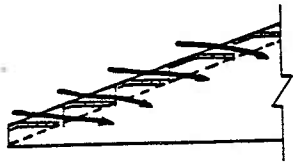
Elevation



Isometric Detail of Louver



Section A-A

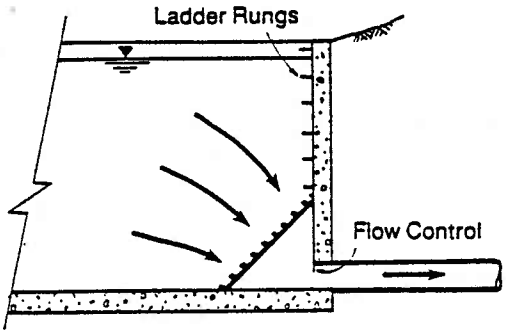


Section A-A

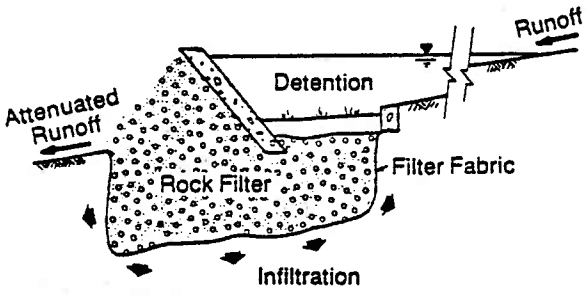
Curvilinear Trash/Safety Rack for Standard Flared End Sections

Narrow Flume Outlet for Detention Ponds

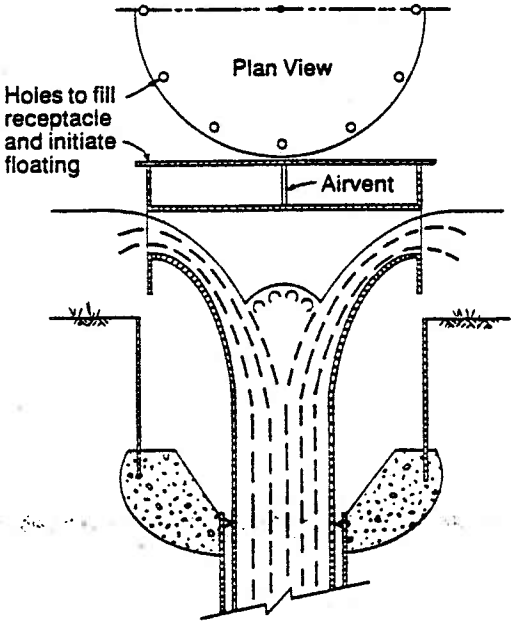
FIGURE IV-14
SUGGESTED SAFETY FEATURES FOR SUBMERGED OUTLETS



Safety Rack for Submerged Outlet
(Rails may be Horizontal to Facilitate Escape)
Source: Marcy and Flack, 1981.



Porous Dam for Detention Pond with Low Velocity Discharge
Source: Marcy and Flack, 1981.



Floating Inlet with Receiving Receptacle Recessed
Source: Marcy and Flack, 1981.

DISTRIBUTED STORAGE

GENERAL

The stormwater management techniques discussed thus far have been geared primarily to on-site control methods. It is likely that on-site controls will be the predominant form of stormwater management in the Monongahela River watershed. Off-site, distributed storage is, however, an alternative or adjunct to on-site control techniques which should be recognized and considered for use where appropriate. Simply defined, distributed storage is the process of utilizing the most suitable site or sites for regional detention facilities.

The combination of on-site detention and distributed storage approaches may significantly improve the capability of land developers and communities to control stormwater on a watershed basis. Distributed storage may also offer a means of accommodating relatively dense commercial development in a manner which minimizes total costs and optimizes land utilization through the sharing of a single, strategically located detention or retention facility. Finally, the use of distributed storage may increase the feasibility of dual or multi-purpose facilities. For example, certain recreation areas might easily be used to provide temporary stormwater storage; natural or artificial ponds and lakes can serve both recreation and stormwater management objectives; and stormwater management facilities may be constructed as replacement wetlands.

SELECTING DISTRIBUTED STORAGE LOCATIONS

There are two general methods for selecting appropriate or candidate sites for distributed storage facilities. These are: 1) selection to accommodate dense commercial development; and 2) selection based upon hydraulic factors. The first basis of selection is highly dependent upon existing and anticipated future commercial development conditions in specific locations in the watershed, the spatial distribution and timing of the development activities and the availability of suitable sites. This method of selection should be used and considered on an on-going basis by each municipality as the potential for significant strip type development is recognized.

Selection of candidate sites based upon hydraulic factors employs an analysis of storm flow routing in the watershed. The key under this approach is the selection of sites are hydraulically most advantageous for off-site (regional) storage. The final determination of which, if any, storage area is ultimately constructed should be made by subsequently assessing the need for regional storage, the economics of this alternative and the associated advantages and disadvantages of distributed storage in specific locations.

To assist in future considerations of the potential use of distributed storage, candidate distributed storage locations have been identified based upon an analysis of basin hydraulics. These candidate locations are listed in Table VI-5.

The subbasins listed in Table VI-5 refer to those identified previously in Plate IV-1, introduced in Section IV of this Plan.

Locations for distributed storage were determined by analyzing the flow routing in the watershed and selecting spots where streams join (confluences), and where peak runoff rates from two subbasins pass at approximately the same time. Areas where distributed storage would be most effective in terms of potential stream flow reductions are those where the timing of the peak discharges and the peak discharge rates are nearly equal.

Delaying one of the subbasins by using a detention pond or some other delaying facility would separate the peak runoff rates passing the confluence point would result in a decrease in the combined peak rate of stream flow at the downstream locations.

Since there are a large of stream confluence locations in the Monongahela River watershed, the following screening procedure was followed in order to identify the locations presented in Table VI-5.

1. A list was made of all of the subbasins which have two or more upstream channels entering them (confluences).

2. From the list, those subbasins where peak runoff rates form upstream subbasins pass at the same time were identified. These areas should be given the highest priority as potential distributed storage locations. Subbasins where peak runoff rates occur within 5 and 10 minutes of one another were defined as potential, albeit lower priority, distributed storage locations.

3. For all of the subbasins identified above, the ratios of the peak runoff from the tributary subbasins were calculated and categorized into three ratio groups: ratios = 1 to 1.25; ratios = 1.26 to 1.50 and greater than 1.50. The subbasins with the lower ratios are those for which the peak discharges from the tributary subbasins are most nearly equal and, consequently, are those in which distributed storage may be most effective.

4. The potential distributed storage sites were compared and rated in terms of potential effectiveness and a location for such facilities. In general, those locations which exhibited the most nearly coincidental peaks and most nearly equivalent peak discharges from the tributary legs were rated highest.

TABLE VI-5
MONONGAHELA RIVER WATERSHED
ANALYSIS OF THE POTENTIAL FOR EFFECTIVE DISTRIBUTED STORAGE

Watershed	Downstream Watershed ID	Upstream Watershed ID	Peak Discharge (cfs)	Peak Time (minutes)	Subbasins for Distribution Storage With: Peak Time Difference (minutes) 0	5	10	Peak Runoff Ratio 1.00 – 1.25	1.26 – 1.50	Potential for Effective Distributed Storage
Beckets Run	5	4	182	720						Moderate
		2	394	725		2,4				
Beckets Run	8	17	857	725						Moderate
		7	371	720		7,17				
Beckets Run	16	13	299	725						High
		15	298	720		13,15		13,15		
Beckets Run	17	16	665	730						Moderate
		9	16	720			9,16			
Beckets Run	18	8	1202	740						Moderate
		5	666	730				5,8		
Beckets Run	23	20	411	720						Moderate
		22	183	720	20,22					
Coal Valley Run	230	223	1534	745						Moderate
		227	720	735			223,227			
Beckets Run	24	23	1964	740						Moderate
		18	641	730			18,23			
Sunfish Run	30	27	758	730						Moderate
		29	194	720			27,29			
Sunfish Run	33	30	1084	740						Low
		32	254	720						
Kelly Run	44	41	343	720						High
		43	255	720	41,43				41,43	
Kelly Run	48	45	970	740						Low
		47	241	725						
Kelly Run	51	48	1403	750						Low
		50	165	720						
Bunola Run	57	54	403	720						High
		56	406	720	54,56			54,56		
Bunola Run	60	59	93	720						Low
		57	864	730			57,59			
Mill Run	68	67	215	720						High
		65	324	730			65,67		65,67	
Mill Run	71	68	763	730						Moderate
		70	164	720			68,70			
Mill Run	74	71	1037	735						Low
		73	389	720						
Mill Run	79	76	136	720						High
		78	104	720	76,78				76,78	
Mill Run	83	80	2040	750						Low
		82	452	720						
Mill Run	88	85	65	720						High
		87	78	720	85,87			85,87		
Mill Run	89	83	2400	735						Low
		88	474	720						

TABLE VI–5
MONONGAHELA RIVER WATERSHED
ANALYSIS OF THE POTENTIAL FOR EFFECTIVE DISTRIBUTED STORAGE

Watershed	Downstream Watershed ID	Upstream Watershed ID	Peak Discharge (cfs)	Peak Time (minutes)	Subbasins for Distribution Storage With: Peak Time Difference (minutes) 0	5	10	Peak Runoff Ratio 1.00 – 1.25	1.26 – 1.50	Potential for Effective Distributed Storage
Fallen Timber Run	101	98	253	720						Moderate
		100	100	720	98,100					
Fallen Timber Run	104	101	693	725						Moderate
		106	199	720		101,106				
Fallen Timber Run	107	104	985	730						Moderate
		106	273	720			104,106			
Fallen Timber Run	112	111	66	720						Moderate
		109	419	725		109,111				
Fallen Timber Run	113	107	1334	735						Moderate
		112	719	730		107,112				
Fallen Timber Run	118	113	2050	735						Low
		115	412	720						
		117	412	720	115,117			115,117		
Fallen Timber Run	119	118	2813	735						Low
		382	596	720						
Fallen Timber Run	123	119	3486	745						Low
		121	402	720						
Fallen Timber Run	126	123	3774	755						Low
		125	132	720						
Fallen Timber Run	129	126	3848	770						Low
		128	194	720						
Wylie Run	136	132	362	725						High
		135	312	730		135,132		135,132		
Wylie Run	142	141	365	720						High
		139	534	720	139,141			139,141		
Wylie Run	146	142	968	730						Moderate
		145	384	725		142,145				
Wylie Run	147	146	1349	730						Moderate
		207	502	725		146,207				
Wylie Run	152	147	1614	735						Low
		151	361	720						
		149	25	720	149,151					
Wylie Run	153	137	987	755						Moderate
		152	2399	750		137,152				
Lobbs Run	160	157	111	720						Moderate
		159	188	720	157,159					
Lobbs Run	163	160	456	725						Moderate
		162	230	720		160,162				
Lobbs Run	164	163	777	730						Moderate
		380	143	720			163,380			
Lobbs Run	167	164	924	740						Low
		166	135	720						
Lobbs Run	169	167	1043	745						Low
		379	195	720						
		385	369	720	379,385					

TABLE VI-5
MONONGAHELA RIVER WATERSHED
ANALYSIS OF THE POTENTIAL FOR EFFECTIVE DISTRIBUTED STORAGE

Watershed	Downstream Watershed ID	Upstream Watershed ID	Peak Discharge (cfs)	Peak Time (minutes)	Subbasins for Distribution Storage With: Peak Time Difference (minutes) 0	5	10	Peak Runoff Ratio 1.00 – 1.25	1.26 – 1.50	Potential for Effective Distributed Storage
Lobbs Run	172	169	1536	735						Low
		171	167	720						
Lobbs Run	177	174	103	720						Moderate
		176	178	720	174,176					
Lobbs Run	180	177	496	725						Moderate
		179	81	720		177,179				
Lobbs Run	183	180	595	720						Moderate
		182	153	720	180,182					
Lobbs Run	184	172	1731	745						Low
		183	823	730						
Lobbs Run	187	184	2579	750						Low
		186	103	720						
Courain Hill	205	202	476	720						Moderate
		204	201	720	202,204					
Coal Valley Run	213	210	515	720						Moderate
		212	261	720	210,212					
Coal Valley Run	216	213	798	730						Moderate
		215	138	720			213,215			
Coal Valley Run	219	216	979	740						Low
		218	211	720						
Coal Valley Run	223	219	1212	735						Low
		222	215	720						
Curry Hollow Run	238	235	1114	720						Moderate
		237	251	720	235,237					
Thompson Run	247	244	154	725						Moderate
		245	71	720		244,245				
Thompson Run	249	242	2626	730						Low
		248	535	725		242,248				
Thompson Run	252	249	3222	740						Low
		251	279	720						
Thompson Run	257	254	141	720						Moderate
		256	226	720	254,256					
Thompson Run	258	252	3491	750						Low
		257	402	730						
Thompson Run	261	258	4119	760						Low
		260	759	720						
Homestead Run	276	271	853	720						High
		275	1026	730			271,275	271,275		
Streets Run	282	280	492	720						High
		281	699	720	280,281				280,281	
Streets Run	285	283	1451	735						Low
		284	421	720						
Streets Run	289	286	2465	740						Low
		288	944.5	720						

TABLE VI-5
MONONGAHELA RIVER WATERSHED
ANALYSIS OF THE POTENTIAL FOR EFFECTIVE DISTRIBUTED STORAGE

Watershed	Downstream Watershed ID	Upstream Watershed ID	Peak Discharge (cfs)	Peak Time (minutes)	Subbasins for Distribution Storage With: Peak Time Difference (minutes) 0	5	10	Peak Runoff Ratio 1.00 – 1.25	1.26 – 1.50	Potential for Effective Distributed Storage
Streets Run	294	291	660	720						High
		293	514	720	291,293			291,293		
Streets Run	295	289	3366	745						Moderate
		294	1431	745	289,294					
Streets Run	298	295	4855	755						Low
		297	947	720						
Streets Run	302	298	5458	755						Low
		301	837	720						
Streets Run	305	302	6071	760						Low
		304	164	720						
Streets Run	310	307	592	720						High
		309	461	720	307,309				307,309	
Streets Run	311	305	6275	770						Low
		310	1261	730						
Streets Run	318	311	6871	780						Low
		313	140	720						
		317	1118	745						
West Run	323	320	261	720						Moderate
		322	108	725		320,322				
West Run	327	324	866	720						Moderate
		326	348	720	324,326					
Becks Run	335	332	874	720						High
		334	678	720	332,334				332,334	
Crooked Run	367	364	872	725						Moderate
		366	444	720		364,366				
Crooked Run	373	367	1689	745						Low
		372	133	720						
Crooked Run	377	373	1760	755						Low
		376	541	720						

The resulting identified potential distributed storage locations represent those points in the watershed that the construction of distributed storage facilities are most likely to economically reduce downstream peak discharges. As such, they represent primary locations to be considered if the feasibility of the application of the distributed storage approach comes under consideration at points throughout the watershed. This analysis does not include evaluations of other important factors affecting the ultimate feasibility of distributed storage including the availability of land. While this analysis provides a guide for identifying potentially effective general areas for the operation of such facilities, a complete assessment of feasibility must include a broader and more intensive evaluation of conditions.

In the event that distributed storage is desired and the identified candidate points prove unacceptable, the search for an acceptable location could be broadened to consider other locations which may offer less favorable timing and evenly divided stream discharge characteristics.

MONONGAHELA RIVER WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION VII
EXISTING MUNICIPAL ORDINANCES

EXISTING MUNICIPAL ORDINANCES

As part of the development of this watershed stormwater management plan for the Monongahela River Watershed, each of the municipalities in the watershed was asked to provide copies of their current zoning, subdivision and land development, erosion / sedimentation, grading and floodplain ordinances and building codes to the consultant. Ordinances were obtained for eighteen municipalities encompassing nearly 88% of the area of the watershed.

These municipalities' ordinances were reviewed to identify, to the extent expressed in the ordinances, development objectives, the current extent of control of stormwater related aspects of development, existing enabling ordinance provisions, and current stormwater management responsibilities and procedures.

Table VII-1 summarizes the stormwater management provisions in the existing ordinances. The accompanying matrix provides a graphic summary of the ordinance review.

All but two of the eighteen municipalities submitting ordinances for review have some type of stormwater runoff control provisions in their ordinance packages. However, the extent and specificity of the requirements vary widely. Some municipalities enforce relatively detailed and specific control requirements directed toward managing the impacts of off-site effects of runoff from land development activities. Several ordinances specifically reference Act 167. In many cases, however, the ordinance provisions are limited to minimal engineering criteria for storm sewers and or requirements for unspecified "adequate" drainage facilities. None of the ordinances reviewed included a truly watershed wide approach to stormwater management.

It is anticipated that all of the municipalities in the watershed will need to adopt modifications and/or additions to their existing ordinances in order to permit effective implementation of this Plan. Specific information describing the desired content of the municipal ordinances is provided in Section VIII of the Plan.

TABLE VII-1
STORMWATER PROVISIONS IN EXISTING MUNICIPAL ORDINANCES

Municipality	Storm Frequencies	Release Rate %	"No Harm" Evaluation	Calculation Method	Onsite Infiltration Standards	Detention Facilities Standards	Plan Submission Requirements	Plan Review Procedures	Maintenance Agreements	Inspection Schedule	Inspection Fees	Enforcement Procedures
Baldwin Borough	●			●		●	●	●	●	●	●	
Braddock Hills * Borough											⊘	
Duquesne ** City	●	●		●		●	●	●	●	●	●	
Elizabeth Township	⊘			⊘								
Forward Township										●	●	
Homestead Borough												
Jefferson Borough	●			●		●	●	●	●	●		
Lincoln Borough											⊘	
McKeesport ** Borough				●						●		
Mt. Oliver Borough											⊘	
Munhall Borough								⊘			●	
North Versailles * Township								⊘				
Penn Hills * Municipality				●		●		●			●	
Pittsburgh ** City						⊘		●			⊘	
Rankin Borough								⊘				
Swissvale ** Borough	●	●		●		●	●	●	●	●	●	
West Mifflin Borough								⊘	●	⊘	⊘	
Whitehall Borough	●			●		●	●	●	●	●	●	

KEY

● Provision covered in existing ordinances; may require modification to implement the watershed plan.

⊘ Provision partially covered in existing ordinances; will require revisions to implement the watershed plan.

NOTES

* Municipality scheduled to update its ordinances to implement the Turtle Creek Watershed Plan.

** Ordinances require compliance with standards of any approved watershed plan.

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	Baldwin Borough
Relevant Ordinances	Zoning (Ord #557, codified at Ch. 168); Subdivision and Land Development (Ord #558, codified at Ch. 42); Grading (Ord #318, codified at Ch. 99); Soil Erosion/Sedimentation (Ord #142); Stormwater Mgmt. (Ord #142); Floodplain Regulations (Ord #92); Building (BOCA, Ord #616, #615).
Land Use Planning Standards	Zoning permits planned residential districts; slope controls. Subdivision Ordinance sets design standards for storm drainage plans; Stormwater Mgmt Ord. requires stormwater management plan
Stormwater Controls	Stormwater Mgmt. Ord. to ensure compliance with Act 167. "small development" exemption provided. No subdivision approval without approved stormwater plan Maximum rate of stormwater runoff no greater after development than before development, or to adequately protect health and property from possible injury.
Specific Calculation Method	SCS TR–55 for > 3 acres, rational method for < 3 acres and conveyance facilities
Design Standards for Stormwater Controls	Criteria for detention facilities, collection/conveyance facilities, E/S controls. Specific design storms: 2, 25 and 100 year.
Erosion/Sedimentation Controls	Grading Ord. requires permits; performance standards for E/S controls; E/S permit or plan necessary for subdivision approval
Plan Review Process	Stormwater Mgmt. Ord. requires preliminary & final stormwater plans to be submitted with subdivision plan applications; plan review by Borough Engineer (< 3 acres), County Conservation Distirct (> 3 acres) with written report to the Planning Commission
Fees	Fee Schedule set in Subdivision Ord., Grading Ord.
Inspection Schedule	Grading Ord. provides for periodic inspections during work; Stormwater Mgmt. Ord. requires Engineer to inspect each phase and at completion
Maintenance Provisions	Stormwater Mgmt. Ord. requires plan to establish O&M responsibilities. Borough can accept or reject responsibility. Privately owned facility requires written agreement for O&M prior to plan approval

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	Braddock Hills Borough
Relevant Ordinances	Zoning (Ord #66–5); Subdivsion/Land Development (Ord #69–6); Grading (Ord #72–4); Floodplain (Ord #85–2)
Land Use Planning Standards	Zoning Ord allows unit development projects with lot averaging
Stormwater Controls	Ord #69–6 contains general performance standards for storm sewers and street drainage; Ord #72–4 requires erosion & sedimentation controls; Ord #85–2 requires adequate drainage in floodplains
Specific Calculation Method	none
Design Standards for Stormwater	No specific standard; as approved by the municipal engineer
Erosion/Sedimentation Controls	Ord #72–4: follow the E/S guidelines in the Allegheny County Conservation District Handbook
Plan Review Process	Ord #72–4: approval by "administrator"; Ord #69–6: S/D approval by the municipal engineer and council; Ord #85–2: ACCD reviews plans in floodplain approved by building permit officer
Fees	Ord #69–6: applicant pays cost for inspection; Ord #72–4: applicant pays cost of review and inspection; Ord 85–2: fees based on estimated cost of construction
Inspection Schedule	None
Maintenance Provisions	Ord #72–4: owners responsible for maintaining protective structures installed during grading. Borough may revoke certificate of completion

Note: Ordinance package scheduled for modification to conform with recommendation contained in the Turtle Creek Act 167 Watershed Stormwater Management Plan.

Existing Regulatory Controls	Municipality
	City of Duquesne
Relevant Ordinances	Zoning (Dec. 1991); Building (BOCA); Subdivision/Land Development (Dec. 1991)
Land Use Planning Standards	Zoning requires site landscaping; standards for buffers. S/LD discourages building on steep slopes, other sensitive land. References federal and state requirements for wetlands.
Stormwater Controls	S/LD Ordinance follows Allegeny County's model stormwater management ordinance.
Specific Calculation Method	S/LD: SCS TR−55 for > 3 acres; rational method for <3 acres and conveyance facilities.
Design Standards for Stormwater Controls	S/LD: Use release rates and design storms required by adopted watershed plans as or as approved by City Engineer. Design/ performance standards for sewers and detention facilities.
Erosion/Sedimentation Controls	Performance standards reference County Conservation District & DER regulations. E/S permit or plan required for S/LD or site development approval.
Plan Review Process	Stormwater and E/S plans reviewed by City Engineer; final approval by Council (part of S/LD or Zoning approval).
Fees	S/LD and Zoning provide authority to adopt fees; new schedule being reviewed by Council.
Inspection Schedule	S/LD: Inspections by engineer at completion of major phases and when completed.
Maintenance Provisions	Maintenance plan required for stormwater and E/S facilities; bond for 18 months.

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	Elizabeth Township
Relevant Ordinances	Zoning (Ord. #410, 5/22/73); Subdivision (Ord. #394, 11/3/71)
Land Use Planning Standards	#410 – includes two conservation districts with restricted uses and large lots; allows planned residential developments (no specific standards); allows mining & well drilling, landfills, stripping of topsoil (for other than on–site construction) as special exemption uses. #394 – requires not more than 10% of subdivision to be set aside for recreation uses.
Stormwater Controls	#394 – general standard to provide adequate drainage and protect adjacent properties; storm sewers to discharge into a natural watercourse
Specific Calculation Method	#394 – use rational to design drainage structures
Design Standards for Stormwater Controls	#394 – design drainage structures to handle 25–year storms; obtain any required state premits for encroachments
Erosion/Sedimentation Controls	#394 – if topsoil removed on slopes, must reseed or otherwise prevent erosion
Plan Review Process	#410 – zoning officer issues permits; special exception uses require Zoning Hearing Board approval. #394 – final plan approval by township commissioners
Fees	None specified
Inspection Schedule	None
Maintenance Provisions	#394 – bond (2 years) for 50% of the cost of improvements to be accepted by the township

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	Forward Township
Relevant Ordinances	Zoning (Ord #83–1); Subdivision & Land Development (Ord #83–2); PRD (Ord #83–3)
Land Use Planning Standards	Zoning – minimum lot area; Para. 309 establishes environmental protection requirement for grading, seeding; Subdivision Ord sets design standards for slope development. PRD Ord contains 15% open space requirement
Stormwater Controls	Subdivision Ord requires storm drainage facilities and areas subject to stormwater identified on application
Specific Calculation Method	None
Design Standards for Stormwater Controls	Must have hydraulic calculations relative to the type and size of stormwater facilities
Erosion/Sedimentation Controls	Subdivision Ord requires erosion control for open watercourses, slope development; PRD approval requires E/S plan
Plan Review Process	Storm drainage facilities must be approved by "Governing Body"
Fees	Subdivision Ord sets schedule of fees
Inspection Schedule	Set by Subdivision Ord
Maintenance Provisions	Bond for 2 years after acceptance by the municipality

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	Homestead Borough
Relevant Ordinances	Zoning (Ord #846, codified at Para 98–101); Building (BOCA); Floodplain Mgmt. (1985)
Land Use Planning Standards	Para. 98–612 establishes lot area requirements; Para. 98–803 requires registration of non–conforming uses; Para 98–807 sets standards for planned development
Stormwater Controls	None
Specific Calculation Method	None
Design Standards for Stormwater Controls	None
Erosion/Sedimentation Controls	None
Plan Review Process	Para. 98–801 – zoning officer approves permitted uses; Zoning Hearing Board approves special exemptions including planned developments
Fees	Para. 98–814 provides a fee schedule for building permits, occupancy permits, special exemptions
Inspection Schedule	None
Maintenance Provisions	None

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	Jefferson Borough
Relevant Ordinances	Zoning (Ord # 606); Subdivision/Land Development (Ord #603); Stormwater Management (Ord #561); Floodplain (Ord# 407).
Land Use Planning Standards	Standards for surface mining restrict activity near streams; provisions for planned residential, commercial, industrial development limit grading and building on steep slopes.
Stormwater Controls	#561 consistent with Act 167. "Small Development" exemption. Utilizes "no increase in peak rate" approach.
Specific Calculation Method	SCS TR–55 for runoff calculations; rational method for facility design.
Design Standards for Stormwater Controls	Utilizes 2– & 25– year storms; all facilities protected from damage in 100 year storm. Specific standards for facility design.
Erosion/Sedimentation Controls	S/LD plans for major excavation, grading and filling approved by the Engineer.
Plan Review Process	Stormwater plans reviewed by the Engineer. No final development approved until satisfactory stormwater management plan is presented.
Fees	None
Inspection Schedule	Inspections by Engineer during & upon completion of development.
Maintenance Provisions	Maintenance plan required for privately owned stormwater facilities; 2– year bond for any facilities dedicated to municipality.

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	Lincoln Borough
Relevant Ordinances	Zoning (#74–1, 7/10/74, Chapter 27 of Codified Ord.); Subdivision/Land Development (#74–5, 5/14/75, Chapter 22); Building Code (#78–3, 7/17/78, Chapter 9)
Land Use Planning Standards	Chapter 27 includes conservation districts & planned residential developments (PRD); allows mining & well drilling, sanitary landfills & stripping of topsoil (for other than construction on–site) as special exception uses; floodplain areas are overlay district with restricted uses (agriculture, recreation, etc.). Chapter 22 – no subdivision of land with improer drainage.
Stormwater Controls	Chapter 27 – restricts any land distrurbance within 50 foot of natural drainage courses. Chapter 22 requires safe efficient storm drainage in floodplain areas.
Specific Calculation Method	None
Design Standards for Stormwater Controls	Chapter 22 – drainage systems to construct to Borough "standards of construction"; follow PennDOT standards in designing storm sewers.
Erosion/Sedimentation Controls (1)	Chapter 27 – prohibits cuts/fills with > 33.3% slope for areas > 100 sq. ft.; requires cleared areas to be graded & seeded promptly; in conservation districts, no more than 10% of natural cover to be removed. Chp. 22 – general requirement to provide erosion no reference to DER or ACCD standards.
Plan Review Process	Chp. 22 – preliminary S/D plans approved by planning commission; final plan approval by borough council. Chp. 27 – zoning officer approves most permits; special exception uses handled by zoning hearing board.
Fees	Chp. 22 – fee for inspection of required improvements
Inspection Schedule	None
Maintenance Provisions	Chp. 22 – maintenance bond (3 year) for facilities dedicated to borough.

(1) Note: zoning and subdivision regulations refer to grading permit, but grading ordinance not available for this review.

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	Borough of Mt. Oliver
Relevant Ordinances	Zoning (Ord #612 of 1972); Builiding (BOCA)
Land Use Planning Standards	Article 200 contains area and lot size regulations; Para. 702 requires plot plan for building permit application
Stormwater Controls	None
Specific Calculation Method	None
Design Standards for Stormwater Controls	None
Erosion/Sedimentation Controls	None
Plan Review Process	Para. 702 – plot plan specifications must be accepted by the Building Inspector; Para. 701 – Zoning Officer approves permitted uses; Para. 802 – Zoning Hearing Board approves special exemptions
Fees	Para. 702.4 establishes fee schedule of Building Permits; Para 702.5 provides for excrow fund for developers, contractors (1% of project costs)
Inspection Schedule	None
Maintenance Provisions	None

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	Munhall Borough
Relevant Ordinances	Zoning (Ord #1215); Subdivision (Ord #1171); Grading (Ord #1224); Floodplain Regulations (Ord #1277)
Land Use Planning Standards	Zoning Ord sets density requirements; slope districts with minimal lot size and planned development; Subdivision Ord provides standards for "community facilities"
Stormwater Controls	Floodplain Ord requires stormwater drainage facilities along streets, away from buildings; Subdivision Ord requires "adequate" drainage
Specific Calculation Method	None
Design Standards for Stormwater Controls	Subdivision Ord standards require design and installation approved by Borough Engineer; Floodplain Ord sets standard "safe and efficient"
Erosion/Sedimentation Controls	Grading Ord requires permit for grading, excavation or fill; standards for slop treatment and drainage structures required to prevent erosion damage
Plan Review Process	Grading permit application reviewed by the Borough Engineer; subdivision plns approved by Planning Commission & Borough Council; Zoning Ord requires Building Inspector to approve permitted uses; Zoning Hearing Board approves special exemptions
Fees	Subdivision Ord provides for fee schedule for plan review; and inspection costs
Inspection Schedule	Subdivision Ord sets inspection for construction; Grading Ord requires inspection of all work including installation of drainage facilities
Maintenance Provisions	Grading Ord provides for revocation of certificate of completion if maintenance not satisfactory

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	North Versailles Township
Relevant Ordinances	Zoning (Ord #170); Excavating and Grading (Ord #833); Subdivision Regulations (Ord #768); Floodplains (Ord #768)
Land Use Planning Standards	Zoning Ord regulates building area to lot size; Excavation and Grading Ord specifies maximum slope steepness; Subdivision Reg establish that the Township may require 0.02 acre/dwelling unit for recreation land in 5+ acre developments
Stormwater Controls	Floodplain Ord, Excavation and Grading Ord and Subdivisions contain general requirements for control of stormwater
Specific Calculation Method	None
Design Standards for Stormwater Controls	No specific standard. Ord #767 contains general no harm language; Ord #833 required that Erosion and Sediment Control Handbook be followed; Ord #768 requires that storm drainage be provided per "good engineering practice"
Erosion/Sedimentation Controls	Consultation with Conservation District required; soil report may be required
Plan Review Process	All plans reviewed by Conservation District (Ord #767); E/S reveiw by Conservation District is required
Fees	Fee schedule for planning and inspection costs
Inspection Schedule	Ord #833 requires inspections during the work period
Maintenance Provisions	Ord #833 establishes owner's responsibility to maintain; remedial work may be ordered by the municipality

Note: Ordinance package scheduled for modification to conform with recommendation contained in the Turtle Creek Act 167 Watershed Stormwater Management Plan.

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	Municipality of Penn Hills
Relevant Ordinances	Zoning (Ord #1617); Subdivision/Land Development (Ord #1837); Grading (Ord #1220); Floodplain (no number)
Land Use Planning Standards	Ord #1617 allows "major excavation & grading" (mining, removal of > 10,000 sf of trees) as conditional use in most residential districts, but only 1 active operation/watershed; prohibits clear cutting not incidental to development; sets; minimum open space and recreation requirements; allows PRDs
Stormwater Controls	Ord #1617, Ord #1837; Ord #1280; and Floodplain Ord contain references to stormwater control
Specific Calculation Method	Ord #1617 and Ord #1837 specify use of the rational method
Design Standards for Stormwater	Ord #1617 & #1837 list 7 approved retention methods; design facilities according to Penn Hills construction standards or PENNDOT 408 specifications; certain facilities to be approved by municipal engineer; street curbs may be eliminated to facilitate stormwater management
Erosion/Sedimentation Controls	Ord #1617: meet standard in ACCD Handbook; 8 general performance standards; no ACCD plan review; Ord #1280 requires grading permit to prevent erosion and runoff damage; Floodplain Ordinance: advisory review by ACCD
Plan Review Process	Ord #1617 & #1837: site plan and S/LD approved by the planning commission (2 lot S/D by zoning officer); Ord #1280: grading permit approved by the municipal engineer; Floodplains approved by code enforcement officer
Fees	Ord #1617 references "municipal schedule of fees"
Inspection Schedule	None
Maintenance Provisions	Ord #1837 provides for construction guarantees but no maintenance bonds; Ord #1280 (grading) specifies owner responsible for maintenance

Note: Ordinance package scheduled for modification to conform with recommendation contained in the Turtle Creek Act 167 Watershed Stormwater Management Plan.

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	City of Pittsburgh
Relevant Ordinances	Zoning (Title 9 of City Code, 1988); Subdivision Regulations & Standards (1986); Building (Title 10 of City Code, 1990)
Land Use Planning Standards	Zoning – special district for hillsides and other areas not suitable for intensive development; overlay districts for floodplains, riverfronts, landslide prone, undermined and view protection districts; planned residential, commercial, industrial, institutional districts; special standards for hillside development.
Stormwater Controls	Subdivision (S/D) – lots to have drainage away from buildings, avoid concentrating runoff and conform to any approved Act 167 plan. Pre & post development peak discharges to be equal (same language as Act 167. Building – requires sufficient drainage controls for land operation activities (i.e. grading)
Specific Calculation Method	None
Design Standards for Stormwater Controls	Building (land operations) – drainage facilities approved by Department of Public Works
Erosion/Sedimentation Controls	Building – prevent erosion during construction, requirement for interim and permanent ground cover
Plan Review Process	Zoning & S/D – zoning administrator approves most applications. Special uses approved by Board of Adjustment or City Council. Building – permits issued by Chief of Building Inspection
Fees	Specified for zoning reviews, land operation permits; none specified in in subdivision regulations
Inspection Schedule	None specified
Maintenance Provisions	S/D & Building – maintenance bonds required

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	Rankin Borough
Relevant Ordinances	Zoning (#105, 6/14/54 amended by #213, 9/8/77); Floodplain Ordinance (#234, no date); Mobile Home Park Ord.(#229 dated 11/8/79)
Land Use Planning Standards	#213 – Zoning objectives include goals to provide recreation/ open space with efforts to protect watersheds and prevent flooding; also calls for preservation of slopes and installation of adequate storm drainage facilities. #213 – includes special slope district (>20%) with limited uses.
Stormwater Controls	#229 – requires adequate site drainage for mobile home sites/ parks. #234 – requires safe, efficient storm drainage for any construction in floodplain
Specific Calculation Method	None
Design Standards for Stormwater Controls	None
Erosion/Sedimentation Controls	#213 – general ordinance objectives mention adequate storm drainage to prevent erosion. #229 – requires exposed ground surfaces in mobile home parks to be paved, grassed, etc. to prevent erosion and dust.
Plan Review Process	#105 & #213 – Zoning officer approves most applications; Zoning Hearing Board approves uses in slope district
Fees	None specified in ordinances
Inspection Schedule	None
Maintenance Provisions	None

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	Borough of Swissvale
Relevant Ordinances	Zoning (1991, includes floodplain regulations), Subdivision/ Land Development (1992), Building (BOCA)
Land Use Planning Standards	Zoning requires landscaping for all developments, also open space and buffering standards.
Stormwater Controls	New S/LD incorporates Allegheny County's model stormwater management provisions.
Specific Calculation Method	S/LD: TR–55 for > 3 acres; rational method for <3 acres and conveyance facilities.
Design Standards for Stormwater Controls	S/LD: Use release rates and design storms required by approved watershed plan or as approved by the Borough Engineer. Design/ performance standards for detention facilities, sewers, etc.
Erosion/Sedimentation Controls	S/LD: References Conservation District / DER regulations. E/S permit or plan is required for S/LD or site development approval
Plan Review Process	E/S and stormwater plans reviewed by Borough Engineer; final approval by Council (part of S/LD or Zoning approval)
Fees	Zoning and S/LD provide authority to adopt fees; new fee schedules being considered by Council
Inspection Schedule	S/LD: Inspections by Engineer at completion of major phases and at completion
Maintenance Provisions	Maintenance plan required for stormwater and E/S facilities; bond for 18 months

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	West Mifflin Borough
Relevant Ordinances	Zoning (Ord #737); Floodplain Management (Ord #852); Flood Way District (Ord #851); Subdivision (Ord #780); Grading (Ord #743); BOCA as amended (Ord #853)
Land Use Planning Standards	Zoning Para. 204 allows Planned Urban Development ((PUD) with 15% open space requirement; special districts for commercial with maximum paving area: 60%; Flood Way District; landscaping requirements. Subdivision Para. 5.5 presents PUD design standards
Stormwater Controls	Subdivision Ord requires drainage study; Floodplain mgmt sets standards for drainage facilities. Floodplain Ord requires plans to prevent discharge of excess runoff onto adjacent property
Specific Calculation Method	None
Design Standards for Stormwater Controls	Subdivision Ord contains design standards to provide drainage without ponding; to handle anticipated peak discharge from property being developed and anticipate future development; Floodplain Mgmt standard: safe & efficient manner
Erosion/Sedimentation Controls	Floodplain Mgmt. Ord requires E/S plan & permit under County Conservation District guideline. Subdivsion Ord requires E/S minimum under the Allegheny County Conservation District Handbook
Plan Review Process	Review of subdivision plan by the Allegheny County Planning Commission; storm drainage review by the Borough Engineer
Fees	Subdivision Ord provides fee schedule; Zoning Ord provides for fees set by council
Inspection Schedule	Subdivision Ord provides for inspection during construction
Maintenance Provisions	Zoning Ord: PUDs must provide for O&M of open space; Subdivision Ord: if Borough does not accept storm drainage facilites, must be trust agreement for O&M as deed restriction

Table VII–2
Existing Municipal Ordinance Matrix

Existing Regulatory Controls	Municipality
	Whitehall Borough
Relevant Ordinances	Zoning (Ord #669, 1983, codified at Ch. 89); Subdivision (Ord #296 of 1957, codified in Ch. 157); Grading (Ord #613, codified at Ch. 107); Stormwater Mgmt (Ord #729, codified at Ch. 153)
Land Use Planning Standards	Para. 180–48 of Zoning Ord. allows planned residential development on 4 acres or more with dwelling density and land coverage regulated. Para. 180–54 establishes Civic District including parks and recreational areas. Subdivision Ord. sets design standards with storm drainage plan; Stormwater Mgmt. Ord. requires stormwater plan (Para. 153)
Stormwater Controls	Stormwater Mgmt. Ord. to ensure compliance with Act 167. "Small development" exemption; no subdivision approval without approved stormwater plan. Para. 153–18(A)(1) – "maximum rate of stormwater runoff is no greater after development than prior or to adequately protect health and property from possible injury
Specific Calculation Method	SCS TR–55 for 3 acres or more development site; rational method for under 3 acres and collection/conveyance facilities. Design storms: 2–yr, 25–yr and 100–year.
Design Standards for Stormwater Controls	Para. 153–20–23: criteria for detention facilities, collection/ conveyance facilities, E/S controls
Erosion/Sedimentation Controls	Ch. 107 requires permit for any excavation; performance standard includes guidelines for E/S control handbook; no subdivision/devel. plan approval without E/S permit (153–15E); E/S controls must be part of stormwater plan (Para. 153–23)
Plan Review Process	Para. 153–15 requires preliminary and final stormwater plans submitted with subdivision plan applications; plan review by Borough Engineer (<3 acres) and County Conservation District (> 3 acres) with written report to Planning Commission.
	Proposed ownership of stormwater mgmt. facility by municipality will require maintenance program prepared by Engineer and approved by Council; non–municipal ownership, financing for O&M must be identified
Fees	Fee schedule set in Subdivision Ordinance, Grading Ordinance
Inspection Schedule	Grading Ord. provides for periodic inspections during work (Para. 107–10); Stormwater Mgmt. Ord. requires Engineer to inspect each phase & completion of construction
Maintenance Provisions	Stormwater Mgmt. Ordinance requires plan to establish O&M responsiblity. Borough can accept/reject responsiblity. Privately owned facility requires written agreement for O&M prior to plan approval

MONONGAHELA RIVER WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION VIII
INSTITUTIONAL AND REGULATORY REQUIREMENTS

INTRODUCTION

The purpose of stormwater management is to control surface drainage, flooding, soil erosion and to a certain extent, pollutants in stormwater runoff. In Pennsylvania, stormwater management is regulated on a watershed-wide basis by the terms and provisions of Act 167, The Storm Water Management Act. The primary objective of the Act is to prevent or mitigate potential adverse impacts from increased runoff by making those altering land responsible for safely managing the stormwater runoff resulting from their activities.

Also, as part of the prevention efforts, the Act requires counties to prepare stormwater management plans for each state designated watershed within their jurisdiction; subsequent land development must include stormwater management measures that are consistent with the county plans to assure that stormwater problems are not created or worsened in the watershed.

WATERSHED STORMWATER MANAGEMENT PLAN IMPLEMENTATION

The process for adopting a watershed stormwater management plan as required by Act 167, includes the following steps:

PLANNING

The county's responsibility for developing a watershed plan includes the preparation of a planning program and the establishment of an advisory committee composed of representatives of each municipality within the watershed and the conservation district.

REVIEW

The county's watershed plan must be reviewed by the advisory committee, the planning commission and governing body of each municipality within the watershed, and county and regional planning agencies.

ADOPTION

Once a plan has been prepared, the county must schedule public hearings with public notice, prior to adoption of the plan by a majority vote of the county commissioners.

APPROVAL

The watershed stormwater plan must be submitted to the Pennsylvania Department of Environmental Resources (DER) for approval. DER has ninety (90) days to review the plan using the following criteria:

1. Is it consistent with flood plain management plans, flood control programs, and dams and encroachment regulations?

2. Is it compatible with the stormwater management plans of other watersheds in the basin?

3. Is it compatible with the purposes and policies of Act 167?

IMPLEMENTATION

Within six (6) months of the watershed plan's adoption and approval, Act 167 requires each municipality within the watershed to adopt and implement ordinances which "regulate development within the municipality in a manner consistent with the provisions of the Act." Penalties for failure to adopt such ordinances are included in Section 12 of the Act.

The Act emphasizes the importance of local support for the watershed plan and recognizes the ability of the municipalities to use their police powers to enforce the plan and assure safe stormwater management in the watershed.

STORMWATER MANAGEMENT FUNCTIONS

The stormwater activities necessary to implement the plan are implied by Section 11 of Act 167 and by the watershed stormwater management plan itself. Municipal ordinances that satisfy these requirements must provide for the various stormwater activities or functions. However, not all of these activities must be performed by the municipality; the county planning agency, the county conservation district and other private and public sector organizations can participate in stormwater management throughout the watershed.

Before presenting an analysis of a model ordinance, the stormwater functions must be reviewed. Stormwater management consists of the following key functions:

-- Planning (watershed plan updates)

-- Development Regulations (site plan review and approval)

-- Construction

-- Inspection

-- Maintenance

-- Financing

-- Monitoring and Enforcement

-- Information and Education

PLANNING

Act 167 requires watershed stormwater plans to be reviewed, revised and updated at least every five years. In order to perform this task, the data base on stormwater facilities within the watershed that had been developed for the initial plan should be maintained. Another aspect of the planning function should be the coordination of the stormwater management plan with other functional type plans that are required for development in the watershed, i.e. land use plans, recreation plans, etc.

DEVELOPMENT REGULATION

Stormwater facilities and construction practices must comply with the standards and criteria established in the watershed stormwater management plan. The municipalities must adopt and enforce ordinances to implement these standards and criteria, and apply them to all types of development activity to assure compliance with the stormwater plan. For example, subdivision plans that are routinely reviewed by the local and county planning agencies, must also be reviewed and approved for compliance with the stormwater plan.

Other regulatory activities that could be undertaken as part of this stormwater management function include: a review of site development plans to assure that erosion and sedimentation plans and/or permits are in place and a review of all public improvement projects to assure their compliance with the standards and criteria of the watershed stormwater management plan.

CONSTRUCTION

This function includes providing private developers with the specifications for construction of stormwater facilities, and assuring that publicly-built stormwater control facilities are designed and constructed in conformance with the standards and criteria of the watershed plan. Also is coordination with other public agencies involved in the construction of stormwater-related structures, such as flood control projects, to assure consistency with the watershed plan.

INSPECTION

From preliminary site preparation through completion of final grading of a development, it is important that stormwater controls be inspected regularly. To satisfy this requirement, it is necessary that inspectors have the legal right of entry onto private property and the right to stop work if soil conditions are different from the plan application or if stormwater controls are not being built in accordance with the standards and criteria of the watershed plan. This stormwater management function can be broadened to include the scheduling of inspections of stormwater facilities annually, or after a major storm event.

MAINTENANCE

Stormwater maintenance includes such tasks as clearing debris from detention ponds, cleaning catch basins, dredging creeks and repairing stream embankments. Provision to perform this task vary according to ownership and responsibility for maintenance of stormwater control facilities. Publicly owned facilities require ongoing maintenance; formal agreements may be executed to assure maintenance of privately owned stormwater control facilities; coordination with state agencies may be necessary to be sure that state-owned stormwater control structures (i.e., culverts, bridges) are adequately maintained; services may be provided by contract for the maintenance of both public and private facilities within the watershed.

FINANCING

This function includes such items as funding for the costs associated with the administration of the stormwater ordinances, inspections and maintenance, ongoing planning and monitoring of stormwater facilities, and long-term financing for the construction of any public stormwater control facilities.

In the past, the financial burden for stormwater control rested with the local municipality, the private developer and the new user or property owner. More recently, however, stormwater runoff has been viewed as a concern of all the municipalities, developers and users within the watershed, and stormwater management, as a watershed-wide responsibility. This approach to the management of stormwater runoff would ensure the consistent implementation of the plan throughout the watershed and would allocate the management costs in an equitable manner throughout the watershed as well.

MONITORING AND ENFORCEMENT

This is a police function that is essential to any stormwater management program. The municipalities can exercise their police powers to take a variety of enforcement actions, such as fines, the use of permits, court actions and civil penalties. With regard to enforcement of erosion and sedimentation controls, the County Conservation District and DER have the power to enforce compliance with state regulations.

INFORMATION AND EDUCATION

In order to prepare specifications and review site development plans for consistency with the standards and criteria of the watershed stormwater management plan, municipal officials must have a working knowledge of the technical aspects of the plan. Similarly, information regarding the stormwater plan and stormwater control facilities should be available to private developers. Workshops, seminars and well-informed agency staff can perform this stormwater management function.

RECOMMENDATIONS FOR PERFORMING THE MANAGEMENT FUNCTIONS

The responsibility for performing the stormwater management functions may be shared among public agencies and the private sector. In the case of the Monongahela River Watershed, the planning and development regulation activities described above may be performed by the County Planning Department, the Conservation District and local municipalities. The recommended delineation of stormwater management responsibilities for the various governmental and quasi-governmental agencies active in the watershed is as follows:

1. Local municipalities: Primary responsibility for the administration and enforcement of stormwater management ordinances and regulations, including plan review and approval; inspections; and either performing or requiring the performance of routine maintenance.

2. County Agencies: Monitoring of the municipal enforcement of watershed standards and provision of technical assistance to the municipalities in reviewing development plans to assure compliance with watershed plan standards and criteria and prevent the occurrence of negative downstream impacts. Where warranted and agreeable to both the County and the municipality, this basic review function could be expanded and strengthened to provide more detailed plan reviews by the County.

It is recognized that the implementation and on-going administration of the watershed stormwater management plan will be a dynamic process. The roles and functions of the various involved entities should be sufficiently fluid to permit shifts of responsibilities and activities as necessary to maximize the particular capabilities of the agencies involved and deal with specific limitations. This is particularly true in the early stages of plan implementation when the application of new stormwater management requirements, standards and criteria may tax the capabilities of some of the smaller or financially distressed municipalities. In such cases, the resources of the county agencies may be used to maximum benefit until local capabilities are increased. Similarly, if the proliferation of stormwater detention facilities warrant, future cooperative arrangements for shared labor, equipment and materials utilization for facility maintenance may be explored through increased county level involvement.

STORMWATER MANAGEMENT ORDINANCES

The Storm Water Management Act recognizes that the alteration of land may increase the rate of runoff, and accelerated runoff must be controlled to prevent downstream flooding, siltation and other water related damage. Section 13 of the Act makes those altering land, whether public or private entities, responsible for managing any increased runoff resulting from their activities. Since, in Pennsylvania, local municipalities have almost exclusive control over land use and development activities, Section 11 of the Act assigns them the responsibility of regulating development consistent with the watershed stormwater plan.

The approach recommended by this Plan, consistent with Act 167, is for municipalities to adopt regulations to minimize the potential for future stormwater problems from private land development as well as from public improvement projects.

In order to implement the standards and criteria of the Monongahela River Stormwater Management Plan, the municipal ordinances must contain certain key provisions. These include the following items:

- Storm frequencies
- Release rate percentages
- "No harm" evaluation
- Method of calculation
- Control techniques
- Site plan requirements
- Plan review procedures
- Continuing maintenance agreements
- Fees
- Enforcement remedies and penalties

STORM FREQUENCIES OR CONTROL STORM

The design frequency criteria developed in the watershed plan refers to the peak rates of discharge for which the components of drainage systems are designed, i.e., the 2-, 10-, 25- and 100-year storms. Typical criteria require stormwater facilities to manage the runoff in such a manner that the discharge from new development will maintain the predevelopment discharge level.

The design frequency criteria that is developed as part of the watershed plan must be implemented by the municipalities as a provision of their stormwater management ordinances.

RELEASE RATE PERCENTAGES

The Monongahela River Watershed Stormwater Management Plan divided the watershed into subareas, each of which was assigned a release rate percentage that had been calculated by engineering analysis and computer modeling. The release rate percentage is used to assure that the post-development runoff volume does not exceed the predevelopment volume. The percentage is multiplied by the pre-development peak rate of runoff from the site to determine the allowable post-development peak discharge from the site.

The release rate percentage is a reasonably straight forward and easily applied regulatory tool. The incorporation of the percentage into the municipal ordinances will encourage its use and make its application easier for both developers and municipalities.

NO HARM EVALUATION

In certain limited cases, a land developer may be able to utilize the no harm evaluation to exceed the otherwise applicable release rate. The use of the option

will be permitted only in very restricted circumstances (i.e., a site that may discharge directly into a major river), which are spelled out in the watershed plan and the municipal ordinances.

METHOD OF CALCULATION

The ordinance must prescribe the acceptable calculation methods for use in determining storm water runoff. To maintain a uniform, watershed-wide approach, the following methods have been stipulated in the standards and criteria of the watershed plan: SCS TR-55 and TR-20, HEC-1, the Penn State Runoff Model and the modified rational method.

CONTROL TECHNIQUES

Each developer must select the technique or combination of techniques that are most appropriate to the site. In order to make these selections, the developer may be required to perform soil or geotechnical investigations. It is important to encourage the developer to utilize the techniques that reduce runoff volume and promote groundwater discharge; therefore, in selecting control techniques the developer should first apply all suitable runoff infiltration techniques, then apply flow attenuation methods by the use of vegetated swales and natural depressions, and finally, utilize stormwater retention/detention facilities.

The watershed plan includes a section on the possible infiltration techniques and the developer will have to justify the rejection of each practice based on site conditions. The municipal stormwater management ordinance should also contain certain design performance standards for retention and detention facilities.

SITE PLAN REQUIREMENTS

Local ordinances should precisely describe site plan submission requirements for stormwater management. For example, the ordinance should require stormwater plans to be prepared by a registered professional, engineer, surveyor or landscape architect, and should set forth the content and form of information that must be included on the plan. Generally, the stormwater plan submission will be made in two stages: preliminary and final. The watershed plan will probably recommend simplified plan submission requirements for "small developments" or certain special uses.

PLAN REVIEW PROCEDURE

Ordinarily, all stormwater plans will be submitted to the local municipality as part of the overall development plan application. The County Planning Department will review the stormwater plan to check for downstream impacts and to assure that the plan meets the general release rate requirements of the watershed plan. The department can run the computer model if necessary to assure compliance. The local municipality reviews and approves the design of specific control measures in accordance with each municipality's specifications.

The extent and depth to which the County provides reviews should be negotiated between the county and municipalities. More detailed routine county reviews can be provided as a service if requested by the municipalities.

CONTINUING MAINTENANCE AGREEMENTS

As a condition of stormwater plan approval, the developer must submit a maintenance plan for all proposed stormwater control facilities. This maintenance plan is necessary regardless of whether the facilities will be publicly or privately owned. The maintenance plan should indicate the proposed ownership arrangement, the type and frequency of required maintenance activities, personnel and equipment necessary for adequate maintenance, the estimated annual cost, and the method of financing the cost of maintenance and a signed maintenance agreement if the facilities will be privately owned. The plan must be approved by the municipal engineer and governing body.

In addition to the maintenance plan and agreement, the municipal ordinances should also provide for the submission of construction or performance bonds and maintenance bonds consistent with the Municipalities Planning Code. The ordinances may also establish a system of financing maintenance activities through a special fund. In the case of privately owned facilities, the ordinance may require developers to deposit fees to cover municipal inspections for a stated period of time (i.e., 10 years).

FEES

The municipal ordinances may provide for the adoption of a fee schedule to cover the cost of administering the stormwater program and implementing the requirements of the ordinance. A system of flat fees or direct reimbursement for costs may be imposed if consistent with the Municipalities Planning Code. Municipalities may also be able to be reimbursed for some of their administrative costs through the Pennsylvania Department of Environmental Resources under the terms of Act 167.

INSPECTIONS

The ordinance should include a schedule for periodic inspections of stormwater facilities during the course of construction to assure that they are installed as specified in the approved stormwater plan application.

ENFORCEMENT, REMEDIES AND PENALTIES

In order to enforce the provisions of the stormwater management ordinance, municipalities may incorporate into the ordinance remedies and penalties similar to those prescribed by the Municipalities Planning Code for violations of zoning, subdivision and land development, or other municipal codes. Recent changes in the Municipalities Planning Code eliminate criminal penalties and substitute civil judgements.

Municipalities can also utilize the enforcement remedies of Act 167, whereby action to enforce the provisions of the watershed plan or the stormwater management ordinance can be instituted by the municipality or any "aggrieved person."

MODEL STORMWATER PROVISIONS

INTRODUCTION

The model ordinance provisions presented in Appendix D provide a guide for constructing a workable regulatory approach using the legal authorities established by the Pennsylvania Municipalities Planning Code (MPC) which enables local governments to adopt and enforce zoning and subdivision and land development ordinances.

It is anticipated that most land alteration activities requiring stormwater management controls will fall within the scope of these ordinances. By using the legal authorities of both ordinances, it is possible to assure that all types of land alterations, whether new development, expansion of existing facilities or redevelopment of existing lots and structures, are adequately covered.

In addition, most municipalities in the watershed presently enforce these ordinances. They have established processes for reviewing development applications and taking enforcement actions under these ordinances. Therefore, it should be less confusing for the municipalities (and developers) to add the necessary stormwater provisions and reviews to their existing regulations, rather than to create a new and separate ordinance.

STORMWATER PROVISIONS IN THE SUBDIVISION AND LAND DEVELOPMENT ORDINANCE

The model ordinance provisions include a new stormwater management article or section that can be added to the subdivision/land development (S/LD) ordinance. This article contains all of the key stormwater management provisions required to implement the watershed plan. It also incorporates erosion and sedimentation controls, and it is suggested that, if a municipality has grading (excavation and filling) regulations, that they are also included in the S/LD ordinance.

It is important to note that not all of the required ordinance provisions may be equally applicable in all of the watershed municipalities. The municipalities reflect different levels, types and patterns of development as well as different growth objectives. Thus, each municipality will have to tailor the ordinances provisions to its own special needs and conditions. However, the watershed municipalities should be careful to coordinate their ordinances with one another and to avoid modifications which would make the ordinances inconsistent with the standards and criteria of the watershed plan.

Also, it bears repeating that adding stormwater controls solely in the S/LD will not guarantee control of runoff from all types of land alteration activities. The S/LD ordinance applies to only land which is being subdivided into two or more parcels or an action that constitutes a "land development" as defined by Section 107 of the Planning Code.

While this definition includes most types of larger and nonresidential developments, such as shopping centers, office and industrial buildings, it does exclude developments with a single structure used only by one occupant, regardless of the size or magnitude of the facility and its potential effect on stormwater runoff. This situation highlights the importance of municipalities utilizing both zoning and subdivision/land development authorities to provide the broadest possible coverage.

STORMWATER PROVISIONS IN THE ZONING ORDINANCE

There are several ways that communities can use their zoning ordinances to implement the stormwater management plan. Some of these relate directly to inclusion of language in the ordinance which assures that stormwater controls are applied to all types of land use activities, including single-structure developments, extensions of existing uses and various special activities such as farming and mining operations. The model ordinance provisions present some simple amendments to the municipal zoning ordinances to accomplish this objective.

Communities can also use their zoning ordinances to promote stormwater management by utilizing various techniques including planned residential developments, density transfers, clustering, lot averaging and performance zoning, which encourage better site design the use of land capabilities. These techniques basically permit the concentration of development on more suitable portions of the site, in exchange for preservation of substantial portions of the site as open space which may include steep slopes, stream valleys, woodlands and other natural areas. Limiting development of such areas can often reduce stormwater runoff and maintain areas for natural stormwater retention.

Providing this flexibility for site development is going to become increasingly important in municipalities where many prime sites which contain minimum natural constraints have already been developed. Thus, much of the future development will take place on sites with various limitations, such as steep slopes and poorly drained soils. Through the use of such flexible zoning techniques, a developer can make use of a difficult site while still preserving sensitive environmental areas and meeting stormwater management requirements.

Another application of zoning to stormwater management involves its use to restrict development in certain natural areas. Floodplain zoning is probably one of the most common examples of this approach. Others include restrictions on the use of steep slope areas, wetlands or geological hazard areas (e.g., landslide prone soils). These control stormwater indirectly by reducing the potential for excessive runoff and siltation from the exposure of slope areas or by preventing the use of natural retention areas. While they are highly desirable, they alone will not assure adequate stormwater management. Direct stormwater management regulations will still be required to accomplish the objectives of Act 167 and this Watershed Stormwater Management Plan.

GENERAL OBJECTIVES FOR ORDINANCE PROVISIONS

Before concluding this section on model stormwater ordinances, some general comments on ordinance drafting may be helpful. From meetings with local officials,

developers and builders, it is clear that all parties are concerned with implementing a successful regulatory effort with respect to a complex issue like stormwater. Therefore, it is essential that the stormwater management ordinances must be:

-- clear (understandable) and readily obtainable.

-- flexible (encourage creative solutions to stormwater problems).

-- uniform throughout the area.

Clarity is very important both for the technical and engineering requirements, as well as for administrative processes. Developers should be able to obtain copies of all applicable ordinances, and they should be able to determine what is expected of them. Similarly, municipalities should be clear about what their ordinances mean and what they want developers to do. Vague, general or complex ordinances usually only result in legal problems (and costs) for all involved entities.

Flexibility in stormwater management is extremely important. Since it is impossible to write an ordinance that will apply equally to all sites and conditions, the municipality will want to encourage developers to seek solutions that best fit their site, while meeting the objectives of the stormwater plan. Whenever possible, ordinances should use incentives to encourage good stormwater management practices rather than negative regulations. Both developer and municipality will profit when the most technically feasible and economically efficient approaches are applied.

Flexibility in stormwater management can best be obtained by using a performance standard approach in the municipal regulations, as recommended in this study. A performance standard states an end result or out some which is to be achieved but does not prescribe specific means for achieving it. In contrast, a specification standard specifies the exact characteristic or design standard to be used. The release rate percentage is an example of a performance standard, while a standard for the maximum percent of impervious surface per lot is a specification standard.

Finally, **uniformity** of the regulatory measures will be essential within the watershed. Each municipality cannot adopt a different approach and set of technical standards. Ordinances must be compatible with one another and with the watershed plan, or the result may be even a greater potential for flooding and stormwater damage to downstream communities.

A uniform approach has several other advantages. Municipalities can save by joint administration of the stormwater portions of their ordinances. This more efficient administration can also translate into cost savings for developers. With today's high cost of financing, unnecessary administrative delays for development reviews and inspections can add substantially to project costs.

A uniform system of stormwater regulations will make it easier for developers to know what is expected of them. Also, it minimizes the potential for unfair competition resulting from situations where one developer is required to provide only minimal stormwater controls, while another in a neighboring municipality must invest substantially more to meet the ordinance standards.

MONONGAHELA RIVER WATERSHED
STORMWATER MANAGEMENT PLAN

SECTION IX

IMPLEMENTATION, ADOPTION AND UPDATING

PRIORITIES FOR IMPLEMENTATION

The Monongahela River Stormwater Management Plan preparation process for Allegheny County and the affected municipalities will be complete with the adoption of the final plan by the County Commissioners, receipt of Department of Environmental Resources' approval, the completion of the associated training program and the delivery of the supporting documentation to the County.

The plan has been prepared in order to present the mechanisms through which the requirements of Act 167 can met throughout the watershed. The specific standards and criteria presented in this plan have been developed to represent a rationally derived set of requirements which must be satisfied by land developers in order to protect downstream persons and/or properties from damage from stormwater runoff originating at the development site. The measures to be taken by the developers actions as required to:

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

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

This plan also contains recommendations relative to the roles to be played by the various governmental agencies in the watershed and presents specific ordinance provisions recommended for inclusion in local municipal ordinances. These recommendations are presented in order to assist local governments in fulfilling their mandated role in the administration of stormwater management requirements within the watershed. Since Act 167 places the ultimate responsibility for implementation and on-going administration and enforcement of stormwater management requirements in the hands of the local municipalities, each of the municipalities in the watershed will be involved in plan implementation.

PRIORITIES FOR IMPLEMENTATION

The Monongahela River Watershed Stormwater Management Plan preparation process is complete with the Allegheny County Commissioners' adoption of the Plan and submission of the Plan to DER for approval. Subsequent activities necessary to carry out the provisions of the Plan are considered by DER to be part of the implementation of the Plan. The initial step in Plan implementation is DER approval. Plan approval sets in motion the mandatory schedule of adoption of municipal ordinance provisions to implement the stormwater management standards and criteria. The Monongahela River watershed municipalities will have

six (6) months from the date of DER approval within which to adopt the necessary ordinance provisions. Failure to do so could result in the withholding of all state funds to the municipality per Act 167.

Additional implementation activities are the development of a local program to coordinate DER Chapter 105 and 106 permit application reviews and the development of a systematic approach for the correction of storm drainage problem areas.

County Plan Adoption

Formal adoption of the Plan is the responsibility of the Board of Commissioners of Allegheny County. Under the requirements of Act 167, prior adoption of the Plan, the county will hold a public hearing pursuant to public notice of not less than two (2) weeks prior to the hearing date. Act 167 also stipulates that adoption of the Plan must be by a resolution carried by an affirmative vote of at least a majority of the members of the Board of Commissioners. The resolution must refer expressly to the plan and all associated maps, charts and textural materials.

DER Approval of the Plan

Upon adoption of the watershed plan by the County, the Plan is submitted to DER for approval. The DER review process involves the determination that all of the activities specified in the approved Scope of Work have been satisfactorily completed in the Plan. Further, DER will only approve the Plan if it determines the following:

1. That the Plan is consistent with municipal, flood plain management plans, State programs which regulate dams, encroachments and other water obstructions and State and Federal flood control programs; and

2. That the Plan is compatible with other watershed stormwater plans for the basin in which the watershed is located and is consistent with the policies and purposes of Act 167.

DER action to either approve or disapprove the Plan must take place within ninety (90) days of receipt of the Plan by DER. Otherwise, the Plan would be approved by default.

Municipal Adoption of Ordinance Provisions to Implement the Plan

The key ingredient for implementation of the Plan is the adoption of the necessary ordinance provisions by the Monongahela River watershed municipalities. Model subdivision / land development and zoning ordinance provisions to be used by the municipalities as a guide to modifying their ordinances are provided as part of the Plan (Appendix D).

Development of a Local Program to Coordinate With DER Regarding Chapter 105 and 106 Permit Application Reviews

Stream encroachments, stream enclosures, waterway diversions and other activities regulated by Chapters 105 and 106 of DER's Rules and Regulations may have a bearing on the effectiveness of the runoff control strategy developed or the Monongahela River watershed. Activities of these types may modify the conveyance characteristics of the watershed and, thereby, impact the relative timing of watershed peak flows and/or the ability of the conveyance facilities to safely transport peak flows. Therefore, to ensure that the DER permitting process is consistent with the adopted and approved watershed plan, a local review of Chapter 105 and 106 applications should be coordinated with the DER review process.

It is recommended that the local review be performed by the Allegheny County Department of Planning and would be accomplished by monitoring the applications as published in the Pennsylvania Bulletin. The Planning Department will provide comments consistent with the adopted Act 167 Plan within the DER review period. Further, the Planning Department will keep records of applications reviewed and the DER actions.

Development of a Systematic Approach for the Correction of Storm Drainage Problems

Correction of storm drainage problem areas in the watershed is not specifically part of the Act 167 planning process. However, the development of a watershed plan has provided a framework for the correction of problems because: (1) existing storm drainage problems have been identified; (2) implementation of the runoff control criteria specified in this Plan should prevent the existing drainage problems from becoming worse; (3) the hydrologic model developed to formulate the runoff control criteria could be used as an analytical tool for identifying engineering solutions to major drainage problems; and (4) this Plan provides suggested approaches to addressing specific reported stormwater problems (Appendix C).

Another way in which the completion and implementation of this plan can be of assistance in addressing storm drainage problems is by opening the avenue of funding assistance through the PENNVEST program. The PENNVEST Act of 1988, as amended, provides low interest loans to governmental entities for the construction, improvement or rehabilitation of stormwater projects including the transport, storage and infiltration of stormwater and best management practices to address point or nonpoint source pollution associated with stormwater.

In order to qualify for a loan under PENNVEST, the municipality or county:

1. must be located in a watershed for which there is an existing county adopted and DER approved stormwater plan with enacted stormwater ordinances consistent with the plan or,

2. has enacted a stormwater control ordinance consistent with the Storm Water Management Act.

With the above in mind, the Monongahela River watershed municipalities should include the following steps in any efforts to implement solutions to significant storm drainage problems:

1. Prioritize storm drainage problems within the municipality based upon frequency of occurrence, potential for injury to persons or property, damage history, public perception of the problems and other appropriate criteria.

2. For the top priority drainage problems in the municipality, conduct detailed engineering evaluations to determine the exact nature of the problems, identify alternative solutions, provide cost estimates for the alternative solutions and recommend a course of municipal action. The number or drainage problems to be evaluated by a municipality as a first cut from the priority list should be based on a schedule commensurate with completing engineering studies on all problem areas. The Monongahela River watershed hydraulic model will be available through the County to provide input to the engineering studies. The engineering studies must include consideration of the downstream effects of eliminating specific drainage problems so as to avoid the transfer of problems progressively downstream.

3. On a priority and cost basis, incorporate implementation of recommended solutions to the drainage problems in the annual municipal capital or maintenance budgets as funds are available. Funding investigations should consider available funding assistance programs and joint municipal project implementation.

The procedure outlined above for dealing with storm drainage problems is not a mandatory action placed on the municipalities with the adoption of this Plan. Rather, it represents a systematic method for approaching the problems uniformly throughout the watershed in an attempt to improve the current runoff situation in the basin. The key elements involved in the success of the remedial strategy will be the ability of the municipalities to construct any required corrective measures and the consistent and proper application of the runoff control standards and criteria specified in this Plan. The latter element is essential to ensure that remedial measures do not become obsolete (under-designed) by increases in peak flows as a consequence of development activities.

PLAN UPDATING

GENERAL

Allegheny County has been provided with data describing the physical system of the Monongahela River watershed which affect local hydrology and hydraulics. Principal types of data and information provided to the counties include: Penn State Runoff Models for the watershed, input data for the runoff models which reflect existing hydrologic and hydraulic conditions. These materials serve as the basis for the development of the standards and criteria presented in this Plan. Changes to the hydrologic and hydraulic conditions in the watershed as reflected in the Penn

State Runoff Model input data files may warrant changes in the resulting standards and criteria.

PROVISIONS FOR UPDATING THE PLAN

The previously referenced data files provided to the counties can be updated to reflect: 1) changes in land use / land cover which may affect runoff conditions; 2) changes to the streams, major culverts and other flow conduits which may materially affect watershed hydraulics; 4) and the construction of regional detention facilities which may significantly affect watershed peak discharge timings associated release rate percentages.

Once the input data files have been modified as necessary to reflect the changed conditions, the Penn State Runoff Model can be run under the new conditions in order to identify needed changes (if any) to the standards and criteria presented in this Plan. In order to facilitate updating this Plan, the counties have been provided with a custom "users' manual" which describes the structure, application and interpretation of the Penn State Runoff Model used in the development of this Plan.

SCHEDULE FOR PLAN UPDATING

Under the requirements of Act 167, this Plan should be updated at intervals not exceeding five (5) years. More frequent updating of this plan may be warranted if significant changes in the watershed occur sooner. Factors which would warrant an update prior to the statutory date may include the following:

1. Changes to major stream segments or primary stormwater conveyance elements which serve to affect watershed hydraulics such that the potential for damage is materially changed or peak discharge timings are significantly changed.

2. Regional detention facilities are constructed, such that changes to the release rate percentages assigned to tributary subbasins are warranted.

3. Extensive changes to land use occur to the extent that significant changes to subbasin times of concentration and runoff volumes are changed.

4. Peculiarities in the application of specific standards and criteria are experienced which interfere with the effective and equitable administration of the Plan requirements.

All of the involved agencies (county, municipalities, and DER) should monitor conditions in the watershed. In the event that any of the above listed conditions (or others) arise, the county should proceed with updating this Plan as warranted.

APPENDIX A
ESTIMATED OBSTRUCTION CAPACITIES

TABLE A–1
ESTIMATED OBSTRUCTION CAPACITIES

ID Number	Model Reach Number	Stream	Adequacy Notation
A1	385	LOBBS RUN	Q < 1–YR
A1.1	385	LOBBS RUN	Q < 1–YR
A1.2	385	LOBBS RUN	Q < 1–YR
A2	385	LOBBS RUN	Q < 1–YR
A2.2	385	LOBBS RUN	Q < 1–YR
A3	385	LOBBS RUN	Q < 1–YR
A4	169	LOBBS RUN	1–YR < Q < 10–YR
A4.1	169	LOBBS RUN	Q < 1–YR
A5	379	LOBBS RUN	Q < 1–YR
A6.1	172	LOBBS RUN	Q < 1–YR
A6.2	172	LOBBS RUN	Q < 1–YR
A6	172	LOBBS RUN	Q < 1–YR
A7	172	LOBBS RUN	1–YR < Q < 10–YR
A7.1	172	LOBBS RUN	Q < 1–YR
A8	172	LOBBS RUN	1–YR < Q < 10–YR
A8.1	183	LOBBS RUN	Q < 1–YR
A9	183	LOBBS RUN	Q < 1–YR
A10	184	LOBBS RUN	1–YR < Q < 10–YR
A11	184	LOBBS RUN	1–YR < Q < 10–YR
A12	184	LOBBS RUN	Q > 100–YR
A13	187	LOBBS RUN	10–YR < Q < 25–YR
A14	187	LOBBS RUN	Q < 1–YR
A15	187	LOBBS RUN	50–YR < Q < 100–YR
A16	187	LOBBS RUN	25–YR < Q < 50–YR
A17	187	LOBBS RUN	25–YR < Q < 50–YR
A18	182	LOBBS RUN	Q > 100–YR
A18.1	180	LOBBS RUN	Q < 1–YR
A18.2	180	LOBBS RUN	Q < 1–YR
A18.3	180	LOBBS RUN	1–YR < Q < 10–YR
A18.4	180	LOBBS RUN	Q < 1–YR
A18.5	177	LOBBS RUN	1–YR < Q < 10–YR
A18.6	177	LOBBS RUN	Q < 1–YR
A18.7	177	LOBBS RUN	Q < 1–YR
A18.8	177	LOBBS RUN	Q < 1–YR
A18.9	177	LOBBS RUN	Q < 1–YR
A18.10	177	LOBBS RUN	Q < 1–YR
A18.11	177	LOBBS RUN	Q < 1–YR

Note: Q estimated from Abers Creek gauge using basin transfer techniques

TABLE A–1
ESTIMATED OBSTRUCTION CAPACITIES

ID Number	Model Reach Number	Stream	Adequacy Notation
A19	177	LOBBS RUN	Q < 1–YR
A19.1	177	LOBBS RUN	Q < 1–YR
A19.2	177	LOBBS RUN	Q < 1–YR
A19.3	177	LOBBS RUN	Q < 1–YR
A19.4	177	LOBBS RUN	Q < 1–YR
A19.5	177	LOBBS RUN	Q < 1–YR
A19.6	177	LOBBS RUN	Q < 1–YR
A19.7	177	LOBBS RUN	Q < 1–YR
A20	177	LOBBS RUN	Q < 1–YR
A21	190	"23D5"	Q < 1–YR
A22	190	"23D5"	Q < 1–YR
A22.1	190	"23D5"	Q < 1–YR
A22.2	190	"23D5"	Q < 1–YR
A22.3	190	"23D5"	Q < 1–YR
A22.4	190	"23D5"	Q < 1–YR
A22.5	190	"23D5"	1–YR < Q < 10–YR
A22.6	190	"23D5"	1–YR < Q < 10–YR
A22.7	190	"23D5"	Q < 1–YR
A23	190	"23D5"	Q < 1–YR
A23.1	190	"23D5"	Q < 1–YR
A23.2	190	"23D5"	Q < 1–YR
A23.3	190	"23D5"	Q < 1–YR
A23.4	190	"23D5"	1–YR < Q < 10–YR
A23.5	190	"23D5"	Q < 1–YR
A24	189	"23D5"	Q < 1–YR
A24.1	189	"23D5"	Q < 1–YR
A25	89	MILL RUN	Q > 100–YR
A25.1	89	MILL RUN	10–YR < Q < 25–YR
A26	92	"24DO"	Q < 1–YR
A29	95	SMITHS RUN	50–YR < Q < 100–YR
A30	129	FALLEN TIMBER RUN	1–YR < Q < 10–YR
A31	129	FALLEN TIMBER RUN	Q > 100–YR
A32	126	FALLEN TIMBER RUN	1–YR < Q < 10–YR
A33	123	FALLEN TIMBER RUN	Q < 1–YR
A34	123	FALLEN TIMBER RUN	1–YR < Q < 10–YR
A35	123	FALLEN TIMBER RUN	50–YR < Q < 100–YR
A36	118	FALLEN TIMBER RUN	Q < 1–YR

Note: Q estimated from Abers Creek gauge using basin transfer techniques

TABLE A–1
ESTIMATED OBSTRUCTION CAPACITIES

ID Number	Model Reach Number	Stream	Adequacy Notation
A36.1	118	FALLEN TIMBER RUN	50–YR < Q < 100–YR
A37	113	FALLEN TIMBER RUN	10–YR < Q < 25–YR
A37.1	113	FALLEN TIMBER RUN	Q < 1–YR
A38	113	FALLEN TIMBER RUN	Q < 1–YR
A38.1	113	FALLEN TIMBER RUN	10–YR < Q < 25–YR
A38.2	113	FALLEN TIMBER RUN	Q > 100–YR
A38.3	113	FALLEN TIMBER RUN	1–YR < Q < 10–YR
A39	281	STREETS RUN	Q < 1–YR
A40	281	STREETS RUN	Q < 1–YR
A41	281	STREETS RUN	Q < 1–YR
A42	281	STREETS RUN	Q < 1–YR
A42	281	STREETS RUN	Q < 1–YR
A43	282	STREETS RUN	Q < 1–YR
A44	282	STREETS RUN	Q > 100–YR
A44.1	282	STREETS RUN	Q > 100–YR
A45	284	STREETS RUN	Q < 1–YR
A46	284	STREETS RUN	Q < 1–YR
A47	285	STREETS RUN	Q > 100–YR
A48	282	STREETS RUN	Q > 100–YR
A49	286	STREETS RUN	50–YR < Q < 100–YR
A50	286	STREETS RUN	10–YR < Q < 25–YR
A51	289	STREETS RUN	25–YR < Q < 50–YR
A52	295	STREETS RUN	1–YR < Q < 10–YR
A53	295	STREETS RUN	Q < 1–YR
A54	295	STREETS RUN	Q < 1–YR
A55	301	STREETS RUN	Q < 1–YR
A55.1	301	STREETS RUN	1–YR < Q < 10–YR
A56	294	STREETS RUN	10–YR < Q < 25–YR
A57	294	STREETS RUN	1–YR < Q < 10–YR
A58	293	STREETS RUN	1–YR < Q < 10–YR
A58.1	291	STREETS RUN	Q < 1–YR
A58.2	291	STREETS RUN	Q < 1–YR
A59	291	STREETS RUN	Q < 1–YR
A60	291	STREETS RUN	1–YR < Q < 10–YR
A61	227	M. BR. COAL VALLEY RUN	Q < 1–YR
A62	227	M. BR. COAL VALLEY RUN	Q > 100–YR
A65	227	M. BR. COAL VALLEY RUN	Q > 100–YR

Note: Q estimated from Abers Creek gauge using basin transfer techniques

TABLE A–1
ESTIMATED OBSTRUCTION CAPACITIES

ID Number	Model Reach Number	Stream	Adequacy Notation
A65.1	227	M. BR. COAL VALLEY RUN	1–YR < Q < 10–YR
A65.2	227	M. BR. COAL VALLEY RUN	Q < 1–YR
A65.3	227	M. BR. COAL VALLEY RUN	Q < 1–YR
A65.4	227	M. BR. COAL VALLEY RUN	Q < 1–YR
A65.5	227	M. BR. COAL VALLEY RUN	Q < 1–YR
A65.6	227	M. BR. COAL VALLEY RUN	Q < 1–YR
A66	227	M. BR. COAL VALLEY RUN	1–YR < Q < 10–YR
A66.1	227	M. BR. COAL VALLEY RUN	Q < 1–YR
A66.2	227	M. BR. COAL VALLEY RUN	1–YR < Q < 10–YR
A66.3	227	M. BR. COAL VALLEY RUN	1–YR < Q < 10–YR
A67	226	M. BR. COAL VALLEY RUN	Q < 1–YR
A67.A	226	M. BR. COAL VALLEY RUN	Q > 100–YR
A67.B	226	M. BR. COAL VALLEY RUN	Q < 1–YR
A67.1	226	M. BR. COAL VALLEY RUN	10–YR < Q < 25–YR
A67.2	226	M. BR. COAL VALLEY RUN	Q < 1–YR
A67.3	226	M. BR. COAL VALLEY RUN	Q < 1–YR
A67.4	226	M. BR. COAL VALLEY RUN	1–YR < Q < 10–YR
A67.5	226	M. BR. COAL VALLEY RUN	Q < 1–YR
A67.6	226	M. BR. COAL VALLEY RUN	Q < 1–YR
A68	226	M. BR. COAL VALLEY RUN	Q < 1–YR
A68.1	226	M. BR. COAL VALLEY RUN	Q < 1–YR
A69	226	M. BR. COAL VALLEY RUN	Q < 1–YR
A70	238	CURRY HOLLOW RUN	Q < 1–YR
A70–M	238	CURRY HOLLOW RUN	Q < 1–YR
A70.1	238	CURRY HOLLOW RUN	Q < 1–YR
A71	238	CURRY HOLLOW RUN	Q < 1–YR
A72	235	CURRY HOLLOW RUN	1–YR < Q < 10–YR
A72.1	235	CURRY HOLLOW RUN	Q < 1–YR
A73	234	CURRY HOLLOW RUN	Q < 1–YR
A73.1	234	CURRY HOLLOW RUN	Q < 1–YR
A74	234	CURRY HOLLOW RUN	50–YR < Q < 100–YR
A75	234	CURRY HOLLOW RUN	Q < 1–YR
A75.1	234	CURRY HOLLOW RUN	Q < 1–YR
A76	237	CURRY HOLLOW RUN	Q < 1–YR
A77	251	THOMPSON RUN	Q < 1–YR
A78	249	THOMPSON RUN	Q < 1–YR
A79	249	THOMPSON RUN	Q < 1–YR

Note: Q estimated from Abers Creek gauge using basin transfer techniques

TABLE A–1
ESTIMATED OBSTRUCTION CAPACITIES

ID Number	Model Reach Number	Stream	Adequacy Notation
A80	241	THOMPSON RUN	10–YR < Q < 25–YR
A81	241	THOMPSON RUN	10–YR < Q < 25–YR
A82.1	241	THOMPSON RUN	10–YR < Q < 25–YR
A83	241	THOMPSON RUN	Q < 1–YR
A84	241	THOMPSON RUN	1–YR < Q < 10–YR
A84.1	241	THOMPSON RUN	Q < 1–YR
A85	241	THOMPSON RUN	Q < 1–YR
A85.1	241	THOMPSON RUN	Q < 1–YR
A85.2	241	THOMPSON RUN	Q < 1–YR
A85.3	241	THOMPSON RUN	Q < 1–YR
A85.4	241	THOMPSON RUN	Q < 1–YR
A86	241	THOMPSON RUN	Q < 1–YR
A87	241	THOMPSON RUN	Q < 1–YR
A88	241	THOMPSON RUN	Q < 1–YR
A89	307	STREETS RUN	Q < 1–YR
A90	307	STREETS RUN	1–YR < Q < 10–YR
A91	307	STREETS RUN	Q < 1–YR
A92	307	STREETS RUN	Q < 1–YR
A93	219	N. BR. COAL VALLEY RUN	Q < 1–YR
A94	219	N. BR. COAL VALLEY RUN	10–YR < Q < 25–YR
A95	212	N. BR. COAL VALLEY RUN	Q > 100–YR
A95.1	212	N. BR. COAL VALLEY RUN	25–YR < Q < 50–YR
A95.2	212	N. BR. COAL VALLEY RUN	1–YR < Q < 10–YR
A95.3	212	N. BR. COAL VALLEY RUN	1–YR < Q < 10–YR
A95.3	210	N. BR. COAL VALLEY RUN	Q < 1–YR
A96	210	N. BR. COAL VALLEY RUN	Q < 1–YR
A96.1	209	N. BR. COAL VALLEY RUN	Q < 1–YR
A96.2	209	N. BR. COAL VALLEY RUN	Q < 1–YR
A96.3	209	N. BR. COAL VALLEY RUN	10–YR < Q < 25–YR
A96.4	209	N. BR. COAL VALLEY RUN	Q < 1–YR
B1	24	BECKETS RUN	1–YR < Q < 10–YR
B2	24	BECKETS RUN	Q < 1–YR
B3	24	BECKETS RUN	10–YR < Q < 25–YR
B4	23	BECKETS RUN	Q > 100–YR
B4A	18	BECKETS RUN	Q < 1–YR
B5	18	BECKETS RUN	Q < 1–YR
B5.1	18	BECKETS RUN	1–YR < Q < 10–YR

Note: Q estimated from Abers Creek gauge using basin transfer techniques

TABLE A–1
ESTIMATED OBSTRUCTION CAPACITIES

ID Number	Model Reach Number	Stream	Adequacy Notation
B6	20	BECKETS RUN	10–YR < Q < 25–YR
B–7	20	BECKETS RUN	50–YR < Q < 100–YR
B7.1	20	BECKETS RUN	1–YR < Q < 10–YR
B8	20	BECKETS RUN	Q > 100–YR
B9	18	BECKETS RUN	1–YR < Q < 10–YR
B10	5	BECKETS RUN	25–YR < Q < 50–YR
B11	8	BECKETS RUN	1–YR < Q < 10–YR
B12	8	BECKETS RUN	1–YR < Q < 10–YR
B13	7	BECKETS RUN	50–YR < Q < 100–YR
B14	10	BECKETS RUN	Q < 1–YR
B15	17	BECKETS RUN	Q < 1–YR
B16	16	BECKETS RUN	1–YR < Q < 10–YR
B17	15	BECKETS RUN	1–YR < Q < 10–YR
B17.1	15	BECKETS RUN	Q < 1–YR
B17.2	15	BECKETS RUN	Q < 1–YR
B18	15	BECKETS RUN	Q < 1–YR
B19	98	FALLEN TIMBER RUN	Q < 1–YR
B20	98	FALLEN TIMBER RUN	Q < 1–YR
B21	109	FALLEN TIMBER RUN	Q < 1–YR
B21.1	109	FALLEN TIMBER RUN	Q < 1–YR
B22	109	FALLEN TIMBER RUN	1–YR < Q < 10–YR
B22.1	109	FALLEN TIMBER RUN	1–YR < Q < 10–YR
B23	112	FALLEN TIMBER RUN	1–YR < Q < 10–YR
B23.1	111	FALLEN TIMBER RUN	Q < 1–YR
C–1	132	WYLIE RUN	Q < 1–YR
C–2	132	WYLIE RUN	Q < 1–YR
C–3	134	WYLIE RUN	Q < 1–YR
C–3.1	134	WYLIE RUN	1–YR < Q < 10–YR
C–4	134	WYLIE RUN	Q < 1–YR
C–4.1	132	WYLIE RUN	Q < 1–YR
C–4.2	132	WYLIE RUN	Q < 1–YR
C–4.3	132	WYLIE RUN	Q < 1–YR
C–5	136	WYLIE RUN	Q < 1–YR
C–6	136	WYLIE RUN	Q < 1–YR
C–6.1	136	WYLIE RUN	Q < 1–YR
C–6.2	136	WYLIE RUN	Q < 1–YR
C–7	141	WYLIE RUN	50–YR < Q < 100–YR

Note: Q estimated from Abers Creek gauge using basin transfer techniques

TABLE A–1
ESTIMATED OBSTRUCTION CAPACITIES

ID Number	Model Reach Number	Stream	Adequacy Notation
C–8	141	WYLIE RUN	Q > 100–YR
C–8.1	139	WYLIE RUN	Q < 1–YR
C–9	142	WYLIE RUN	1–YR < Q < 10–YR
C–9.1	142	WYLIE RUN	1–YR < Q < 10–YR
C–10	146	WYLIE RUN	Q < 1–YR
C–11	145	WYLIE RUN	25–YR < Q < 50–YR
C–11.1	145	WYLIE RUN	Q < 1–YR
C–11.2	145	WYLIE RUN	1–YR < Q < 10–YR
C–11.3	145	WYLIE RUN	Q < 1–YR
C–12	145	WYLIE RUN	Q < 1–YR
C–12.1	145	WYLIE RUN	10–YR < Q < 25–YR
C–12.2	145	WYLIE RUN	Q > 100–YR
C–12.3	145	WYLIE RUN	50–YR < Q < 100–YR
C–13	146	WYLIE RUN	10–YR < Q < 25–YR
C–14	147	WYLIE RUN	10–YR < Q < 25–YR
C–15	152	WYLIE RUN	10–YR < Q < 25–YR
C–16	152	WYLIE RUN	Q > 100–YR
C–16.1	152	WYLIE RUN	1–YR < Q < 10–YR
C–16.2	152	WYLIE RUN	10–YR < Q < 25–YR
C–16.3	152	WYLIE RUN	10–YR < Q < 25–YR
C–16.4	152	WYLIE RUN	1–YR < Q < 10–YR
C–16.5	152	WYLIE RUN	1–YR < Q < 10–YR
C–17	152	WYLIE RUN	Q < 1–YR
C–18	137	WYLIE RUN	Q < 1–YR
C–18.1	153	WYLIE RUN	1–YR < Q < 10–YR
C–19	153	WYLIE RUN	10–YR < Q < 25–YR
C–20	155	DIRECT RUNOFF	Q < 1–YR
C–20.1	155	DIRECT RUNOFF	Q < 1–YR
C–20.2	155	DIRECT RUNOFF	Q < 1–YR
C–21	197	"S. BELLE BRIDGE RUN"	1–YR < Q < 10–YR
C–22	199	"N. BELLE BRIDGE RUN"	Q > 100–YR
C–23.1	252	THOMPSON RUN	10–YR < Q < 25–YR
C–24	375	CROOKED RUN	Q < 1–YR
C–25	375	CROOKED RUN	Q < 1–YR
C–25.1	375	CROOKED RUN	25–YR < Q < 50–YR
C–26	375	CROOKED RUN	Q < 1–YR
C–27	376	CROOKED RUN	Q < 1–YR

Note: Q estimated from Abers Creek gauge using basin transfer techniques

TABLE A–1
ESTIMATED OBSTRUCTION CAPACITIES

ID Number	Model Reach Number	Stream	Adequacy Notation
C–28	367	CROOKED RUN	1–YR < Q < 10–YR
C–29	367	CROOKED RUN	1–YR < Q < 10–YR
C–30	367	CROOKED RUN	10–YR < Q < 25–YR
C–30.1	367	CROOKED RUN	10–YR < Q < 25–YR
C–30.2	367	CROOKED RUN	50–YR < Q < 100–YR
C–31	367	CROOKED RUN	25–YR < Q < 50–YR
C–31.1	367	CROOKED RUN	1–YR < Q < 10–YR
C–31.2	367	CROOKED RUN	Q < 1–YR
C–31.3	367	CROOKED RUN	Q < 1–YR
C–32	367	CROOKED RUN	10–YR < Q < 25–YR
C–32.1	367	CROOKED RUN	Q < 1–YR
C–32.2	367	CROOKED RUN	1–YR < Q < 10–YR
C–32.3	367	CROOKED RUN	Q > 100–YR
C–32.4	367	CROOKED RUN	1–YR < Q < 10–YR
C–32.5	367	CROOKED RUN	Q < 1–YR
C–32.6	367	CROOKED RUN	1–YR < Q < 10–YR
C–32.7	367	CROOKED RUN	1–YR < Q < 10–YR
C–32.8	367	CROOKED RUN	1–YR < Q < 10–YR
C–32.9	367	CROOKED RUN	10–YR < Q < 25–YR
C–32.10	367	CROOKED RUN	1–YR < Q < 10–YR
C–32.11	367	CROOKED RUN	1–YR < Q < 10–YR
C–32.12	367	CROOKED RUN	1–YR < Q < 10–YR
C–32.13	367	CROOKED RUN	1–YR < Q < 10–YR
C–32.14	367	CROOKED RUN	10–YR < Q < 25–YR
C–32.15	367	CROOKED RUN	25–YR < Q < 50–YR
C–33	366	CROOKED RUN	Q < 1–YR
C–34	364	CROOKED RUN	Q > 100–YR
C–34.1	364	CROOKED RUN	Q > 100–YR
C–34.2	364	CROOKED RUN	25–YR < Q < 50–YR
C–34.3	364	CROOKED RUN	10–YR < Q < 25–YR
C–35	364	CROOKED RUN	10–YR < Q < 25–YR
C–36	363	CROOKED RUN	Q > 100–YR
C–36.1	363	CROOKED RUN	Q > 100–YR
C–37	363	CROOKED RUN	Q > 100–YR
C–38	363	CROOKED RUN	50–YR < Q < 100–YR
C–38.1	363	CROOKED RUN	50–YR < Q < 100–YR
C–39	363	CROOKED RUN	1–YR < Q < 10–YR

Note: Q estimated from Abers Creek gauge using basin transfer techniques

TABLE A–1
ESTIMATED OBSTRUCTION CAPACITIES

ID Number	Model Reach Number	Stream	Adequacy Notation
D–1	261	THOMPSON RUN	1–YR < Q < 10–YR
D–2	357	"9DT"	Q > 100–YR
D–2.1	357	"9DT"	Q < 1–YR
E1	274	HOMESTEAD RUN	Q < 1–YR
E2	274	HOMESTEAD RUN	Q < 1–YR
E3	274	HOMESTEAD RUN	Q < 1–YR
E4	275	HOMESTEAD RUN	1–YR < Q < 10–YR
E5	275	HOMESTEAD RUN	10–YR < Q < 25–YR
E5–A	275	HOMESTEAD RUN	Q > 100–YR
E5–B	275	HOMESTEAD RUN	Q > 100–YR
E5–C	275	HOMESTEAD RUN	1–YR < Q < 10–YR
E6	275	HOMESTEAD RUN	Q > 100–YR
E7	271	HOMESTEAD RUN	Q > 100–YR
E8	271	HOMESTEAD RUN	25–YR < Q < 50–YR
E8–A	270	HOMESTEAD RUN	1–YR < Q < 10–YR
E9	270	HOMESTEAD RUN	Q > 100–YR
E9–A	270	HOMESTEAD RUN	1–YR < Q < 10–YR
E9–B	270	HOMESTEAD RUN	Q > 100–YR
E10	276	HOMESTEAD RUN	Q > 100–YR
E10–A	276	HOMESTEAD RUN	Q < 1–YR
E11	276	HOMESTEAD RUN	Q > 100–YR
E11–A	276	HOMESTEAD RUN	Q > 100–YR
E11–B	276	HOMESTEAD RUN	Q > 100–YR
E11–C	276	HOMESTEAD RUN	Q > 100–YR
E12	276	HOMESTEAD RUN	Q > 100–YR
E12–A	276	HOMESTEAD RUN	Q > 100–YR
E12–B	276	HOMESTEAD RUN	50–YR < Q < 100–YR
E13	276	HOMESTEAD RUN	Q > 100–YR
E13–A	276	HOMESTEAD RUN	Q > 100–YR
E14	276	HOMESTEAD RUN	Q > 100–YR
E15	323	WEST RUN	Q < 1–YR
E15–A	323	WEST RUN	10–YR < Q < 25–YR
E16	323	WEST RUN	25–YR < Q < 50–YR
E17	323	WEST RUN	Q > 100–YR
E18	324	WEST RUN	Q < 1–YR
E19	324	WEST RUN	1–YR < Q < 10–YR
E20	324	WEST RUN	Q > 100–YR

Note: Q estimated from Abers Creek gauge using basin transfer techniques

TABLE A–1
ESTIMATED OBSTRUCTION CAPACITIES

ID Number	Model Reach Number	Stream	Adequacy Notation
E21	324	WEST RUN	50–YR < Q < 100–YR
E22	324	WEST RUN	Q < 1–YR
E22–A	324	WEST RUN	50–YR < Q < 100–YR
E23	324	WEST RUN	10–YR < Q < 25–YR
E24	324	WEST RUN	Q < 1–YR
E25	328	WEST RUN	50–YR < Q < 100–YR
E26	328	WEST RUN	Q < 1–YR
E27	326	WEST RUN	Q < 1–YR
E28	326	WEST RUN	Q < 1–YR
E29	326	WEST RUN	Q < 1–YR
E30	310	STREETS RUN	1–YR < Q < 10–YR
E30–A	310	STREETS RUN	Q < 1–YR
E30–B	310	STREETS RUN	Q < 1–YR
E31	310	STREETS RUN	Q > 100–YR
E32	310	STREETS RUN	10–YR < Q < 25–YR
E33	305	STREETS RUN	Q < 1–YR
E33–A	305	STREETS RUN	Q < 1–YR
E34	305	STREETS RUN	Q < 1–YR
E34–A	305	STREETS RUN	Q < 1–YR
E35	305	STREETS RUN	Q < 1–YR
E36	305	STREETS RUN	10–YR < Q < 25–YR
E37	305	STREETS RUN	Q < 1–YR
E38	305	STREETS RUN	Q < 1–YR
E38–A	305	STREETS RUN	1–YR < Q < 10–YR
E39	305	STREETS RUN	1–YR < Q < 10–YR
E39–A	305	STREETS RUN	Q < 1–YR
E–40	311	STREETS RUN	Q > 100–YR
E41	311	STREETS RUN	1–YR < Q < 10–YR
E41–A	311	STREETS RUN	Q < 1–YR
E41–B	311	STREETS RUN	Q < 1–YR
E41–C	311	STREETS RUN	Q < 1–YR
E41–D	311	STREETS RUN	Q < 1–YR
E–42	311	STREETS RUN	Q < 1–YR
E42–A	311	STREETS RUN	Q < 1–YR
E43	317	STREETS RUN	10–YR < Q < 25–YR
E44	317	STREETS RUN	50–YR < Q < 100–YR
E45	317	STREETS RUN	Q < 1–YR

Note: Q estimated from Abers Creek gauge using basin transfer techniques

TABLE A–1
ESTIMATED OBSTRUCTION CAPACITIES

ID Number	Model Reach Number	Stream	Adequacy Notation
E45–A	317	STREETS RUN	Q < 1–YR
E–46	317	STREETS RUN	1–YR < Q < 10–YR
E–47	317	STREETS RUN	Q > 100–YR
E–48	317	STREETS RUN	1–YR < Q < 10–YR
E–49	316	STREETS RUN	1–YR < Q < 10–YR
E–50	315	STREETS RUN	50–YR < Q < 100–YR
E–51	315	STREETS RUN	50–YR < Q < 100–YR
E–52	338	BECKS RUN	Q > 100–YR
E–53	338	BECKS RUN	Q > 100–YR
E–54	338	BECKS RUN	Q < 1–YR
E–55	338	BECKS RUN	Q < 1–YR
E–56	338	BECKS RUN	Q < 1–YR
E–57	334	BECKS RUN	Q > 100–YR
E–58	334	BECKS RUN	Q > 100–YR
E–59	332	BECKS RUN	50–YR < Q < 100–YR
E–60	332	BECKS RUN	50–YR < Q < 100–YR
E60–A	332	BECKS RUN	25–YR < Q < 50–YR
E61	332	BECKS RUN	1–YR < Q < 10–YR
E62	350	NINEMILE RUN	Q < 1–YR
E63	353	NINEMILE RUN	Q < 1–YR
E64	353	NINEMILE RUN	Q < 1–YR
E65	354	NINEMILE RUN	Q > 100–YR
E66	354	NINEMILE RUN	Q > 100–YR
E67	354	NINEMILE RUN	Q > 100–YR
F–1	26	SUNFISH RUN	Q < 1–YR
F–1.1	26	SUNFISH RUN	Q < 1–YR
F–2	26	SUNFISH RUN	Q < 1–YR
F–3	30	SUNFISH RUN	10–YR < Q < 25–YR
F–4	33	SUNFISH RUN	1–YR < Q < 10–YR
F–4.1	32	SUNFISH RUN	Q < 1–YR
F–5	33	SUNFISH RUN	1–YR < Q < 10–YR
F–6	41	KELLY RUN	Q < 1–YR
F–7	41	KELLY RUN	Q < 1–YR
F–8	44	KELLY RUN	Q < 1–YR
F–9	44	KELLY RUN	1–YR < Q < 10–YR
F–10	48	KELLY RUN	1–YR < Q < 10–YR
F–11	53	BUNOLA RUN	Q < 1–YR

Note: Q estimated from Abers Creek gauge using basin transfer techniques

TABLE A–1
ESTIMATED OBSTRUCTION CAPACITIES

ID Number	Model Reach Number	Stream	Adequacy Notation
F–12	53	BUNOLA RUN	Q < 1–YR
F–13	53	BUNOLA RUN	Q < 1–YR
F–14	53	BUNOLA RUN	Q < 1–YR
F–15	54	BUNOLA RUN	Q < 1–YR
F–16	54	BUNOLA RUN	Q < 1–YR
F–16.1	56	BUNOLA RUN	1–YR < Q < 10–YR
F–17	57	BUNOLA RUN	Q < 1–YR
F–18	57	BUNOLA RUN	Q < 1–YR
F–19	60	BUNOLA RUN	Q < 1–YR
F–20	60	BUNOLA RUN	Q < 1–YR
F–21	51	KELLY RUN	50–YR < Q < 100–YR
F–21.1	51	KELLY RUN	25–YR < Q < 50–YR
F–22	83	MILL RUN	1–YR < Q < 10–YR
F–23	83	MILL RUN	1–YR < Q < 10–YR
F–24	83	MILL RUN	Q < 1–YR
F–25	80	MILL RUN	Q < 1–YR
F–25.1	80	MILL RUN	Q < 1–YR
F–26	82	MILL RUN	Q < 1–YR
F–27	82	MILL RUN	Q < 1–YR
F–28	79	MILL RUN	50–YR < Q < 100–YR
F–29	74	MILL RUN	Q < 1–YR
F–29.1	74	MILL RUN	1–YR < Q < 10–YR
F–30	73	MILL RUN	Q < 1–YR
F–31	71	MILL RUN	1–YR < Q < 10–YR
F–32	71	MILL RUN	1–YR < Q < 10–YR
F–33	71	MILL RUN	1–YR < Q < 10–YR
F–34	71	MILL RUN	10–YR < Q < 25–YR
F–35	98	FALLEN TIMBER RUN	Q < 1–YR
F–35.1	98	FALLEN TIMBER RUN	Q < 1–YR
F–36	98	FALLEN TIMBER RUN	10–YR < Q < 25–YR
F–37	101	FALLEN TIMBER RUN	Q < 1–YR
F–37.1	101	FALLEN TIMBER RUN	Q < 1–YR
F–38	101	FALLEN TIMBER RUN	Q < 1–YR
F–38.1	103	FALLEN TIMBER RUN	Q < 1–YR
F–39	104	FALLEN TIMBER RUN	1–YR < Q < 10–YR
F–39.1	104	FALLEN TIMBER RUN	Q < 1–YR
F–39.2	104	FALLEN TIMBER RUN	1–YR < Q < 10–YR

Note: Q estimated from Abers Creek gauge using basin transfer techniques

TABLE A–1
ESTIMATED OBSTRUCTION CAPACITIES

ID Number	Model Reach Number	Stream	Adequacy Notation
F–40	106	FALLEN TIMBER RUN	25–YR < Q < 50–YR
F–41	107	FALLEN TIMBER RUN	Q < 1–YR
F–42	107	FALLEN TIMBER RUN	Q > 100–YR

Note: Q estimated from Abers Creek gauge using basin transfer techniques

APPENDIX C
EXPANDED DISCUSSION OF REPORTED STORMWATER PROBLEMS

BECKS RUN
REPORTED PROBLEMS

GENERAL DESCRIPTION OF THE WATERSHED

The Becks Run Watershed encompasses approximately 1,670 acres of land in the City of Pittsburgh and the boroughs of Mt. Oliver and Baldwin. The stream flows in an essentially westward direction to its mouth at approximately mile point 4.5 on the Monongahela River.

Statistics descriptive of the watershed developed as part of this planning process are as follows:

Becks Run Watershed

Total Area:	1,670 acres
Land Use Distribution:	
Residential	43.92%
Commercial	10.10%
Industrial	0.01%
Open Space	45.97%
Composite Runoff Curve No.:	79.1
Peak Discharge at Mouth *:	
Mean Annual	320 cfs
10 - Year	660 cfs
25 - Year	890 cfs
50 - Year	1,070 cfs
100 Year	1,355 cfs

* Estimated using basin transfer technique from Abers Creek gauge data.

REPORTED PROBLEMS

City of Pittsburgh Area

In its municipal questionnaire, the City of Pittsburgh identified the occurrence of flooding in the lower reaches of Becks Run. Flooding problems were identified as occurring at two locations: 1) in the vicinity of the intersection of Susquehanna Street and Becks Run Road; and 2) in the vicinity of Becks Run Road and Parkwood.

In the vicinity of Susquehanna Street, the channel of Becks Run makes a sharp bend to the south away from Becks Run Road, loops behind several residences and back toward Becks Run Road and, finally makes a sharp bend to the east to essentially parallel Becks Run Road in front of a number of residences to its mouth on the Monongahela River. The Susquehanna Street culvert has an estimated nominal capacity sufficient to carry less than the mean annual flood. The major obstructions in below this reach appear to have sufficient capacity to convey floods up to the 100-year flood.

Our review of the situation indicates that the likely cause of the flooding problems in this area is the abrupt change in channel alignment and the limited capacity of the culvert at Susquehanna Street.

In the vicinity of the second problem area (just below the intersection of Becks Run Road at Parkwood), Becks Run passes under a culvert. At the time of our site visit, there were signs of elevated water levels in the channel just upstream of the culvert. The capacity of the culvert is estimated to approximate that of the 10-year return storm. The likely cause of the reported flooding problems in this area is the limited capacity of the culvert.

Mt. Oliver Area

The Borough of Mt. Oliver reported the occurrence flooding problems in the Walter Avenue area. This area is a densely developed areas situated in the upper reaches of the watershed. These problems appear to be related to localized drainage and sewer capacity problems.

POTENTIAL SOLUTIONS

City of Pittsburgh Area

The potential solutions to the identified problems are increasing the channel capacity by straightening the channel and increasing the capacity of the two identified culverts.

These are capital intensive actions whose feasibility hinges on the availability and commitment of the necessary funds. The problems lie at the bottom of the watershed and appear to affect a limited number of structures. Moreover, any channel alignment is likely to affect or take portions of the properties to be protected. Consequently, it is important to identify alternatives, their cost and the value of the increased protection afforded.

The following course of action should be considered in order to move forward toward identifying and implementing cost effective flood protection improvements in this area:

1. Conduct a detailed Flood and Erosion Protection Study of the affected areas of the watershed.

- Development of a damage assessment defining the cost of flooding and erosion damages.

- Utilization of the U.S. Army Corps of Engineers' HEC - 2 "Water Surface Profiles" computer program to develop and evaluate alternative solutions to identified problems. Solutions to be considered should include, channel improvements, and the replacement of bridges and/or culverts.

- Development of cost estimates for the identified optimal improvements.

- Completion of a cost - benefit analysis which ways the cost of improvements against the value of the benefits realized through the elimination of damage / problems.

A study such as the one described above is often prepared by the Commonwealth of Pennsylvania Department of Environmental Resources' Bureau of Water Projects. As indicated above, this agency has previously completed engineering reviews of various locations within the watershed and have concluded that they are unable to provide direct assistance. The agency may be approached again to complete a comprehensive investigation as outlined above. Failing that, other potential sponsors of the study should be explored, including the County and municipalities.

2. The results of the Feasibility Study should be discussed and considered by the public, the affected municipalities, the County and the State. The merits of the remedial actions should be considered in view of their cost. Potential funding options and cost sharing arrangements should be investigated and the agency(ies) responsible for project implementation should be identified. A joint decision should be reached as to which, if any, elements of the remedial project should be implemented.

3. If a decision is reached to implement the project, the identified responsible agency(ies) should proceed through the traditional public works process of design and construction.

Borough of Mt. Oliver Area

The problem in the Walter Avenue area of Mt. Oliver appears to be caused by localized drainage and sewer capacity problems. The Borough has reported that flooding problems in other areas of the Borough have been alleviated through the completion of various sanitary sewer, storm sewer and backflow preventer projects. Our preliminary review of the Walter Avenue situation indicates that similar activities may comprise the solutions there. Engineering investigations should be completed to adequately define the problem and identify remedial actions for implementation.

COURAIN HILL RUN
REPORTED PROBLEMS

GENERAL DESCRIPTION OF THE WATERSHED

Courain Hill Run is a small tributary which drains approximately 520 acres of Lincoln Borough. The stream flow is a westerly direction to its mouth at approximately Monongahela River mile 19.8.

Statistics descriptive of the watershed developed as part of this planning process are as follows:

Courain Run Watershed

Total Area:	510 acres
Land Use Distribution:	
Residential	4.79%
Commercial	2.12%
Industrial	0.22%
Open Space	92.87%
Composite Runoff Curve No.:	74.1
Peak Discharge at Mouth *:	
Mean Annual	120 cfs
10 - Year	260 cfs
25 - Year	350 cfs
50 - Year	420 cfs
100 Year	530 cfs

* Estimated using basin transfer technique from Abers Creek gauge data.

REPORTED PROBLEMS

In its municipal questionnaire, Lincoln Borough reported the occurrence of accelerated erosion problems affecting several residential properties in this watershed.

POTENTIAL SOLUTIONS

The likely solution to this problem is stabilization of the stream banks where the erosion is occurring. This can be accomplished through stream bank armoring through the construction of retaining walls or the installation of gabions or riprap. From a technical standpoint, this problem is isolated, straight forward and easily

addressed. The major impediment to resolving this problem is limited amount of funds available to complete such work and the difficulties associated with allocating the needed funds to resolve relatively isolated problems affecting private properties.

CROOKED RUN
REPORTED PROBLEMS

GENERAL DESCRIPTION OF THE WATERSHED

The Crooked Run watershed drains areas of the City of McKeesport, the boroughs of East McKeesport and White Oak and North Versailles Township.

Statistics descriptive of the portions of the watershed developed as part of this planning process are as follows:

Crooked Run Watershed

Total Area (above problem): 560 acres

Land Use Distribution (above problem):

Residential	28.6%
Commercial	9.5%
Industrial	0.8%
Open Space	60.1%

Composite Runoff Curve No.: 77.8

Peak Discharge at Mouth (above problem)*:

Mean Annual	80 cfs
10 - Year	170 cfs
25 - Year	230 cfs
50 - Year	280 cfs
100 Year	350 cfs

* Estimated using basin transfer technique from Abers Creek gauge data.

REPORTED PROBLEMS

North Versailles Township reported the occurrence of accelerated bank erosion of Crooked Run in the vicinity of the intersection of Crooked Run Road and Fifth Avenue. A site visit to this location verified that the southern stream bank in this area shows evidence of significant erosion. The stream in this area directly abuts Crooked Run Road. The road bed appears to consist of relatively loose gravel which is susceptible to stream erosion. The potential for damage to the road appears to be real.

POTENTIAL SOLUTIONS

The apparent solution to this problem is the installation of bank armoring in this vicinity. According to our information, Crooked Run Road is a County road. Consequently, efforts should be directed through the County to secure the necessary funding for the construction of the bank protection necessary to adequately protect the roadway in the area.

FOUR MILE RUN
REPORTED PROBLEMS

GENERAL DESCRIPTION OF THE WATERSHED

Nine Mile Run watershed portions of the City of Pittsburgh. It encompasses an area of approximately 2,120 acres. The area is highly urbanized and drainage in the watershed is provided by a closed conduit combined sewer system. The general direction of flow is east

to west toward approximately mile four of the Monongahela River.

Statistics descriptive of the watershed developed as part of this planning process are as follows:

Four Mile Run Watershed

Total Area:	2,120 acres
Land Use Distribution:	
Residential	52.32%
Commercial	24.33%
Industrial	0.50%
Open Space	22.85%
Composite Runoff Curve No.:	83.7
Peak Discharge at Mouth *:	
Mean Annual	390 cfs
10 - Year	810 cfs
25 - Year	1,100 cfs
50 - Year	1,300 cfs
100 Year	1,660 cfs

* Estimated using basin transfer technique from Abers Creek gauge data.

REPORTED PROBLEMS

The City of Pittsburgh reported problems in this watershed associated with surcharging of the combined sewer system. In addition, during our field investigations we discovered evidence of street flooding on Saline Street.

POTENTIAL SOLUTIONS

In its questionnaire, the City of Pittsburgh, identified the construction of retention ponds and a nine foot diameter relief sewer as potential solutions for the reported problems. The City also reported that the construction of the Boundary Street relief sewer and outfall has been proposed and is in the study phase. This project is anticipated to address the reported flooding/sewer surcharging problems in this watershed.

The observed evidence of flooding on Saline Street appears to be caused by an partially clogged and possibly undersized inlet structure located at the dead end of the street abutting Route 376. The likely solution to this problem is the construction of a improved inlet structure and frequently clearing of debris from the structure.

HOMESTEAD RUN
REPORTED PROBLEMS

GENERAL DESCRIPTION OF THE WATERSHED

Homestead Run flows in a northerly direction from its headwaters in West Mifflin to its mouth on the Monongahela River at Homestead. The watershed drains areas of Homestead, Munhall, West Mifflin and Wittaker

Statistics descriptive of the watershed developed as part of this planning process are as follows:

Homestead Run Watershed	
Total Area:	1,800 acres
Land Use Distribution:	
Residential	53.1%
Commercial	8.2%
Industrial	0.9%
Open Space	37.8%
Composite Runoff Curve No.:	79.9
Peak Discharge at Mouth *:	
Mean Annual:	340 cfs
10 - Year:	700 cfs
25 - Year	950 cfs
50 - Year	1,140 cfs
100 Year	1,440 cfs

* Estimated using basin transfer technique from Abers Creek gauge data.

REPORTED PROBLEMS

The WPAC representative from the Borough of Munhall, provided information describing problems in the Ravine Street area of the Homestead Run Watershed: The problems in this area are primarily related to erosion, sedimentation and deterioration of some channel walls.

POTENTIAL SOLUTIONS

In 1985, the Pennsylvania Department of Environmental Resources completed an evaluation of these problems. The area studied extends from the boundary line between West Mifflin and Munhall where Ravine Street forks into Green Springs

Avenue and Duquesne-Homestead Road to the arch culvert that extends under Eighth Avenue and the U.S. Steel Homestead Works.

The report described that existing problems as follows:

> "Existing problems experienced along Homestead Run are deteriorating channel walls and/or stream bank erosion. These channel walls, some of them dating back to the WPA program, consist of either concrete, masonry or timber and are in poor condition due to their age and/or the undermining effect caused by high velocity flood waters. Sanitary sewer lines crossing the channel have been encased in concrete to protect the lines from rupture. In the areas where concrete encasement has been applied, the entire channel invert was paved. These concrete channel reaches, that occur at a number of sites along the subject stream, increase channel velocities causing erosive flood waters to scour the unprotected stream banks and undermine the channel walls."

The DER investigation considered a comprehensive structural flood protection project in the form of a rectangular reinforced concrete channel, to contain the 100-year flood discharge. A rough cost estimate for such a project was given as $3 million. In addition, four bridge structures along Ravine Street and numerous foot bridges would have to be modified or replaced to accommodate the required channel and alignment. The cost of these bridge modifications would be over and above the $3 million for channelization and would have to be borne by the local municipality.

Based upon a benefit cost assessment, the investigation did not recommend the flood protection project.

The referenced DER investigation suggested that the local municipalities may wish to consider the potential for a less comprehensive project. This would consist of protecting the most seriously threatened areas and/or areas of most concern.

The following course of actions should be considered in order to move forward with such a more limited approach to the problems in the Homestead Run watershed:

1. Conduct a detailed Flood and Erosion Protection Study of the entire length of the watershed. This will include the following activities:

   - Compilation of an exhaustive inventory of current and developing problems in the watershed. This should include a detailed survey of the stream channel and interviews with municipal officials and property owners.

   - Development of a damage assessment defining the cost of flooding and erosion damages.

- Utilization of the U.S. Army Corps of Engineers' HEC - 2 "Water Surface Profiles" computer program to develop and evaluate alternative solutions to identified problems. Solutions to be considered should include a prioritized program of channel improvements, stream bank protection and/or relocation of structures. The hydraulic analysis should evaluate the effects of all improvements on downstream portions of the watershed.

- Development of cost estimates for the identified optimal, prioritized improvements.

- Completion of a cost - benefit analysis which ways the cost of improvements against the value of the benefits realized through the elimination of damage / problems.

A study such as the one described above is often prepared by the Commonwealth of Pennsylvania Department of Environmental Resources. Although this agency has previously completed an evaluation of the Ravine Street area of the watershed, they may be approached again to complete a comprehensive investigation as outlined above. Failing that, other potential sponsors of the study should be explored, including the County and municipalities.

2. The results of the Feasibility Study should be discussed and considered by the public, the affected municipalities, the County and the State. The merits of the remedial actions should be considered in view of their cost. Potential funding options and cost sharing arrangements should be investigated and the agency(ies) responsible for project implementation should be identified. A joint decision should be reached as to which, if any, elements of the remedial project should be implemented.

3. If a decision is reached to implement the project, the identified responsible agency(ies) should proceed through the traditional public works process of design and construction.

JEFFERSON BOROUGH FIFTH STREET AREA
REPORTED PROBLEMS

GENERAL DESCRIPTION OF THE WATERSHED

The Fifth Street area of Jefferson Borough lies within one of the direct discharge areas of the Monongahela River watershed. The area lies within the Monongahela River flood plain and is quite flat. The area is comprised of a mixture of commercial, light industrial and residential land uses.

REPORTED PROBLEMS

In its Municipal Questionnaire, Jefferson Borough identified the occurrence of flooding problems in the all along the Fifth Street area. Minor flooding is reported to occur during short, intense storm events and major flooding is reported to occur as a result of long duration rainfall events. During minor floods, basements have small amounts of water in them. Major flood basements fill with water and other property damage occurs. The problems were attributed to excessive stormwater runoff velocity and volumes.

POTENTIAL SOLUTION

Solutions to these problems suggested in the Jefferson Borough Municipal Questionnaire consist of replacing undersized pipes and dredging and widening waterways and streams in the area. It is likely that the solution to the problems in this area will include specific, localized drainage improvements, stormwater collection and conveyance system improvements and, perhaps, individual backflow prevention actions.

It is recommended that a drainage study be performed in the Fifth Street area to identify the site specific drainage improvement options available to the municipality, recommend feasible improvements and provide a basis for proceeding with financing, designing and constructing necessary improvements.

NINE MILE RUN
REPORTED PROBLEMS

GENERAL DESCRIPTION OF THE WATERSHED

Nine Mile Run drains an area of approximately 3,140 acres of portions of the City of Pittsburgh, Wilkinsburg, Edgewood and Swissvale. The stream flows in a predominantly southerly direction to its mouth at approximately Monongahela River mile 7.5.

Statistics descriptive of the watershed developed as part of this planning process are as follows:

Nine Mile Run Watershed

Total Area:	3,140 acres
Land Use Distribution:	
Residential	44.24 %
Commercial	22.52 %
Industrial	0.65 %
Open Space	32.58 %
Composite Runoff Curve No.:	81.7
Peak Discharge at Mouth *:	
Mean Annual	530 cfs
10 - Year	1,100 cfs
25 - Year	1,490 cfs
50 - Year	1,780 cfs
100 Year	2,250 cfs

* Estimated using basin transfer technique from Abers Creek gauge data.

REPORTED PROBLEMS

The City of Pittsburgh reported that erosion, sedimentation and pollution of Nine Mile Run is a problem. These problems are symptomatic of problems typical of a highly urbanized watershed.

POTENTIAL SOLUTIONS

In its questionnaire, the City of Pittsburgh identified cleaning of the creek bed and bank stabilization as solutions to the erosion and sedimentation problems. These solutions are appropriate responses to the types of problems encountered and are

not difficult to implement from a technical standpoint. The availability of funds is a principle factor blocking implementation of the improvements. Initial steps should emphasize a detailed description of the problems and recommended solutions and the development of cost estimates which can be used to pursue funding of the project.

The solution of the water quality problems are likely to be more complicated in nature. These problems appear to be caused urban stormwater runoff and the bypassing and/or overflowing of inadequately treated sewage. Detailed investigations of the storm and sewage collection systems in the area must be completed in order to identify the source(s) of the pollution and develop feasible mitigation measures. Once the source of the problem and potential solutions are adequately documented, progress can be made toward the reduction or elimination of the problem.

STREETS RUN
REPORTED PROBLEMS

GENERAL DESCRIPTION OF THE WATERSHED

The Streets Run Watershed encompasses approximately 6,590 acres of land and flows in a northerly direction from its headwaters in the Baldwin, Whitehall area to its mouth on the Monongahela River near the Glenwood Bridge.

Statistics descriptive of the watershed developed as part of this planning process are as follows:

Streets Run Watershed

Total Area:	6,590 acres
Land Use Distribution:	
Residential	35.1%
Commercial	8.4%
Industrial	2.2%
Open Space	54.3%
Composite Runoff Curve No.:	79.9
Peak Discharge at Mouth *:	
Mean Annual:	980 cfs
10 - Year:	2,050 cfs
25 - Year	2,760 cfs
50 - Year	3,310 cfs
100 Year	4,180 cfs

* Estimated using basin transfer technique from Abers Creek gauge data.

REPORTED PROBLEMS

Baldwin Borough and the City of Pittsburgh reported the existence of stormwater runoff relate problems at several locations within the Streets Run Watershed. The problems we characterized as flooding, sedimentation and erosion and sanitary sewer overflows. Information provided by Baldwin Borough attributed the existence of the flooding problems to excessive stream flow and velocity. The City of Pittsburgh response pointed to stream encroachment and the existence of undersized obstructions causes of the problems experienced.

An April 1990 Flood Protection Study: Streets Run, Hays Section prepared by the Pennsylvania Department of Environmental Resources' Bureau of Water Projects identified the following problems in the portion of the watershed investigated:

- In past flood events, sections of concrete and/or masonry retaining walls along Baldwin Road have fallen into Streets Run, obstructing the flow and threatening the shoulder of Baldwin Road.
- There is continued deterioration of the remaining retaining walls which are presently being undermined by the stream flow.
- There is inadequate capacity of the channel resulting in floodwaters overtopping the channel and resulting in floodwaters overtopping the stream channel and flowing either into adjacent residential properties or down Baldwin Road.
- There is a flood threat due to low stream bank protection and low-lying residences along Calera Avenue and Baldwin Road.
- Erosion has been a recurring problem along a railroad embankment located on the east stream bank.

POTENTIAL SOLUTIONS

The Department of Environmental Resources has made a number of investigations of problem areas in the Hayes section of the Streets Run watershed. The following is a brief summary of the results of these investigations:

1. An inspection by the Department of Environmental Resources was conducted in May 1962. Up to six structures were found to be affected by street overflow and basement flooding during flood flows in 1956 and 1958. A conservative damage estimate was made and a project was proposed in August of that year. Local participation items were not met and the project never developed.

2. The Department of Environmental Resources made a site investigation of the area in the vicinity of Holy Angels Church in 1969. A project was recommended but never implemented because of financial difficulties.

3. In 1982, the Department of Environmental Resources recommended placing riprap along a section of the stream and removing bedload deposits from the stream channel. The project was never implemented because of the inability to secure a necessary right-of-way.

4. The previously referenced 1990 report identified the following improvements as necessary to provide flood protection in the face of 100 year frequency stream flows:

   - Approximately 4,700 feet of concrete channel would be constructed through the community of Hayes, beginning approximately 500 feet upstream of the Corley Street bridge and ending at the entrance to the Streets Run culvert.

   - In the vicinity of 90 degree bends in the stream channel at the Calera Avenue bridge, the channel would be realigned to eliminate the two sharp turns. This would require the acquisition of to private properties and structures.

   - Downstream of the concrete channel, remedial work would be done to the existing culvert. The first 1,470 feet of rectangular culvert and open channel would be retained, but the natural invert would be replaced with concrete. A 70 foot section of arch culvert which restricts flow would be replaced with a concrete rectangular culvert. Finally, approximately 840 feet of concrete arch culvert would be removed and replaced with a trapezoidal channel lined with rock riprap.

   The total estimated cost of this project is estimated to be $7.3 million.

   The Flood Protection Study concluded the project should not be undertaken due to a low benefit-cost ratio.

   As an alternative, the Study recommended that the owners of structures institute individual flood proofing measures.

The investigations reported above, did not address several of the problem areas reported by Baldwin Borough, areas which are situated along Streets Run upstream of the Hayes area. The inventory of obstructions compiled during the development of this stormwater management plan identified six stream crossings in the vicinity of these reported flooding problems. Three of these obstructions have limited stream flow capacities. The capacities (estimated as top of pipe, inlet control capacities) of these three obstruction are estimated to approximate the 1 year frequency peak flow rate (calculated using basin transfer methods from the Abers Creek gauge information). The limited capacities of these obstructions are likely to be the primary cause of stream flooding in these areas.

The problems and potential solutions for the flooding and erosion problems in the lower reaches of the Streets Run watershed are well documented. As a result, the problem definition and solution development aspects of the process of solving the problems have been completed. Successful implementation of the recommended

improvements will hinge upon the availability of sufficient funds (estimated at $7.3 million). The finding of the 1990 Flood Protection Study that the Commonwealth should not participate in funding the project due to an unfavorable cost - benefit ratio increases the difficulty of securing the necessary funds.

Efforts to move toward mitigation of the problems in the lower reaches should initially consist of investigating alternative funding sources. In the likely event that sufficient funding is found not to be available for the 100-year flood protection improvements identified in the 1990 Flood Protection Study, the alternative of considering more limited, potentially more affordable improvements which would afford a intermediate degree of protection. Considerations could be given to providing flood protection designed for more frequent flood events. Such consideration would require that such intermediate scale improvements be identified (using procedures similar to those employed in the Flood Protection Study). These intermediate scale improvements would be described in terms of cost and extent of protection afforded with the intent of identifying affordable improvements which offer acceptable degrees of flood protection.

Actions necessary to mitigate the reported problems in the higher reaches of the watershed should include the following:

1. The preliminary obstruction capacity estimates developed as part of this plan should be verified.

2. Consideration should be given to the potential effects of the elimination of these upstream restrictions on downstream flood conditions. It should be realized that reducing flooding in upstream through the elimination of flow restrictions could exacerbate downstream flood conditions. This assessment can best be performed by using the HEC - 2 computer program to calculate water surface profiles throughout the watershed resulting from changes made to channel and obstruction capacities.

3. Appropriate improvements should be identified based upon the initial investigations.

4. Funding commitments should be secured and the typical public works design and construction process should be completed.

THOMPSON RUN
REPORTED PROBLEMS

GENERAL DESCRIPTION OF THE WATERSHED

The Thompson Run Watershed encompasses approximately 3,870 acres of land in the City of Pittsburgh, the City of Duquesne and West Mifflin Borough. The stream flows in an essentially eastward direction to its mouth at approximately mile point 11.5 on the Monongahela River.

Statistics descriptive of the watershed developed as part of this planning process are as follows:

Thompson Run Watershed

Total Area:	3,870 acres
Land Use Distribution:	
Residential	33.31%
Commercial	12.43%
Industrial	3.56%
Open Space	50.70%
Composite Runoff Curve No.:	80.0
Peak Discharge at Mouth *:	
Mean Annual	630 cfs
10 - Year	1,300 cfs
25 - Year	1,750 cfs
50 - Year	2,100 cfs
100 Year	2,660 cfs

* Estimated using the basin transfer technique from Abers Creek gauge data.

REPORTED PROBLEMS

The City of Duquesne reported water quality problems attributed to mine drainage and discharges of inadequately treated sewage. The City of Duquesne Flood Insurance Study reported flooding problems in the vicinity of the wastewater treatment plant at the upstream side of the railroad tracts. Flooding in this location was attributed to backwater effects of the Monongahela River and debris in the culvert underneath the railroad tracks. The West Mifflin Borough Flood Insurance Study referred to flooding which occurred at unspecified locations on Thompson Run in 1956

POTENTIAL SOLUTIONS

The water quality problems identified by the City of Duquesne lie well beyond the purview of this Act 167 stormwater management plan. They should be addressed through the appropriate County and/or State agencies.

Little can be done to effect flooding caused by backwater from the Monongahela River. However, concerns related to debris in the culverts in the lower reaches can be addressed by instituting a schedule of periodic inspections followed up by necessary clearing activities as warranted. It is recommended that the owner of the railroad culvert be identified and notified when the accumulation of debris significant reduces the flow capacity of the structure.

WEST RUN
REPORTED PROBLEMS

GENERAL DESCRIPTION OF THE WATERSHED

The West Run watershed encompasses approximately 990 acres of land in the City of Pittsburgh and the Boroughs of Munhall, Homestead and West Homestead. The stream flows in a northerly direction from its headwaters within the Pittsburgh city limits to its mouth on the Monongahela River at Homestead.

Statistics descriptive of the watershed developed as part of this planning process are as follows:

West Run Watershed

Total Area:	993 acres
Land Use Distribution:	
Residential	53.5%
Commercial	9.0%
Industrial	1.1%
Open Space	36.4%
Composite Runoff Curve No.:	79.8
Peak Discharge at Mouth *:	
Mean Annual	210 cfs
10 - Year	440 cfs
25 - Year	590 cfs
50 - Year	709 cfs
100 Year	900 cfs

* Estimated using basin transfer technique from Abers Creek gauge data.

REPORTED PROBLEMS

In its municipal questionnaire, the City of Pittsburgh identified accelerated erosion and sedimentation as a problem in the West Run watershed in the vicinity of Longfellow Drive.

In addition, the WPAC representative from the Borough of Munhall, provided information describing problems in the following areas in the West Run Watershed:

- erosion and flooding in the vicinity of West Homestead Automotive Supply Company in West Homestead;

- erosion in the vicinity of 849 Forrest Avenue in West Homestead;
- erosion and flooding in the vicinity of 3632 West Run Road in Munhall;
- water quality problems in the upper reaches of West Run.

A review of conditions in the watershed indicates that the identified problems are caused by a combination of the following conditions.

- The watershed is relatively extensively developed, particularly in the upper and lower reaches.
- Sediment load is contributed by runoff carrying sediment from unpaved streets, earth moving activities and unvegetated banks along West Run Road.
- A exposed stream crossing pipe is situated in the vicinity of Gates Drive.
- In many instances, homes and buildings have been constructed in close proximity to the stream channel. This is true at the locations of reported flooding and erosion problems. In some cases, fill has been placed adjacent to and partially in the stream channel. This increases the natural potential for erosion and sedimentation.
- Significant amounts of debris have collected at the culvert at the intersection of West Road and Laurel Hill Drive. The resulting flow restriction can cause significant backwater effects upstream and could endanger downstream areas.
- Mine drainage and sewage discharges have been reported to enter the stream at several locations.

POTENTIAL SOLUTIONS

Potential solutions to the identified problems include:

- Increasing the channel capacity through dredging and/or channelization;
- Increasing the size and capacity of selected culverts. Our reconnaissance survey of stream obstructions indicates that most of the culverts along the main stem of West Run have capacities in excess of the 10 year return frequency flood. However, culverts located at Gates Drive *(Obstruction 15)*, Laurel Hill Drive *(Obstruction 18)* and *(Obstruction 22)*.

- Protecting the stream banks through armoring;
- Reducing the sediment load by requiring effective soil erosion and sediment controls on earth moving activities;
- Relocation of selected affected structures;
- Frequent and effective clearing of culverts;
- Termination of mine drainage and sewage discharges;

Several investigations of conditions within the watershed have been conducted by the U.S. Army Corps of Engineers and the Pennsylvania Department of Environmental Resources. These investigations produced similar findings concerning the causes of the reported problems.

Recently, a stream bank protection project has been completed by the Corps of Engineers in the vicinity of Mooney Road. Also, a privately owned culvert has been replaced at 3632 West Run Road by the owner of the property. Otherwise, the various federal and state agencies which have reviewed the situation have concluded that they cannot participate in financing improvements.

There is little potential for effectively addressing the identified flooding and erosion/sedimentation problems through the construction and operation of regional distributed storage facilities. The areas upstream of the reported problems are mature, extensively developed neighborhoods with little open space suitable for occupation by storage facilities large enough to materially affect stream flows during larger floods.

There are two general avenues through which the stream flow related problems of flooding and erosion and sedimentation in the West Run watershed can be addressed (the water quality problems are issues separate from the scope of this investigation).

The first set of actions relate to the on-going maintenance of the stream channel and the prohibition of activities which accelerate erosion and sedimentation. Specifically, these actions consist of a formalized program consisting of the following:

- Routine inspections of the channel and obstructions to identify the accumulation of debris;
- Routine removal of debris to maintain a clear channel and open culverts;
- On-going monitoring of earth moving and construction activities and the effective prohibition of encroachments into

the stream channel and activities which accelerate soil erosion and sedimentation;

- Effective and frequent street and catchbasin cleaning to reduce the amount of street debris entering the stream;

- Vegetating road embankments which are subject to erosion to reduce the sediment load on the stream.

These actions are relatively non-capital intensive in that they do not include construction aspects. They do, however, entail a commitment of manpower and equipment on a routine, scheduled or as-needed basis to clear debris from the stream channel and obstructions and perform other housecleaning and maintenance items. These actions also require a commitment of the affected government agencies, municipal, county and state to monitor activities in the watershed and prohibit those which accelerate erosion and sedimentation, encroach on the stream channel or otherwise reduce channel capacity.

The second set of actions includes capital intensive, remedial actions designed to restore / increase the capacity of the channel and obstructions and protect bank sections subject to erosion. The following course of action should be considered in order to move forward toward implementing cost effective stream channel / bank improvements:

1. Conduct a detailed Flood and Erosion Protection Study of the entire length of the watershed. This will include the following activities:

   - Compilation of an exhaustive inventory of current and developing problems in the watershed. This should include a detailed survey of the stream channel and interviews with municipal officials and property owners.

   - Development of a damage assessment defining the cost of flooding and erosion damages.

   - Utilization of the U.S. Army Corps of Engineers' HEC - 2 "Water Surface Profiles" computer program to develop and evaluate alternative solutions to identified problems. Solutions to be considered should include channel dredging, channel improvements, replacement of culverts, stream bank protection and flood protection or relocation of structures. The hydraulic analysis should evaluate the effects of all improvement on downstream portions of the watershed.

   - Development of cost estimates for the identified optimal improvements.

- Completion of a cost - benefit analysis which ways the cost of improvements against the value of the benefits realized through the elimination of damage / problems.

A study such as the one described above is often prepared by the Commonwealth of Pennsylvania Department of Environmental Resources' Bureau of Water Projects. As indicated above, this agency has previously completed engineering reviews of various locations within the watershed and have concluded that they are unable to provide direct assistance. The agency may be approached again to complete a comprehensive investigation as outlined above. Failing that, other potential sponsors of the study should be explored, including the County and municipalities.

2. The results of the Feasibility Study should be discussed and considered by the public, the affected municipalities, the County and the State. The merits of the remedial actions should be considered in view of their cost. Potential funding options and cost sharing arrangements should be investigated and the agency(ies) responsible for project implementation should be identified. A joint decision should be reached as to which, if any, elements of the remedial project should be implemented.

3. If a decision is reached to implement the project, the identified responsible agency(ies) should proceed through the traditional public works process of design and construction.

APPENDIX B
MODEL OUTPUT SUMMARIES

Table B–1
Summary of Modeled Runoff and Discharge
Twenty–Four Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Mile 22 Stream	1	193	53	53	42	42	34	34	22	22	16	16	9	9
Mile 22 Stream	2	194	402	445	330	364	268	293	194	210	145	155	90	95
Mile 23.5 Stream	1	220	15	15	13	13	10	10	8	8	6	6	4	4
Mile 23.5 Stream	2	190	373	387	301	313	248	257	171	177	126	131	79	82
Mile 23.5 Stream	3	191	70	424	60	346	52	288	41	201	33	159	25	103
Mile 9.7 Stream	1	356	325	325	270	270	228	228	168	168	131	131	92	92
Mile 9.7 Stream	2	357	553	840	442	681	348	547	232	378	167	288	107	190
Mile 9.7 Stream	3	358	325	1,015	277	826	236	678	184	483	149	368	109	258
Becks Run	1	331	382	382	315	315	258	258	187	187	145	145	102	102
Becks Run	2	332	547	874	446	712	361	577	255	409	194	321	133	225
Becks Run	3	333	240	240	205	205	176	176	139	139	115	115	87	87
Becks Run	4	334	448	678	371	567	306	475	222	354	173	280	122	207
Becks Run	5	0	0	1,552	0	1,279	0	1,052	0	763	0	601	0	431
Becks Run	6	335	472	1,900	372	1,553	285	1,269	180	906	127	703	73	491
Becks Run	7	336	205	205	170	170	143	143	105	105	83	83	59	59
Becks Run	8	337	406	586	333	483	278	402	198	288	150	224	99	152
Becks Run	9	0	0	2,390	0	1,965	0	1,598	0	1,137	0	880	0	612
Becks Run	10	338	330	2,504	268	2,062	222	1,681	154	1,200	113	928	70	645
Beckets Run	1	11	8	8	6	6	5	5	3	3	2	2	1	1
Beckets Run	2	12	126	134	99	105	77	81	47	50	32	33	16	17
Beckets Run	3	13	194	299	152	239	115	178	68	108	45	72	22	37
Beckets Run	4	14	64	64	51	51	41	41	27	27	19	19	11	11
Beckets Run	5	15	242	298	190	237	144	182	86	110	56	72	28	37
Beckets Run	6	0	0	595	0	476	0	360	0	218	0	143	0	73
Beckets Run	7	16	100	665	80	527	65	401	44	248	31	165	18	86
Beckets Run	8	9	16	16	12	12	10	10	6	6	4	4	2	2
Beckets Run	9	10	162	176	125	135	101	110	64	69	44	47	23	25
Beckets Run	10	0	0	802	0	638	0	491	0	302	0	204	0	109

Table B–1
Summary of Modeled Runoff and Discharge
Twenty–Four Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Beckets Run	11	17	64	857	52	678	41	523	30	321	22	219	13	120
Beckets Run	12	6	18	18	15	15	12	12	9	9	7	7	5	5
Beckets Run	13	7	355	371	274	287	221	232	140	148	93	99	50	54
Beckets Run	14	0	0	1,133	0	892	0	689	0	429	0	302	0	168
Beckets Run	15	8	123	1,202	97	950	79	731	52	460	36	326	20	184
Beckets Run	16	3	43	43	34	34	27	27	18	18	12	12	7	7
Beckets Run	17	4	144	182	111	142	89	116	56	74	38	49	20	26
Beckets Run	18	1	23	23	16	16	11	11	6	6	4	4	2	2
Beckets Run	19	2	377	394	292	305	219	227	130	135	88	91	47	48
Beckets Run	20	0	0	575	0	447	0	343	0	208	0	140	0	74
Beckets Run	21	5	116	666	91	518	71	396	44	243	30	165	16	89
Beckets Run	22	0	0	1,841	0	1,437	0	1,101	0	671	0	471	0	268
Beckets Run	23	18	230	1,964	177	1,536	142	1,183	90	729	60	510	32	294
Beckets Run	24	19	19	19	16	16	13	13	10	10	7	7	5	5
Beckets Run	25	20	394	411	303	317	243	255	153	162	103	110	56	59
Beckets Run	26	21	10	10	8	8	6	6	4	4	3	3	2	2
Beckets Run	27	22	174	183	140	147	115	120	78	82	56	59	33	34
Beckets Run	28	0	0	594	0	464	0	370	0	244	0	168	0	93
Beckets Run	29	23	70	641	56	507	46	404	31	263	23	183	13	104
Beckets Run	30	0	0	2,474	0	1,930	0	1,475	0	931	0	648	0	383
Beckets Run	31	24	76	2,499	63	1,949	50	1,490	38	943	28	658	18	391
Belle Bridge Stream	1	196	20	20	16	16	12	12	7	7	5	5	3	3
Belle Bridge Stream	2	197	294	314	227	243	182	194	117	124	80	85	42	45
Belle Bridge Stream	3	198	49	49	36	36	26	26	15	15	10	10	5	5
Belle Bridge Stream	4	199	117	156	92	124	75	98	49	64	35	44	20	24
Belle Bridge Stream	5	0	0	470	0	366	0	293	0	187	0	129	0	69
Bunola Run	1	52	49	49	40	40	32	32	23	23	17	17	10	10
Bunola Run	2	53	182	223	146	181	120	149	82	103	59	74	34	43

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Table B–1
Summary of Modeled Runoff and Discharge
Twenty–Four Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Bunola Run	3	54	218	403	177	324	141	264	101	182	74	137	44	79
Bunola Run	4	55	122	122	98	98	75	75	47	47	32	32	17	17
Bunola Run	5	56	310	406	245	325	187	253	114	153	76	101	39	53
Bunola Run	6	0	0	809	0	648	0	517	0	335	0	239	0	132
Bunola Run	7	57	81	864	65	694	54	549	37	359	26	256	16	143
Bunola Run	8	58	24	24	19	19	16	16	10	10	7	7	4	4
Bunola Run	9	59	71	93	57	75	46	61	31	41	22	29	13	17
Bunola Run	10	0	0	937	0	756	0	590	0	387	0	278	0	157
Bunola Run	11	60	22	949	19	767	16	598	13	393	10	283	8	162
Coal Valley Run	1	208	58	58	47	47	39	39	28	28	21	21	14	14
Coal Valley Run	2	209	99	152	79	123	62	98	40	67	29	49	17	31
Coal Valley Run	3	210	389	515	311	409	243	327	161	219	117	160	75	100
Coal Valley Run	4	211	50	50	41	41	34	34	25	25	20	20	13	13
Coal Valley Run	5	212	215	261	177	217	149	182	108	132	83	101	55	67
Coal Valley Run	6	0	0	776	0	625	0	508	0	347	0	257	0	167
Coal Valley Run	7	213	34	798	28	645	23	524	16	359	12	265	7	172
Coal Valley Run	8	214	66	66	55	55	45	45	34	34	27	27	18	18
Coal Valley Run	9	215	77	138	63	114	52	95	39	70	30	54	19	36
Coal Valley Run	10	0	0	912	0	745	0	607	0	420	0	313	0	203
Coal Valley Run	11	216	128	979	103	800	85	653	58	454	42	340	25	220
Coal Valley Run	12	217	99	99	80	80	67	67	47	47	35	35	23	23
Coal Valley Run	13	218	122	211	96	169	78	140	51	95	35	70	20	43
Coal Valley Run	14	0	0	1,137	0	936	0	755	0	523	0	388	0	251
Coal Valley Run	15	219	147	1,212	117	996	96	802	64	555	45	411	25	266
Coal Valley Run	16	221	93	93	72	72	57	57	37	37	24	24	13	13
Coal Valley Run	17	222	135	215	105	169	84	136	55	90	37	60	20	33
Coal Valley Run	18	0	0	1,390	0	1,122	0	906	0	614	0	454	0	291
Coal Valley Run	19	223	342	1,536	276	1,245	227	999	154	682	111	506	66	325

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Table B–1
Summary of Modeled Runoff and Discharge
Twenty–Four Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Coal Valley Run	20	224	21	21	17	17	13	13	9	9	6	6	4	4
Coal Valley Run	21	225	262	281	206	220	165	177	108	116	76	81	43	46
Coal Valley Run	22	226	321	568	248	451	200	363	128	230	88	167	46	91
Coal Valley Run	23	227	228	720	179	565	144	448	94	291	65	213	37	122
Coal Valley Run	24	228	121	121	88	88	63	63	35	35	22	22	11	11
Coal Valley Run	25	229	164	244	134	191	111	154	77	102	57	71	34	41
Coal Valley Run	26	0	0	2,216	0	1,767	0	1,418	0	950	0	695	0	424
Coal Valley Run	27	230	12	2,219	17	1,770	15	1,420	12	952	10	696	7	425
Coal Valley Run	28	0	0	2,429	0	1,919	0	1,536	0	1,022	0	746	0	457
Courain Hill Stream	1	201	28	28	21	21	17	17	11	11	7	7	4	4
Courain Hill Stream	2	202	452	476	350	370	263	278	156	166	105	111	55	59
Courain Hill Stream	3	203	21	21	17	17	14	14	9	9	6	6	4	4
Courain Hill Stream	4	204	182	201	143	158	115	127	75	83	52	58	29	33
Courain Hill Stream	5	0	0	677	0	519	0	405	0	249	0	169	0	91
Courain Hill Stream	6	205	75	724	61	563	51	431	36	268	27	185	16	104
Crooked Run	1	362	65	65	54	54	46	46	35	35	27	27	19	19
Crooked Run	2	363	474	532	383	431	306	347	209	239	155	178	102	119
Crooked Run	3	364	392	872	314	711	248	566	169	388	124	288	83	189
Crooked Run	4	365	196	196	153	153	119	119	79	79	59	59	40	40
Crooked Run	5	366	288	445	232	351	190	283	130	200	94	145	59	94
Crooked Run	6	0	0	1,309	0	1,053	0	848	0	586	0	433	0	284
Crooked Run	7	367	697	1,689	561	1,356	443	1,089	296	754	213	559	137	363
Crooked Run	8	370	296	296	246	246	203	203	148	148	116	116	82	82
Crooked Run	9	371	58	355	50	295	42	246	33	181	26	142	19	101
Crooked Run	10	368	65	65	51	51	41	41	26	26	18	18	10	10
Crooked Run	11	369	213	270	177	222	149	187	109	133	85	101	59	67
Crooked Run	12	0	0	0	0	0	0	0	0	314	0	0	0	0
Crooked Run	13	372	133	133	112	112	94	94	72	385	57	57	40	40

CHESTER ENVIRONMENTAL

Table B–1
Summary of Modeled Runoff and Discharge
Twenty–Four Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Crooked Run	14	0	0	1,737	0	1,398	0	1,125	0	1,034	0	581	0	391
Crooked Run	15	373	87	1,760	74	1,419	63	1,143	49	1,057	40	592	29	410
Crooked Run	16	374	21	21	17	17	15	15	11	11	9	9	6	6
Crooked Run	17	375	307	326	256	272	215	228	162	172	128	135	90	95
Crooked Run	18	376	236	541	198	451	166	379	126	282	100	223	71	156
Crooked Run	19	0	0	2,197	0	1,781	0	1,440	0	1,315	0	759	0	560
Crooked Run	20	377	213	2,261	182	1,838	156	1,489	123	1,355	101	793	74	586
Curry Hollow Run	1	233	153	153	133	133	117	117	94	94	80	80	64	64
Curry Hollow Run	2	234	525	676	420	551	341	456	232	326	170	248	108	171
Curry Hollow Run	3	235	534	1,114	432	921	342	739	230	512	166	380	105	256
Curry Hollow Run	4	236	112	112	92	92	76	76	55	55	42	42	29	29
Curry Hollow Run	5	237	149	251	123	207	103	171	74	122	56	95	36	64
Curry Hollow Run	6	0	0	1,365	0	1,118	0	903	0	635	0	475	0	319
Curry Hollow Run	7	238	99	1,428	82	1,168	67	940	50	662	38	496	24	338
Homestead Run	1	269	214	214	178	178	151	151	112	112	90	90	65	65
Homestead Run	2	270	390	579	322	479	269	400	194	291	150	231	103	163
Homestead Run	3	271	359	853	294	701	245	586	175	421	134	332	91	228
Homestead Run	4	272	241	241	194	194	155	155	106	106	78	78	51	51
Homestead Run	5	273	237	451	194	367	158	295	111	203	84	157	57	105
Homestead Run	6	274	461	868	373	699	303	563	217	394	168	308	120	219
Homestead Run	7	275	247	1,026	205	841	173	686	127	487	99	380	68	270
Homestead Run	8	0	0	1,869	0	1,523	0	1,260	0	908	0	712	0	495
Homestead Run	9	276	633	2,131	525	1,741	441	1,440	321	1,051	248	828	170	575
Homestead Run	10	277	36	2,138	31	1,747	27	1,445	22	1,055	19	832	15	578
Kelly Run	1	40	21	21	16	16	13	13	8	8	6	6	3	3
Kelly Run	2	41	325	344	259	275	199	211	125	132	84	89	45	48
Kelly Run	3	42	15	15	12	12	9	9	6	6	4	4	2	2
Kelly Run	4	43	242	255	189	199	152	160	98	102	67	70	36	38

CHESTER ENVIRONMENTAL

Table B–1
Summary of Modeled Runoff and Discharge
Twenty–Four Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Kelly Run	5	0	0	599	0	468	0	371	0	234	0	159	0	85
Kelly Run	6	44	362	885	285	691	216	536	129	337	85	230	42	125
Kelly Run	7	45	129	970	102	755	79	585	48	369	32	253	17	139
Kelly Run	8	46	139	139	104	104	77	77	45	45	28	28	14	14
Kelly Run	9	47	128	241	101	187	82	146	54	96	38	63	21	33
Kelly Run	10	0	0	1,191	0	932	0	702	0	441	0	306	0	170
Kelly Run	11	48	403	1,403	317	1,109	257	849	166	535	115	382	62	218
Kelly Run	12	49	43	43	34	34	27	27	18	18	13	13	7	7
Kelly Run	13	50	130	165	106	136	84	107	60	76	44	55	26	32
Kelly Run	14	0	0	1,487	0	1,169	0	900	0	567	0	410	0	239
Kelly Run	15	51	286	1,660	228	1,298	174	1,002	108	641	72	460	38	271
Lobbs Run	1	156	68	68	48	48	34	34	19	19	12	12	7	7
Lobbs Run	2	157	45	111	36	82	27	61	17	36	12	24	6	13
Lobbs Run	3	158	42	42	33	33	26	26	16	16	11	11	6	6
Lobbs Run	4	159	151	188	119	147	96	119	63	77	44	53	24	28
Lobbs Run	5	0	0	298	0	228	0	180	0	112	0	76	0	41
Lobbs Run	6	160	179	456	131	345	95	261	55	160	35	109	17	57
Lobbs Run	7	161	31	31	24	24	19	19	12	12	8	8	4	4
Lobbs Run	8	162	203	230	159	179	128	145	83	93	57	64	30	34
Lobbs Run	9	0	0	672	0	512	0	398	0	242	0	171	0	89
Lobbs Run	10	163	135	777	98	591	70	457	40	278	25	194	12	100
Lobbs Run	11	381	14	14	11	11	9	9	6	6	4	4	2	2
Lobbs Run	12	380	130	143	102	112	82	91	54	59	37	41	20	22
Lobbs Run	13	0	0	886	0	682	0	520	0	322	0	226	0	121
Lobbs Run	14	164	75	924	58	713	47	543	31	341	21	239	12	130
Lobbs Run	15	165	12	12	9	9	7	7	5	5	4	4	2	2
Lobbs Run	16	166	124	135	98	106	80	87	54	58	38	41	21	23
Lobbs Run	17	0	0	1,007	0	772	0	587	0	376	0	263	0	149

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Table B–1
Summary of Modeled Runoff and Discharge
Twenty–Four Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Lobbs Run	18	167	88	1,043	70	798	58	609	38	393	28	275	15	159
Lobbs Run	19	168	37	37	29	29	22	22	14	14	9	9	5	5
Lobbs Run	20	379	158	195	124	152	96	118	59	72	39	48	20	24
Lobbs Run	21	384	17	17	13	13	11	11	7	7	5	5	3	3
Lobbs Run	22	385	352	369	271	285	218	228	138	145	92	97	49	52
Lobbs Run	23	0	0	1,385	0	1,056	0	806	0	524	0	374	0	222
Lobbs Run	24	169	231	1,536	178	1,181	142	902	89	576	61	416	33	249
Lobbs Run	25	170	65	65	51	51	40	40	25	25	16	16	9	9
Lobbs Run	26	171	112	167	91	133	73	106	53	77	39	55	24	31
Lobbs Run	27	0	0	1,670	0	1,290	0	989	0	631	0	457	0	273
Lobbs Run	28	172	126	1,731	101	1,341	82	1,032	55	662	39	481	22	288
Lobbs Run	29	173	24	24	20	20	17	17	12	12	9	9	6	6
Lobbs Run	30	174	81	103	66	85	55	71	38	50	28	37	17	23
Lobbs Run	31	175	51	51	41	41	31	31	20	20	14	14	8	8
Lobbs Run	32	176	74	118	61	94	49	75	36	55	26	39	16	23
Lobbs Run	33	0	0	221	0	179	0	145	0	104	0	76	0	46
Lobbs Run	34	177	308	496	241	399	183	313	110	200	72	142	38	81
Lobbs Run	35	178	22	22	17	17	13	13	8	8	6	6	3	3
Lobbs Run	36	179	62	81	50	65	41	53	28	36	20	25	11	14
Lobbs Run	37	0	0	574	0	460	0	363	0	236	0	165	0	94
Lobbs Run	38	180	22	595	18	476	15	375	11	245	8	172	5	98
Lobbs Run	39	181	43	43	33	33	27	27	17	17	11	11	6	6
Lobbs Run	40	182	116	153	92	124	75	99	51	67	36	47	20	26
Lobbs Run	41	0	0	749	0	592	0	471	0	312	0	219	0	122
Lobbs Run	42	183	112	823	91	663	75	520	52	345	38	245	23	142
Lobbs Run	43	0	0	2,454	0	1,921	0	1,494	0	975	0	703	0	416
Lobbs Run	44	184	282	2,579	217	2,021	174	1,577	111	1,036	74	748	40	444
Lobbs Run	45	185	32	32	27	27	22	22	17	17	13	13	9	9

CHESTER ENVIRONMENTAL

Table B–1
Summary of Modeled Runoff and Discharge
Twenty–Four Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Lobbs Run	46	186	72	103	58	83	47	68	32	48	23	36	13	21
Lobbs Run	47	0	0	2,617	0	2,050	0	1,602	0	1,055	0	764	0	455
Lobbs Run	48	187	308	2,718	249	2,132	204	1,672	141	1,110	103	808	65	485
Mill Run	1	66	47	47	37	37	28	28	17	17	11	11	6	6
Mill Run	2	67	171	215	135	172	102	129	61	77	40	51	20	25
Mill Run	3	64	191	191	140	140	102	102	58	58	36	36	18	18
Mill Run	4	65	156	324	124	242	95	181	59	113	40	73	21	38
Mill Run	5	0	0	529	0	414	0	308	0	190	0	123	0	63
Mill Run	6	68	267	763	193	583	140	434	77	262	49	171	23	86
Mill Run	7	69	24	24	20	20	16	16	11	11	8	8	5	5
Mill Run	8	70	142	164	112	129	91	105	61	71	42	49	24	28
Mill Run	9	0	0	890	0	683	0	510	0	317	0	215	0	111
Mill Run	10	71	212	1,037	166	783	133	591	86	369	59	258	31	138
Mill Run	11	72	76	76	57	57	42	42	25	25	16	16	8	8
Mill Run	12	73	336	389	259	296	208	239	132	149	88	98	48	53
Mill Run	13	0	0	1,350	0	1,035	0	783	0	487	0	342	0	187
Mill Run	14	74	192	1,467	149	1,130	120	862	77	540	52	378	28	210
Mill Run	15	75	34	34	28	28	23	23	16	16	12	12	8	8
Mill Run	16	76	105	136	81	107	65	87	41	57	28	40	15	22
Mill Run	17	77	23	23	18	18	14	14	9	9	7	7	4	4
Mill Run	18	78	83	104	64	81	52	66	33	42	23	29	12	16
Mill Run	19	0	0	241	0	188	0	153	0	99	0	69	0	38
Mill Run	20	79	190	388	146	307	117	241	73	151	49	109	26	61
Mill Run	21	0	0	1,842	0	1,407	0	1,096	0	690	0	486	0	270
Mill Run	22	80	388	2,040	299	1,564	241	1,230	152	784	103	557	53	314
Mill Run	23	81	41	41	32	32	26	26	17	17	11	11	6	6
Mill Run	24	82	419	452	330	358	249	270	151	164	98	106	50	54
Mill Run	25	0	0	2,276	0	1,778	0	1,388	0	893	0	636	0	361

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Table B–1
Summary of Modeled Runoff and Discharge
Twenty–Four Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Mill Run	26	83	251	2,400	198	1,879	160	1,463	106	949	73	679	41	390
Mill Run	27	84	20	20	16	16	13	13	9	9	6	6	4	4
Mill Run	28	85	46	65	37	52	30	43	20	29	15	21	8	12
Mill Run	29	86	13	13	10	10	8	8	6	6	4	4	2	2
Mill Run	30	87	66	78	53	63	43	51	29	34	21	25	12	14
Mill Run	31	0	0	143	0	115	0	94	0	64	0	45	0	26
Mill Run	32	88	353	474	274	370	222	302	142	197	97	134	51	71
Mill Run	33	0	0	2,801	0	2,151	0	1,667	0	1,073	0	773	0	452
Mill Run	34	89	64	2,820	49	2,171	41	1,680	30	1,081	22	780	14	457
River Hill Stream	1	36	45	45	36	36	27	27	17	17	11	11	6	6
River Hill Stream	2	37	133	172	105	138	80	107	50	67	33	44	18	24
River Hill Stream	3	38	428	533	337	440	253	334	154	199	100	128	52	68
Smiths Run	1	94	27	27	21	21	16	16	10	10	7	7	4	4
Smiths Run	2	95	161	183	130	148	108	121	75	82	55	59	34	36
Sunfish Run	1	25	16	16	12	12	9	9	6	6	4	4	2	2
Sunfish Run	2	26	622	633	478	485	382	387	238	241	160	162	86	86
Sunfish Run	3	27	141	758	112	581	86	455	52	285	35	192	18	103
Sunfish Run	4	28	30	30	24	24	18	18	11	11	7	7	4	4
Sunfish Run	5	29	168	194	132	151	103	118	63	72	42	48	21	24
Sunfish Run	6	0	0	923	0	716	0	556	0	345	0	234	0	127
Sunfish Run	7	30	298	1,084	230	855	186	658	118	415	79	284	42	161
Sunfish Run	8	31	51	51	41	41	32	32	20	20	13	13	7	7
Sunfish Run	9	32	211	254	168	200	135	160	90	107	63	74	35	40
Sunfish Run	10	0	0	1,277	0	993	0	768	0	485	0	334	0	195
Sunfish Run	11	33	16	1,283	11	998	9	771	7	487	6	336	4	196
Streets Run	1	278	126	126	111	111	96	96	76	76	62	62	45	45
Streets Run	2	279	220	333	179	282	146	228	104	153	80	130	56	99
Streets Run	3	280	492	492	392	392	313	313	217	217	164	164	114	114

Table B–1
Summary of Modeled Runoff and Discharge
Twenty–Four Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Streets Run	4	281	269	699	225	565	190	461	142	332	111	258	78	185
Streets Run	5	0	0	1,165	0	940	0	773	0	545	0	416	0	299
Streets Run	6	282	385	1,451	312	1,168	250	947	174	669	132	511	91	369
Streets Run	7	283	203	203	168	168	138	138	99	99	77	77	55	55
Streets Run	8	284	246	421	202	344	168	284	120	203	91	158	60	108
Streets Run	9	0	0	1,831	0	1,478	0	1,199	0	848	0	652	0	470
Streets Run	10	285	461	2,147	379	1,736	315	1,413	227	1,005	177	777	124	553
Streets Run	11	286	462	2,465	365	1,988	290	1,619	198	1,149	148	885	101	624
Streets Run	12	287	576	576	494	494	427	427	337	337	279	279	218	218
Streets Run	13	288	420	945	347	794	290	673	212	511	164	414	115	307
Streets Run	14	0	0	3,304	0	2,710	0	2,224	0	1,602	0	1,275	0	908
Streets Run	15	289	138	3,366	109	2,761	89	2,268	59	1,634	41	1,300	23	923
Streets Run	16	290	136	136	114	114	97	97	73	73	58	58	42	42
Streets Run	17	291	538	660	439	541	362	452	255	322	192	245	128	167
Streets Run	18	292	317	317	265	265	224	224	167	167	132	132	95	95
Streets Run	19	293	220	514	178	424	146	354	101	258	74	197	47	136
Streets Run	20	0	0	1,173	0	964	0	803	0	575	0	440	0	301
Streets Run	21	294	475	1,431	376	1,175	289	975	183	694	129	527	74	353
Streets Run	22	0	0	4,797	0	3,936	0	3,243	0	2,328	0	1,827	0	1,277
Streets Run	23	295	143	4,855	112	3,984	89	3,284	58	2,358	40	1,849	23	1,291
Streets Run	24	296	479	479	406	406	346	346	267	267	225	225	170	170
Streets Run	25	297	539	947	446	788	373	662	272	497	210	400	146	283
Streets Run	26	0	0	5,433	0	4,470	0	3,701	0	2,683	0	2,117	0	1,484
Streets Run	27	298	103	5,458	86	4,490	72	3,718	55	2,697	44	2,129	31	1,493
Streets Run	28	299	52	52	44	44	37	37	28	28	22	22	15	15
Streets Run	29	300	303	354	248	290	206	242	147	174	113	133	77	91
Streets Run	30	301	570	837	458	672	374	547	258	379	190	303	122	198
Streets Run	31	0	0	6,006	0	4,920	0	4,044	0	2,944	0	2,291	0	1,604

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Table B–1
Summary of Modeled Runoff and Discharge
Twenty–Four Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Streets Run	32	302	199	6,071	161	4,976	132	4,092	90	2,979	65	2,317	39	1,622
Streets Run	33	303	40	40	32	32	24	24	15	15	10	10	6	6
Streets Run	34	304	131	164	105	131	86	105	58	69	42	50	25	29
Streets Run	35	0	0	6,129	0	5,024	0	4,133	0	3,009	0	2,339	0	1,636
Streets Run	36	305	315	6,275	237	5,145	177	4,230	105	3,074	73	2,386	40	1,664
Streets Run	37	306	86	86	70	70	57	57	40	40	30	30	20	20
Streets Run	38	307	519	592	415	473	324	371	211	243	151	177	92	108
Streets Run	39	308	121	121	101	101	83	83	61	61	47	47	34	34
Streets Run	40	309	355	461	277	366	212	291	132	189	92	137	50	82
Streets Run	41	0	0	1,052	0	837	0	658	0	432	0	314	0	189
Streets Run	42	310	248	1,261	195	1,001	150	787	95	512	66	367	36	221
Streets Run	43	0	0	6,831	0	5,609	0	4,621	0	3,357	0	2,581	0	1,795
Streets Run	44	311	170	6,871	141	5,644	116	4,651	87	3,381	67	2,600	44	1,809
Streets Run	45	312	95	95	70	70	50	50	29	29	18	18	9	9
Streets Run	46	313	66	140	55	107	45	82	34	58	26	41	17	24
Streets Run	47	314	193	193	158	158	130	130	93	93	72	72	51	51
Streets Run	48	315	180	355	147	289	122	238	86	169	65	131	43	92
Streets Run	49	316	515	830	390	646	297	505	186	331	134	255	83	166
Streets Run	50	317	531	1,118	415	875	318	691	195	465	130	346	71	224
Streets Run	51	0	0	7,718	0	6,328	0	5,217	0	3,752	0	2,857	0	1,971
Streets Run	52	318	145	7,745	125	6,351	108	5,238	85	3,767	71	2,869	53	1,981
Thompson Run	1	240	1,102	1,102	927	927	780	780	590	590	474	474	352	352
Thompson Run	2	241	1,242	2,263	996	1,852	804	1,525	569	1,113	437	882	312	634
Thompson Run	3	242	423	2,626	321	2,126	246	1,731	157	1,243	113	973	74	694
Thompson Run	4	243	119	119	98	98	81	81	58	58	45	45	32	32
Thompson Run	5	244	45	154	35	127	28	104	18	73	13	56	7	38
Thompson Run	6	246	19	19	16	16	13	13	10	10	8	8	5	5
Thompson Run	7	245	53	71	42	58	35	48	24	33	17	25	11	16

CHESTER ENVIRONMENTAL

Table B–1
Summary of Modeled Runoff and Discharge
Twenty–Four Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Thompson Run	8	0	0	224	0	182	0	150	0	106	0	79	0	54
Thompson Run	9	247	123	326	97	263	73	212	46	142	31	104	16	69
Thompson Run	10	248	256	535	209	435	169	342	118	230	88	179	60	120
Thompson Run	11	0	0	3,149	0	2,545	0	2,066	0	1,472	0	1,137	0	812
Thompson Run	12	249	152	3,222	126	2,607	106	2,118	77	1,511	59	1,165	40	833
Thompson Run	13	250	71	71	57	57	47	47	32	32	24	24	15	15
Thompson Run	14	251	219	279	172	222	139	181	90	120	62	84	35	49
Thompson Run	15	0	0	3,408	0	2,755	0	2,238	0	1,596	0	1,226	0	871
Thompson Run	16	252	197	3,491	161	2,826	134	2,297	95	1,641	72	1,262	48	895
Thompson Run	17	253	34	34	27	27	22	22	15	15	11	11	6	6
Thompson Run	18	254	110	141	87	112	70	91	46	61	33	43	19	24
Thompson Run	19	255	93	93	76	76	62	62	45	45	34	34	24	24
Thompson Run	20	256	142	226	116	184	96	151	68	108	51	83	32	54
Thompson Run	21	0	0	367	0	296	0	243	0	169	0	125	0	79
Thompson Run	22	257	54	402	44	329	36	269	25	186	18	138	11	87
Thompson Run	23	0	0	3,780	0	3,061	0	2,476	0	1,763	0	1,360	0	951
Thompson Run	24	258	798	4,119	655	3,347	534	2,719	379	1,935	290	1,502	200	1,043
Thompson Run	25	259	130	130	109	109	92	92	69	69	55	55	40	40
Thompson Run	26	260	655	759	546	643	461	542	342	402	270	317	192	226
Thompson Run	27	0	0	4,422	0	3,621	0	2,946	0	2,101	0	1,643	0	1,137
Thompson Run	28	261	152	4,458	131	3,653	113	2,975	90	2,124	75	1,662	58	1,152
Thompson Run	29	262	607	4,647	519	3,816	446	3,118	352	2,236	290	1,757	221	1,229
Fallen Timber Run	1	97	25	25	20	20	15	15	9	9	6	6	3	3
Fallen Timber Run	2	98	231	253	181	199	139	152	86	93	58	62	30	32
Fallen Timber Run	3	99	32	32	25	25	20	20	13	13	9	9	5	5
Fallen Timber Run	4	100	71	100	59	81	47	65	34	47	25	34	15	20
Fallen Timber Run	5	0	0	352	0	277	0	216	0	139	0	96	0	52
Fallen Timber Run	6	101	404	693	323	557	249	423	155	273	103	187	54	101

CHESTER ENVIRONMENTAL

Table B–1
Summary of Modeled Runoff and Discharge
Twenty–Four Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Fallen Timber Run	35	0	0	3,735	0	2,971	0	2,168	0	1,552	0	1,155	0	731
Fallen Timber Run	36	123	123	3,774	101	3,005	83	2,197	61	1,573	46	1,172	30	744
Fallen Timber Run	37	124	44	44	35	35	28	28	19	19	13	13	8	8
Fallen Timber Run	38	125	93	132	76	107	63	89	44	61	32	45	20	27
Fallen Timber Run	39	0	0	3,821	0	3,045	0	2,231	0	1,597	0	1,192	0	757
Fallen Timber Run	40	126	165	3,848	111	3,068	95	2,251	74	1,613	60	1,206	44	768
Fallen Timber Run	41	127	69	69	56	56	46	46	33	33	25	25	15	15
Fallen Timber Run	42	128	135	194	112	160	93	132	70	99	55	75	36	48
Fallen Timber Run	43	0	0	3,903	0	3,116	0	2,292	0	1,644	0	1,232	0	787
Fallen Timber Run	44	129	15	3,912	12	3,123	10	2,299	8	1,649	6	1,236	5	790
West Run	1	319	123	123	103	103	88	88	66	66	52	52	37	37
West Run	2	320	145	261	121	217	102	184	76	137	60	107	42	78
West Run	3	321	85	85	68	68	55	55	37	37	27	27	17	17
West Run	4	322	32	108	26	87	21	70	16	49	12	36	8	24
West Run	5	0	0	368	0	303	0	252	0	183	0	143	0	100
West Run	6	323	94	432	79	357	66	300	51	219	40	171	28	120
West Run	7	324	581	866	485	719	411	602	306	446	241	365	169	262
West Run	8	325	168	168	127	127	98	98	63	63	45	45	30	30
West Run	9	326	220	348	182	277	154	225	112	163	87	123	59	84
West Run	10	0	0	1,213	0	996	0	828	0	609	0	488	0	346
West Run	11	327	425	1,491	347	1,224	288	1,012	204	745	154	593	103	414
West Run	12	328	65	1,506	57	1,237	50	1,024	41	755	35	601	28	421
Wylie Run	1	131	61	61	49	49	38	38	25	25	18	18	11	11
Wylie Run	2	132	301	362	226	275	169	207	101	126	66	84	35	46
Wylie Run	3	133	36	36	28	28	23	23	15	15	10	10	6	6
Wylie Run	4	134	157	191	123	151	95	117	59	74	40	51	22	28
Wylie Run	5	135	139	312	110	248	85	189	53	119	37	85	21	47
Wylie Run	6	0	0	673	0	523	0	396	0	241	0	169	0	93

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Table B–1
Summary of Modeled Runoff and Discharge
Twenty–Four Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Fallen Timber Run	7	102	37	37	28	28	22	22	14	14	10	10	6	6
Fallen Timber Run	8	103	168	199	130	153	105	125	67	79	45	53	24	29
Fallen Timber Run	9	0	0	883	0	706	0	547	0	352	0	237	0	128
Fallen Timber Run	10	104	132	985	103	780	82	607	53	392	36	263	20	144
Fallen Timber Run	11	105	29	29	23	23	18	18	12	12	9	9	5	5
Fallen Timber Run	12	106	248	273	197	216	160	176	107	117	75	82	42	46
Fallen Timber Run	13	0	0	1,205	0	960	0	741	0	486	0	331	0	184
Fallen Timber Run	14	107	228	1,334	185	1,057	153	818	107	540	78	374	49	218
Fallen Timber Run	15	110	10	10	7	7	6	6	4	4	3	3	1	1
Fallen Timber Run	16	111	57	66	46	53	37	43	25	29	18	20	10	11
Fallen Timber Run	17	108	39	39	31	31	25	25	16	16	11	11	6	6
Fallen Timber Run	18	109	382	419	287	315	215	238	128	142	86	95	45	49
Fallen Timber Run	19	0	0	479	0	364	0	278	0	171	0	115	0	61
Fallen Timber Run	20	112	273	719	211	548	157	414	92	250	61	172	31	90
Fallen Timber Run	21	0	0	2,034	0	1,570	0	1,219	0	769	0	517	0	304
Fallen Timber Run	22	113	39	2,050	33	1,584	28	1,231	22	779	18	524	13	311
Fallen Timber Run	23	114	102	102	76	76	56	56	34	34	22	22	12	12
Fallen Timber Run	24	115	341	412	264	315	213	254	135	159	92	107	48	56
Fallen Timber Run	25	116	21	21	17	17	13	13	9	9	6	6	3	3
Fallen Timber Run	26	117	395	412	341	355	296	306	234	240	199	202	153	154
Fallen Timber Run	27	0	0	2,707	0	2,111	0	1,662	0	1,063	0	780	0	481
Fallen Timber Run	28	118	152	2,813	121	2,196	98	1,730	65	1,110	45	815	27	502
Fallen Timber Run	29	122	398	398	333	333	14	14	209	209	167	167	123	123
Fallen Timber Run	30	382	250	596	197	485	279	293	105	293	74	223	41	156
Fallen Timber Run	31	0	0	3,374	0	2,673	0	1,947	0	1,394	0	1,037	0	658
Fallen Timber Run	32	119	266	3,486	213	2,771	174	2,020	117	1,449	83	1,080	50	687
Fallen Timber Run	33	120	73	73	55	55	41	41	24	24	16	16	8	8
Fallen Timber Run	34	121	344	402	264	307	212	247	134	153	89	101	47	53

CHESTER ENVIRONMENTAL

Table B-1
Summary of Modeled Runoff and Discharge
Twenty-Four Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Wylie Run	7	136	480	929	377	726	294	564	183	359	122	265	65	148
Wylie Run	8	137	144	987	113	774	91	603	59	401	41	290	23	165
Wylie Run	9	140	31	31	25	25	19	19	11	11	7	7	4	4
Wylie Run	10	141	341	365	267	284	215	230	139	147	96	101	51	53
Wylie Run	11	138	121	121	96	96	75	75	49	49	35	35	22	22
Wylie Run	12	139	446	534	353	428	283	344	187	227	130	158	75	93
Wylie Run	13	0	0	899	0	711	0	573	0	374	0	259	0	146
Wylie Run	14	142	96	968	77	775	62	616	42	404	29	281	17	157
Wylie Run	15	143	36	36	28	28	23	23	15	15	10	10	5	5
Wylie Run	16	144	186	217	148	172	119	137	80	92	56	64	31	35
Wylie Run	17	145	207	384	163	302	132	247	87	156	60	114	33	64
Wylie Run	18	0	0	1,332	0	1,077	0	853	0	559	0	393	0	220
Wylie Run	19	146	24	1,349	19	1,091	16	865	11	565	8	399	5	224
Wylie Run	20	386	183	183	145	145	116	116	81	81	62	62	44	44
Wylie Run	21	387	399	502	323	399	267	322	195	228	155	177	109	123
Wylie Run	22	0	0	1,846	0	1,480	0	1,179	0	787	0	569	0	343
Wylie Run	23	147	105	1,914	84	1,525	68	1,216	45	811	32	588	18	356
Wylie Run	24	150	38	38	29	29	24	24	15	15	10	10	6	6
Wylie Run	25	151	331	361	256	279	206	225	130	141	88	95	47	50
Wylie Run	26	148	25	25	20	20	17	17	12	12	9	9	5	5
Wylie Run	27	149	103	127	83	103	66	82	48	59	35	43	20	25
Wylie Run	28	0	0	2,275	0	1,803	0	1,436	0	953	0	694	0	423
Wylie Run	29	152	295	2,399	232	1,920	187	1,523	123	1,013	86	741	49	455
Wylie Run	30	0	0	3,384	0	2,666	0	2,103	0	1,401	0	1,020	0	615
Wylie Run	31	153	252	3,480	205	2,755	169	2,173	118	1,451	89	1,063	58	644
Wylie Run	32	154	51	3,487	45	2,760	38	2,178	29	1,455	24	1,066	18	646
Mile 24 Stream	1	91	20	20	15	15	12	12	8	8	6	6	3	3
Mile 24 Stream	2	92	173	191	139	153	114	124	77	84	55	59	32	34

Table B–1
Summary of Modeled Runoff and Discharge
Twenty–Four Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Mile 5 Stream	1	378	22	22	19	19	14	14	10	10	7	7	5	5
Mile 5 Stream	2	388	155	168	122	131	99	113	66	72	46	51	26	29

CHESTER ENVIRONMENTAL

Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Mile 22 Stream	1	193	48	48	38	38	30	30	20	20	14	14	8	8
Mile 22 Stream	2	194	376	413	304	333	251	272	175	189	131	140	83	88
Mile 23.5 Stream	1	220	14	14	12	12	10	10	7	7	5	5	3	3
Mile 23.5 Stream	2	190	342	355	278	289	223	232	155	161	116	120	75	78
Mile 23.5 Stream	3	191	69	391	58	323	50	262	39	184	32	147	24	98
Mile 9.7 Stream	1	356	307	307	212	212	212	212	156	156	123	123	88	88
Mile 9.7 Stream	2	357	497	770	314	497	314	497	215	349	158	273	104	183
Mile 9.7 Stream	3	358	316	929	225	619	225	619	175	460	142	351	105	253
Becks Run	1	331	355	355	290	290	238	238	174	174	137	137	99	99
Becks Run	2	332	506	801	409	649	330	527	237	380	184	309	130	219
Becks Run	3	333	234	234	200	200	172	172	134	134	110	110	84	84
Becks Run	4	334	416	639	344	533	283	445	208	333	164	266	119	200
Becks Run	5	0	0	1,440	0	1,182	0	972	0	714	0	573	0	419
Becks Run	6	335	419	1,755	331	1,431	255	1,168	166	846	121	667	71	476
Becks Run	7	336	193	193	161	161	133	133	99	99	78	78	57	57
Becks Run	8	337	379	547	308	445	256	369	184	267	141	211	96	147
Becks Run	9	0	0	2,188	0	1,795	0	1,469	0	1,066	0	833	0	593
Becks Run	10	338	307	2,297	245	1,887	204	1,548	142	1,126	105	879	67	624
Beckets Run	1	11	8	8	6	6	4	4	3	3	2	2	1	1
Beckets Run	2	12	112	119	90	95	69	73	43	46	29	30	15	16
Beckets Run	3	13	171	266	136	211	102	165	63	101	41	66	22	35
Beckets Run	4	14	58	58	45	45	37	37	24	24	17	17	10	10
Beckets Run	5	15	211	260	168	211	127	160	78	99	51	65	26	34
Beckets Run	6	0	0	525	0	422	0	324	0	200	0	130	0	69
Beckets Run	7	16	91	587	71	468	59	362	40	227	28	151	17	82
Beckets Run	8	9	14	14	11	11	9	9	5	5	4	4	2	2
Beckets Run	9	10	146	157	116	124	91	98	58	63	40	43	21	23
Beckets Run	10	0	0	724	0	564	0	435	0	277	0	188	0	103

Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Beckets Run	11	17	59	766	48	602	39	464	27	294	20	208	12	114
Beckets Run	12	6	17	17	14	14	11	11	8	8	6	6	4	4
Beckets Run	13	7	316	330	254	266	196	206	126	133	86	91	48	51
Beckets Run	14	0	0	1,019	0	790	0	616	0	393	0	286	0	160
Beckets Run	15	8	111	1,085	87	838	71	655	47	421	33	307	19	175
Beckets Run	16	3	39	39	31	31	24	24	16	16	11	11	6	6
Beckets Run	17	4	128	164	103	133	79	103	50	66	35	46	19	25
Beckets Run	18	1	21	21	15	15	11	11	6	6	4	4	2	2
Beckets Run	19	2	341	358	259	271	195	203	121	126	82	85	44	46
Beckets Run	20	0	0	517	0	405	0	307	0	191	0	130	0	70
Beckets Run	21	5	103	604	82	464	63	354	41	224	28	153	15	84
Beckets Run	22	0	0	1,644	0	1,285	0	972	0	620	0	432	0	254
Beckets Run	23	18	205	1,756	164	1,376	127	1,048	81	674	56	467	31	279
Beckets Run	24	19	18	18	15	15	12	12	9	9	7	7	4	4
Beckets Run	25	20	348	364	280	293	216	227	138	145	95	100	52	55
Beckets Run	26	21	9	9	7	7	6	6	4	4	3	3	1	1
Beckets Run	27	22	160	168	127	133	104	108	71	74	51	53	30	31
Beckets Run	28	0	0	532	0	420	0	328	0	219	0	153	0	86
Beckets Run	29	23	64	580	50	459	42	358	28	237	21	167	12	96
Beckets Run	30	0	0	2,202	0	1,710	0	1,315	0	859	0	600	0	363
Beckets Run	31	24	71	2,223	58	1,728	48	1,329	34	870	26	610	16	372
Belle Bridge Stream	1	196	18	18	14	14	11	11	7	7	5	5	2	2
Belle Bridge Stream	2	197	264	282	210	223	164	174	106	112	73	78	40	43
Belle Bridge Stream	3	198	44	44	33	33	24	24	14	14	10	10	4	4
Belle Bridge Stream	4	199	106	141	86	114	68	89	45	59	32	41	19	23
Belle Bridge Stream	5	0	0	423	0	337	0	264	0	171	0	119	0	65
Bunola Run	1	52	45	45	36	36	29	29	20	20	15	15	9	9
Bunola Run	2	53	166	206	132	162	107	135	73	91	53	66	31	39

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Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Bunola Run	3	54	201	362	159	290	131	238	90	158	66	120	39	72
Bunola Run	4	55	107	107	86	86	66	66	42	42	29	29	16	16
Bunola Run	5	56	271	353	217	293	165	222	103	137	69	92	37	50
Bunola Run	6	0	0	715	0	583	0	459	0	295	0	212	0	122
Bunola Run	7	57	75	762	59	618	49	488	33	316	24	228	15	133
Bunola Run	8	58	22	22	17	17	14	14	9	9	7	7	4	4
Bunola Run	9	59	65	86	51	67	42	55	28	37	20	27	12	15
Bunola Run	10	0	0	834	0	664	0	525	0	343	0	248	0	146
Bunola Run	11	60	22	846	18	675	16	532	12	348	10	253	7	151
Coal Valley Run	1	208	54	54	44	44	36	36	26	26	19	19	13	13
Coal Valley Run	2	209	90	138	72	112	56	89	37	62	27	46	17	29
Coal Valley Run	3	210	350	466	279	367	219	297	150	202	110	150	73	97
Coal Valley Run	4	211	47	47	39	39	32	32	24	24	18	18	13	13
Coal Valley Run	5	212	202	245	165	202	137	168	99	121	77	94	52	64
Coal Valley Run	6	0	0	703	0	570	0	463	0	321	0	240	0	161
Coal Valley Run	7	213	32	726	26	588	21	478	15	332	11	249	7	166
Coal Valley Run	8	214	62	62	52	52	43	43	32	32	25	25	17	17
Coal Valley Run	9	215	72	130	59	106	50	89	36	64	27	51	18	34
Coal Valley Run	10	0	0	836	0	682	0	556	0	389	0	292	0	196
Coal Valley Run	11	216	118	899	94	734	77	599	52	420	38	316	23	211
Coal Valley Run	12	217	91	91	75	75	61	61	43	43	33	33	23	23
Coal Valley Run	13	218	110	191	89	155	69	126	46	86	32	65	19	41
Coal Valley Run	14	0	0	1,042	0	850	0	689	0	479	0	361	0	240
Coal Valley Run	15	219	135	1,109	105	906	86	726	58	510	41	384	24	255
Coal Valley Run	16	221	83	83	66	66	51	51	33	33	23	23	13	13
Coal Valley Run	17	222	121	193	97	151	76	121	49	81	35	56	19	31
Coal Valley Run	18	0	0	1,263	0	1,018	0	819	0	566	0	425	0	279
Coal Valley Run	19	223	316	1,402	250	1,117	206	906	140	628	101	474	62	312

CHESTER ENVIRONMENTAL

Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Coal Valley Run	20	224	19	19	15	15	12	12	8	8	6	6	3	3
Coal Valley Run	21	225	236	252	189	202	148	158	98	105	70	74	41	44
Coal Valley Run	22	226	288	508	229	401	179	323	117	210	81	154	43	87
Coal Valley Run	23	227	206	646	165	508	129	402	86	268	61	197	35	115
Coal Valley Run	24	228	103	103	75	75	55	55	32	32	21	21	10	10
Coal Valley Run	25	229	153	215	122	174	101	138	70	93	52	66	32	38
Coal Valley Run	26	0	0	1,999	0	1,595	0	1,273	0	874	0	648	0	409
Coal Valley Run	27	230	12	2,002	16	1,597	15	1,275	12	875	10	650	7	410
Coal Valley Run	28	0	0	2,157	0	1,721	0	1,377	0	940	0	698	0	439
Courain Hill Stream	1	201	25	25	20	20	15	15	10	10	7	7	4	4
Courain Hill Stream	2	202	408	431	308	326	232	245	144	153	100	105	53	56
Courain Hill Stream	3	203	19	19	16	16	12	12	8	8	6	6	4	4
Courain Hill Stream	4	204	165	182	132	146	103	114	69	76	48	54	28	31
Courain Hill Stream	5	0	0	604	0	464	0	359	0	229	0	159	0	87
Courain Hill Stream	6	205	70	653	56	502	47	384	33	247	25	174	15	99
Crooked Run	1	362	62	62	52	52	44	44	32	32	26	26	18	18
Crooked Run	2	363	429	484	347	392	277	315	194	221	146	169	100	116
Crooked Run	3	364	357	803	283	640	226	512	157	359	118	274	82	186
Crooked Run	4	365	176	176	139	139	110	110	76	76	57	57	39	39
Crooked Run	5	366	265	401	216	323	172	259	119	187	88	138	57	92
Crooked Run	6	0	0	1,194	0	955	0	770	0	544	0	411	0	277
Crooked Run	7	367	629	1,536	507	1,232	400	989	274	700	202	529	132	354
Crooked Run	8	370	276	276	228	228	188	188	139	139	109	109	80	80
Crooked Run	9	371	56	332	48	275	41	228	31	169	25	134	19	98
Crooked Run	10	368	59	59	47	47	37	37	24	24	17	17	10	10
Crooked Run	11	369	201	251	166	209	139	172	102	123	80	95	56	64
Crooked Run	12	0	0	583	0	485	0	400	0	292	0	229	0	163
Crooked Run	13	372	128	711	106	591	90	491	67	360	53	282	38	201

CHESTER ENVIRONMENTAL

Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Crooked Run	14	0	0	2,055	0	1,675	0	1,358	0	966	0	744	0	547
Crooked Run	15	373	84	2,107	71	1,712	60	1,387	47	988	38	763	28	566
Crooked Run	16	374	20	20	16	16	14	14	10	10	8	8	6	6
Crooked Run	17	375	292	310	242	257	204	216	152	161	120	127	86	91
Crooked Run	18	376	225	510	187	425	158	354	118	263	94	208	68	150
Crooked Run	19	0	0	2,568	0	2,105	0	1,719	0	1,233	0	958	0	708
Crooked Run	20	377	208	2,631	177	2,161	150	1,767	118	1,272	96	991	71	733
Curry Hollow Run	1	233	153	153	133	133	116	116	93	93	79	79	63	63
Curry Hollow Run	2	234	478	628	387	517	308	422	213	306	159	236	105	167
Curry Hollow Run	3	235	484	1,020	389	836	308	671	211	475	156	360	103	253
Curry Hollow Run	4	236	104	104	86	86	70	70	51	51	40	40	28	28
Curry Hollow Run	5	237	140	234	114	190	95	157	68	113	52	89	34	61
Curry Hollow Run	6	0	0	1,246	0	1,019	0	827	0	588	0	448	0	313
Curry Hollow Run	7	238	93	1,308	76	1,059	64	860	46	613	35	468	23	330
Homestead Run	1	269	202	202	169	169	141	141	106	106	85	85	63	63
Homestead Run	2	270	365	541	303	448	249	370	181	272	141	218	100	157
Homestead Run	3	271	335	788	276	655	226	538	163	395	126	312	88	222
Homestead Run	4	272	218	218	176	176	141	141	98	98	74	74	50	50
Homestead Run	5	273	218	415	178	332	145	267	103	189	80	151	56	103
Homestead Run	6	274	423	788	344	634	281	513	205	371	161	297	118	215
Homestead Run	7	275	233	935	192	773	161	628	118	461	93	367	65	264
Homestead Run	8	0	0	1,709	0	1,405	0	1,158	0	852	0	675	0	483
Homestead Run	9	276	596	1,956	489	1,611	409	1,328	299	986	232	783	163	559
Homestead Run	10	277	36	1,963	31	1,617	27	1,334	22	990	19	787	15	562
Kelly Run	1	40	19	19	15	15	12	12	8	8	5	5	3	3
Kelly Run	2	41	286	302	229	242	176	186	111	117	76	81	41	44
Kelly Run	3	42	13	13	11	11	8	8	5	5	3	3	2	2
Kelly Run	4	43	215	227	173	182	134	141	87	91	60	63	34	36

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Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Kelly Run	5	0	0	528	0	424	0	328	0	208	0	144	0	80
Kelly Run	6	44	313	784	251	613	189	472	116	302	77	213	41	118
Kelly Run	7	45	114	853	91	669	70	517	44	331	30	235	16	131
Kelly Run	8	46	119	119	89	89	66	66	40	40	26	26	13	13
Kelly Run	9	47	116	209	90	163	74	128	48	85	34	57	19	31
Kelly Run	10	0	0	1,041	0	806	0	618	0	396	0	282	0	160
Kelly Run	11	48	360	1,238	290	969	226	745	148	482	103	350	59	205
Kelly Run	12	49	39	39	31	31	24	24	16	16	11	11	7	7
Kelly Run	13	50	121	152	96	122	79	99	55	69	40	50	24	30
Kelly Run	14	0	0	1,306	0	1,025	0	793	0	520	0	376	0	225
Kelly Run	15	51	260	1,453	199	1,139	151	885	96	588	65	423	36	256
Lobbs Run	1	156	58	58	42	42	30	30	18	18	12	12	6	6
Lobbs Run	2	157	41	96	32	74	25	55	16	34	11	22	6	12
Lobbs Run	3	158	37	37	30	30	23	23	15	15	10	10	6	6
Lobbs Run	4	159	137	168	110	133	86	106	57	69	40	48	23	27
Lobbs Run	5	0	0	264	0	205	0	161	0	103	0	70	0	39
Lobbs Run	6	160	159	403	118	311	86	234	51	146	33	102	15	53
Lobbs Run	7	161	28	28	22	22	17	17	11	11	7	7	4	4
Lobbs Run	8	162	182	206	145	163	115	130	75	84	51	57	29	32
Lobbs Run	9	0	0	595	0	460	0	354	0	230	0	158	0	83
Lobbs Run	10	163	119	688	88	532	64	408	36	262	23	179	9	92
Lobbs Run	11	381	12	12	10	10	8	8	5	5	4	4	2	2
Lobbs Run	12	380	117	129	94	103	74	82	49	54	34	37	19	20
Lobbs Run	13	0	0	790	0	606	0	466	0	302	0	208	0	111
Lobbs Run	14	164	67	826	54	636	43	487	28	318	19	220	11	120
Lobbs Run	15	165	11	11	8	8	7	7	5	5	3	3	2	2
Lobbs Run	16	166	114	123	88	96	72	79	49	52	34	37	20	21
Lobbs Run	17	0	0	891	0	690	0	526	0	347	0	246	0	137

CHESTER ENVIRONMENTAL

Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Lobbs Run	18	167	81	920	63	715	52	545	35	361	25	259	14	147
Lobbs Run	19	168	32	32	26	26	20	20	12	12	8	8	4	4
Lobbs Run	20	379	141	173	110	135	89	109	59	72	42	51	24	28
Lobbs Run	21	384	15	15	12	12	10	10	7	7	5	5	3	3
Lobbs Run	22	385	314	326	251	262	194	203	124	130	85	89	47	49
Lobbs Run	23	0	0	1,208	0	937	0	729	0	480	0	357	0	210
Lobbs Run	24	169	204	1,345	163	1,053	126	809	81	539	55	401	30	235
Lobbs Run	25	170	57	57	46	46	35	35	22	22	15	15	8	8
Lobbs Run	26	171	104	152	83	119	68	98	48	69	35	49	21	29
Lobbs Run	27	0	0	1,454	0	1,154	0	883	0	592	0	440	0	258
Lobbs Run	28	172	115	1,512	90	1,202	74	923	49	621	35	463	20	272
Lobbs Run	29	173	23	23	19	19	16	16	11	11	9	9	6	6
Lobbs Run	30	174	75	96	61	78	50	65	35	46	26	34	16	22
Lobbs Run	31	175	46	46	36	36	28	28	18	18	12	12	7	7
Lobbs Run	32	176	69	106	56	84	46	70	32	49	24	35	15	22
Lobbs Run	33	0	0	202	0	162	0	135	0	95	0	69	0	43
Lobbs Run	34	177	280	457	212	356	160	274	99	183	68	131	36	77
Lobbs Run	35	178	19	19	15	15	12	12	7	7	5	5	3	3
Lobbs Run	36	179	57	75	45	58	37	48	25	32	18	23	11	14
Lobbs Run	37	0	0	527	0	413	0	322	0	215	0	152	0	89
Lobbs Run	38	180	20	543	16	427	14	333	10	224	7	159	5	92
Lobbs Run	39	181	38	38	31	31	24	24	15	15	10	10	6	6
Lobbs Run	40	182	106	138	83	110	68	91	46	60	32	42	19	24
Lobbs Run	41	0	0	675	0	537	0	424	0	284	0	201	0	115
Lobbs Run	42	183	104	738	83	588	68	466	47	315	34	225	21	133
Lobbs Run	43	0	0	2,185	0	1,702	0	1,347	0	901	0	666	0	394
Lobbs Run	44	184	251	2,296	201	1,800	155	1,425	99	957	68	706	38	422
Lobbs Run	45	185	31	31	25	25	21	21	15	15	12	12	8	8

CHESTER ENVIRONMENTAL

Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Lobbs Run	46	186	66	95	52	75	42	63	29	44	20	32	12	19
Lobbs Run	47	0	0	2,328	0	1,831	0	1,448	0	975	0	720	0	435
Lobbs Run	48	187	284	2,420	227	1,914	186	1,516	130	1,027	97	760	63	467
Mill Run	1	66	41	41	33	33	25	25	15	15	10	10	5	5
Mill Run	2	67	156	197	119	150	90	114	55	70	37	46	19	24
Mill Run	3	64	163	163	121	121	88	88	52	52	33	33	17	17
Mill Run	4	65	136	279	109	210	83	157	53	101	36	67	20	36
Mill Run	5	0	0	467	0	358	0	268	0	170	0	112	0	60
Mill Run	6	68	228	664	168	507	122	379	70	236	46	157	23	82
Mill Run	7	69	22	22	18	18	15	15	10	10	7	7	5	5
Mill Run	8	70	129	149	101	116	82	95	54	63	39	45	22	26
Mill Run	9	0	0	773	0	593	0	449	0	286	0	198	0	106
Mill Run	10	71	190	898	151	686	119	524	77	334	53	237	30	132
Mill Run	11	72	65	65	49	49	37	37	22	22	15	15	8	8
Mill Run	12	73	298	341	239	275	185	211	119	134	82	91	45	50
Mill Run	13	0	0	1,188	0	899	0	696	0	447	0	315	0	178
Mill Run	14	74	172	1,295	138	986	107	759	69	496	47	352	27	200
Mill Run	15	75	31	31	26	26	21	21	15	15	11	11	7	7
Mill Run	16	76	94	122	75	101	58	79	37	52	26	37	13	20
Mill Run	17	77	21	21	16	16	13	13	8	8	6	6	4	4
Mill Run	18	78	74	93	59	74	46	59	30	38	21	27	11	15
Mill Run	19	0	0	216	0	173	0	138	0	90	0	63	0	35
Mill Run	20	79	168	347	135	278	104	211	67	139	45	100	24	56
Mill Run	21	0	0	1,606	0	1,254	0	964	0	634	0	452	0	255
Mill Run	22	80	343	1,777	276	1,404	214	1,086	135	717	93	518	50	297
Mill Run	23	81	37	37	29	29	23	23	15	15	10	10	6	6
Mill Run	24	82	368	397	295	319	223	241	139	150	92	99	46	50
Mill Run	25	0	0	2,015	0	1,582	0	1,231	0	812	0	592	0	340

CHESTER ENVIRONMENTAL

Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Mill Run	26	83	227	2,127	177	1,666	144	1,302	96	863	67	632	39	368
Mill Run	27	84	19	19	15	15	12	12	8	8	6	6	3	3
Mill Run	28	85	42	59	33	47	27	39	18	26	13	19	8	11
Mill Run	29	86	12	12	9	9	8	8	5	5	4	4	2	2
Mill Run	30	87	61	72	47	56	39	46	26	31	19	22	11	13
Mill Run	31	0	0	130	0	103	0	85	0	58	0	41	0	23
Mill Run	32	88	316	420	254	345	198	275	126	176	87	121	47	66
Mill Run	33	0	0	2,430	0	1,900	0	1,487	0	986	0	719	0	426
Mill Run	34	89	60	2,451	45	1,914	38	1,499	27	995	20	726	13	432
River Hill Stream	1	36	41	41	32	32	25	25	16	16	10	10	6	6
River Hill Stream	2	37	119	156	94	126	72	97	47	62	31	41	17	22
River Hill Stream	3	38	377	481	301	399	227	300	142	186	94	121	47	63
Smiths Run	1	94	24	24	19	19	14	14	9	9	6	6	3	3
Smiths Run	2	95	149	169	120	135	99	110	68	75	51	55	31	34
Sunfish Run	1	25	15	15	11	11	8	8	5	5	3	3	2	2
Sunfish Run	2	26	549	557	441	448	339	344	215	218	146	147	78	79
Sunfish Run	3	27	124	670	99	525	76	404	47	257	32	175	17	95
Sunfish Run	4	28	27	27	21	21	16	16	10	10	7	7	3	3
Sunfish Run	5	29	149	172	120	138	91	105	58	66	38	43	20	22
Sunfish Run	6	0	0	826	0	644	0	492	0	313	0	214	0	116
Sunfish Run	7	30	267	966	212	761	166	587	106	377	73	261	39	148
Sunfish Run	8	31	46	46	35	35	27	27	17	17	12	12	6	6
Sunfish Run	9	32	192	228	149	176	122	145	81	95	57	66	33	38
Sunfish Run	10	0	0	1,130	0	884	0	680	0	441	0	307	0	180
Sunfish Run	11	33	15	1,135	11	888	9	683	7	443	5	309	4	182
Streets Run	1	278	124	124	109	109	94	94	74	74	60	60	44	44
Streets Run	2	279	203	311	164	264	134	212	97	145	76	126	55	96
Streets Run	3	280	443	443	355	355	285	285	203	203	157	157	112	112

CHESTER ENVIRONMENTAL

Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Streets Run	4	281	256	637	212	518	178	427	132	310	105	245	75	180
Streets Run	5	0	0	1,058	0	865	0	706	0	509	0	395	0	291
Streets Run	6	282	352	1,315	283	1,063	229	868	163	624	126	486	89	360
Streets Run	7	283	189	189	155	155	127	127	93	93	73	73	53	53
Streets Run	8	284	230	388	187	315	155	261	111	189	85	149	57	105
Streets Run	9	0	0	1,656	0	1,347	0	1,095	0	792	0	624	0	457
Streets Run	10	285	429	1,952	354	1,582	291	1,298	213	938	167	741	120	541
Streets Run	11	286	414	2,234	329	1,807	263	1,476	186	1,073	142	849	100	610
Streets Run	12	287	566	566	486	486	418	418	329	329	271	271	213	213
Streets Run	13	288	393	907	326	763	269	642	197	489	154	405	111	298
Streets Run	14	0	0	3,036	0	2,502	0	2,058	0	1,510	0	1,226	0	888
Streets Run	15	289	126	3,093	98	2,550	80	2,098	53	1,540	38	1,249	22	903
Streets Run	16	290	129	129	109	109	91	91	69	69	55	55	41	41
Streets Run	17	291	498	613	409	504	332	415	236	299	181	231	124	162
Streets Run	18	292	300	300	251	251	209	209	157	157	125	125	93	93
Streets Run	19	293	203	477	163	392	134	327	93	240	70	185	45	131
Streets Run	20	0	0	1,090	0	895	0	739	0	534	0	414	0	292
Streets Run	21	294	425	1,329	335	1,090	260	898	169	645	121	496	69	340
Streets Run	22	0	0	4,423	0	3,640	0	2,996	0	2,185	0	1,744	0	1,243
Streets Run	23	295	128	4,477	103	3,685	80	3,034	53	2,213	37	1,766	22	1,256
Streets Run	24	296	469	469	397	397	337	337	260	260	219	219	165	165
Streets Run	25	297	505	903	419	753	345	625	252	471	198	382	141	272
Streets Run	26	0	0	5,022	0	4,153	0	3,434	0	2,524	0	2,022	0	1,444
Streets Run	27	298	98	5,044	82	4,172	67	3,451	52	2,539	41	2,033	29	1,453
Streets Run	28	299	50	50	41	41	35	35	26	26	20	20	15	15
Streets Run	29	300	282	329	232	272	189	222	136	161	106	125	74	88
Streets Run	30	301	521	757	424	614	341	495	237	359	177	284	118	192
Streets Run	31	0	0	5,539	0	4,535	0	3,737	0	2,769	0	2,182	0	1,563

CHESTER ENVIRONMENTAL

Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Streets Run	32	302	183	5,601	146	4,588	120	3,782	82	2,802	60	2,206	38	1,582
Streets Run	33	303	36	36	28	28	22	22	14	14	10	10	6	6
Streets Run	34	304	121	152	99	122	79	96	54	64	39	46	23	28
Streets Run	35	0	0	5,655	0	4,633	0	3,821	0	2,829	0	2,227	0	1,596
Streets Run	36	305	279	5,792	211	4,745	158	3,911	99	2,890	69	2,271	40	1,623
Streets Run	37	306	79	79	65	65	52	52	37	37	28	28	20	20
Streets Run	38	307	467	532	373	425	294	336	196	226	142	166	90	106
Streets Run	39	308	113	113	94	94	77	77	57	57	45	45	33	33
Streets Run	40	309	316	412	249	332	191	264	122	175	87	129	49	80
Streets Run	41	0	0	944	0	755	0	597	0	400	0	296	0	184
Streets Run	42	310	221	1,133	175	904	135	713	87	475	62	345	36	217
Streets Run	43	0	0	6,315	0	5,181	0	4,275	0	3,146	0	2,460	0	1,749
Streets Run	44	311	161	6,354	132	5,214	111	4,305	81	3,169	62	2,478	42	1,763
Streets Run	45	312	83	83	62	62	45	45	26	26	17	17	9	9
Streets Run	46	313	62	124	51	97	43	79	31	53	24	38	16	23
Streets Run	47	314	179	179	146	146	120	120	87	87	69	69	50	50
Streets Run	48	315	167	326	137	267	111	218	79	157	60	123	41	88
Streets Run	49	316	454	738	347	578	266	453	175	319	129	245	81	163
Streets Run	50	317	468	1,001	371	789	283	625	178	437	123	332	68	218
Streets Run	51	0	0	7,107	0	5,840	0	4,834	0	3,503	0	2,714	0	1,916
Streets Run	52	318	142	7,130	122	5,864	105	4,855	82	3,517	68	2,727	51	1,926
Thompson Run	1	240	1,050	1,050	878	878	738	738	562	562	453	453	343	343
Thompson Run	2	241	1,129	2,095	913	1,720	743	1,421	539	1,054	422	846	308	621
Thompson Run	3	242	375	2,414	290	1,965	224	1,609	149	1,178	110	934	73	682
Thompson Run	4	243	110	110	91	91	74	74	54	54	42	42	30	30
Thompson Run	5	244	41	143	33	118	26	95	17	68	12	52	7	37
Thompson Run	6	246	18	18	15	15	13	13	9	9	7	7	5	5
Thompson Run	7	245	49	65	40	54	32	44	22	31	17	24	11	16

CHESTER ENVIRONMENTAL

Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Thompson Run	8	0	0	205	0	170	0	138	0	98	0	74	0	52
Thompson Run	9	247	109	297	87	243	66	192	42	132	29	98	15	66
Thompson Run	10	248	235	486	192	392	155	310	110	214	84	171	59	117
Thompson Run	11	0	0	2,888	0	2,345	0	1,913	0	1,392	0	1,091	0	795
Thompson Run	12	249	144	2,958	118	2,403	98	1,962	72	1,429	56	1,121	39	815
Thompson Run	13	250	65	65	52	52	43	43	30	30	22	22	14	14
Thompson Run	14	251	199	252	159	205	124	163	82	109	58	78	34	47
Thompson Run	15	0	0	3,127	0	2,538	0	2,072	0	1,507	0	1,179	0	852
Thompson Run	16	252	183	3,206	151	2,604	123	2,128	89	1,549	68	1,212	47	875
Thompson Run	17	253	31	31	24	24	20	20	13	13	10	10	6	6
Thompson Run	18	254	101	129	81	104	64	82	43	55	31	39	19	23
Thompson Run	19	255	85	85	70	70	57	57	41	41	32	32	23	23
Thompson Run	20	256	132	208	107	168	88	138	61	101	46	77	30	52
Thompson Run	21	0	0	337	0	272	0	219	0	156	0	116	0	75
Thompson Run	22	257	50	374	39	301	33	243	23	171	16	128	10	83
Thompson Run	23	0	0	3,463	0	2,812	0	2,287	0	1,662	0	1,301	0	928
Thompson Run	24	258	734	3,781	602	3,080	491	2,513	354	1,822	275	1,434	195	1,015
Thompson Run	25	259	124	124	103	103	87	87	65	65	52	52	38	38
Thompson Run	26	260	619	717	513	603	431	506	320	376	254	298	185	218
Thompson Run	27	0	0	4,080	0	3,334	0	2,725	0	1,976	0	1,566	0	1,110
Thompson Run	28	261	149	4,116	128	3,365	110	2,753	88	1,998	73	1,585	56	1,125
Thompson Run	29	262	592	4,296	505	3,524	434	2,893	339	2,108	279	1,677	214	1,199
Fallen Timber Run	1	97	23	23	18	18	13	13	8	8	5	5	3	3
Fallen Timber Run	2	98	205	223	163	178	125	136	78	85	54	57	29	30
Fallen Timber Run	3	99	29	29	23	23	18	18	12	12	8	8	5	5
Fallen Timber Run	4	100	67	91	54	74	44	60	31	42	23	31	14	18
Fallen Timber Run	5	0	0	314	0	249	0	194	0	127	0	88	0	49
Fallen Timber Run	6	101	353	614	284	486	218	370	137	246	92	170	50	95

Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Fallen Timber Run	35	0	0	3,350	0	2,655	0	2,106	0	1,445	0	1,087	0	703
Fallen Timber Run	36	123	116	3,388	94	2,686	79	2,132	56	1,467	42	1,105	28	715
Fallen Timber Run	37	124	40	40	32	32	25	25	17	17	12	12	7	7
Fallen Timber Run	38	125	86	121	69	97	58	81	40	56	30	41	19	26
Fallen Timber Run	39	0	0	3,433	0	2,724	0	2,162	0	1,491	0	1,124	0	727
Fallen Timber Run	40	126	160	3,459	107	2,747	90	2,182	71	1,507	57	1,138	42	738
Fallen Timber Run	41	127	64	64	52	52	43	43	30	30	22	22	14	14
Fallen Timber Run	42	128	128	181	106	148	89	122	65	90	51	69	34	45
Fallen Timber Run	43	0	0	3,513	0	2,793	0	2,219	0	1,538	0	1,164	0	755
Fallen Timber Run	44	129	14	3,521	12	2,800	10	2,226	8	1,543	6	1,168	5	759
West Run	1	319	118	118	98	98	83	83	62	62	49	49	36	36
West Run	2	320	138	246	114	205	96	172	71	127	57	101	41	75
West Run	3	321	77	77	62	62	49	49	33	33	25	25	16	16
West Run	4	322	30	98	24	80	20	64	14	44	11	34	7	23
West Run	5	0	0	343	0	282	0	233	0	169	0	135	0	96
West Run	6	323	90	402	75	336	62	278	47	203	38	161	26	115
West Run	7	324	552	806	458	666	385	559	286	414	226	350	163	254
West Run	8	325	148	148	115	115	89	89	59	59	44	44	29	29
West Run	9	326	207	317	171	255	143	210	105	153	81	118	57	82
West Run	10	0	0	1,123	0	921	0	769	0	568	0	467	0	336
West Run	11	327	395	1,384	320	1,133	265	940	189	694	144	565	99	402
West Run	12	328	65	1,399	57	1,146	50	951	40	704	34	573	27	408
Wylie Run	1	131	55	55	44	44	35	35	23	23	17	17	11	11
Wylie Run	2	132	262	317	198	242	148	183	91	114	62	78	35	45
Wylie Run	3	133	32	32	26	26	21	21	14	14	10	10	6	6
Wylie Run	4	134	139	170	110	136	85	105	54	68	38	48	21	27
Wylie Run	5	135	123	279	98	219	75	169	48	109	34	79	19	45
Wylie Run	6	0	0	592	0	461	0	350	0	223	0	158	0	90

Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Fallen Timber Run	7	102	32	32	25	25	19	19	12	12	9	9	5	5
Fallen Timber Run	8	103	151	177	120	140	94	111	61	72	42	49	23	28
Fallen Timber Run	9	0	0	784	0	622	0	481	0	315	0	216	0	120
Fallen Timber Run	10	104	119	870	94	688	74	535	48	352	34	241	19	136
Fallen Timber Run	11	105	26	26	21	21	16	16	11	11	8	8	4	4
Fallen Timber Run	12	106	224	246	175	192	143	157	95	104	67	73	39	42
Fallen Timber Run	13	0	0	1,072	0	846	0	656	0	436	0	302	0	173
Fallen Timber Run	14	107	212	1,183	169	937	140	723	97	486	72	342	46	206
Fallen Timber Run	15	110	9	9	7	7	5	5	4	4	2	2	1	1
Fallen Timber Run	16	111	52	60	41	47	34	39	23	26	16	19	9	10
Fallen Timber Run	17	108	35	35	28	28	22	22	15	15	10	10	6	6
Fallen Timber Run	18	109	334	367	253	279	190	210	117	129	80	88	44	49
Fallen Timber Run	19	0	0	422	0	325	0	249	0	155	0	107	0	59
Fallen Timber Run	20	112	248	635	187	484	140	367	84	228	57	160	30	87
Fallen Timber Run	21	0	0	1,785	0	1,396	0	1,085	0	693	0	479	0	290
Fallen Timber Run	22	113	38	1,801	32	1,409	27	1,096	21	701	17	490	12	298
Fallen Timber Run	23	114	87	87	65	65	48	48	30	30	20	20	12	12
Fallen Timber Run	24	115	306	362	244	292	189	224	122	143	84	98	45	53
Fallen Timber Run	25	116	19	19	15	15	12	12	8	8	6	6	3	3
Fallen Timber Run	26	117	390	405	336	347	291	299	232	236	193	196	148	149
Fallen Timber Run	27	0	0	2,394	0	1,898	0	1,480	0	975	0	729	0	464
Fallen Timber Run	28	118	138	2,490	111	1,974	87	1,543	59	1,019	42	761	26	484
Fallen Timber Run	29	122	377	377	314	314	263	263	198	198	159	159	120	120
Fallen Timber Run	30	382	227	550	182	452	143	379	96	274	68	210	38	151
Fallen Timber Run	31	0	0	3,015	0	2,407	0	1,902	0	1,288	0	971	0	634
Fallen Timber Run	32	119	244	3,124	193	2,489	158	1,971	106	1,345	77	1,013	46	662
Fallen Timber Run	33	120	64	64	48	48	35	35	22	22	15	15	8	8
Fallen Timber Run	34	121	305	353	244	285	188	218	119	137	83	94	44	50

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Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Wylie Run	7	136	425	826	340	649	261	504	165	332	113	247	63	142
Wylie Run	8	137	129	882	103	692	81	540	54	365	37	270	22	158
Wylie Run	9	140	27	27	22	22	17	17	10	10	7	7	4	4
Wylie Run	10	141	307	327	245	259	193	205	126	133	88	92	48	50
Wylie Run	11	138	108	108	86	86	68	68	45	45	33	33	21	21
Wylie Run	12	139	403	487	322	392	252	308	169	206	118	145	71	88
Wylie Run	13	0	0	814	0	646	0	513	0	339	0	237	0	138
Wylie Run	14	142	88	881	69	703	56	551	38	366	27	257	15	152
Wylie Run	15	143	32	32	26	26	20	20	13	13	9	9	5	5
Wylie Run	16	144	169	196	132	152	108	125	71	82	51	58	28	32
Wylie Run	17	145	186	340	145	271	118	215	78	146	54	103	31	59
Wylie Run	18	0	0	1,209	0	974	0	758	0	504	0	359	0	210
Wylie Run	19	146	22	1,225	17	987	14	767	10	510	7	364	4	213
Wylie Run	20	386	71	71	54	54	41	41	25	25	17	17	9	9
Wylie Run	21	387	92	160	72	124	59	99	39	64	27	44	16	24
Wylie Run	22	0	0	1,359	0	1,098	0	853	0	562	0	401	0	236
Wylie Run	23	147	96	1,411	75	1,140	61	888	41	585	29	419	17	248
Wylie Run	24	150	34	34	27	27	21	21	14	14	9	9	5	5
Wylie Run	25	151	295	321	237	259	183	200	117	127	81	88	44	47
Wylie Run	26	148	23	23	19	19	15	15	11	11	8	8	5	5
Wylie Run	27	149	95	117	76	93	62	76	43	53	31	39	19	23
Wylie Run	28	0	0	1,740	0	1,381	0	1,090	0	720	0	516	0	307
Wylie Run	29	152	267	1,864	215	1,479	168	1,171	112	780	79	560	45	336
Wylie Run	30	0	0	2,720	0	2,149	0	1,687	0	1,129	0	821	0	489
Wylie Run	31	153	233	2,814	190	2,223	154	1,752	109	1,176	82	861	56	517
Wylie Run	32	154	51	2,820	45	2,228	38	1,757	29	1,180	24	864	18	520
Mile 24 Stream	1	91	18	18	14	14	11	11	7	7	5	5	3	3
Mile 24 Stream	2	92	159	174	125	137	102	112	70	76	50	54	30	32

Table B–2
Summary of Modeled Runoff and Discharge
Twelve Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Mile 5 Stream	1	378	21	21	16	16	13	13	9	9	6	6	4	4
Mile 5 Stream	2	388	141	162	110	126	89	101	59	68	42	46	24	26

CHESTER ENVIRONMENTAL

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Mile 22 Stream	1	193	35	35	28	28	21	21	13	13	9	9	6	6
Mile 22 Stream	2	194	102	131	78	100	60	76	40	50	31	37	20	24
Mile 23.5 Stream	1	220	11	11	9	9	7	7	5	5	4	4	2	2
Mile 23.5 Stream	2	190	140	150	110	118	86	93	60	64	47	51	33	35
Mile 23.5 Stream	3	191	40	181	33	148	27	118	20	83	17	64	12	46
Mile 9.7 Stream	1	356	241	241	198	198	162	162	118	118	95	95	68	68
Mile 9.7 Stream	2	357	187	405	147	330	116	266	82	196	66	156	46	111
Mile 9.7 Stream	3	358	155	521	128	422	107	342	81	254	67	209	50	152
Becks Run	1	331	272	272	222	222	181	181	132	132	107	107	77	77
Becks Run	2	332	267	503	215	407	174	331	129	251	104	205	75	149
Becks Run	3	333	190	190	162	162	138	138	106	106	89	89	67	67
Becks Run	4	334	260	441	212	365	174	304	127	228	105	191	77	144
Becks Run	5	0	0	939	0	770	0	633	0	479	0	395	0	293
Becks Run	6	335	133	1,056	100	858	76	700	50	521	38	427	25	314
Becks Run	7	336	151	151	124	124	102	102	75	75	60	60	44	44
Becks Run	8	337	145	281	116	227	94	185	69	139	56	113	40	82
Becks Run	9	0	0	1,325	0	1,081	0	881	0	646	0	524	0	384
Becks Run	10	338	76	1,384	59	1,127	45	916	32	669	25	542	17	396
Beckets Run	1	11	5	5	4	4	3	3	1	1	1	1	0	0
Beckets Run	2	12	33	38	23	26	15	18	9	10	6	6	2	2
Beckets Run	3	13	48	84	33	59	23	40	13	23	8	14	5	7
Beckets Run	4	14	43	43	34	34	26	26	16	16	11	11	6	6
Beckets Run	5	15	60	102	42	75	29	54	17	32	11	21	5	10
Beckets Run	6	0	0	184	0	134	0	94	0	53	0	34	0	16
Beckets Run	7	16	37	215	27	156	19	111	11	63	7	41	4	20
Beckets Run	8	9	10	10	8	8	6	6	4	4	2	2	1	1
Beckets Run	9	10	34	44	24	31	17	22	10	12	6	8	3	4
Beckets Run	10	0	0	257	0	186	0	133	0	75	0	48	0	23

CHESTER ENVIRONMENTAL

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Beckets Run	11	17	31	280	23	203	17	147	10	84	7	54	3	26
Beckets Run	12	6	13	13	11	11	9	9	6	6	5	5	3	3
Beckets Run	13	7	56	68	42	50	30	36	17	21	11	14	6	8
Beckets Run	14	0	0	343	0	249	0	180	0	104	0	68	0	33
Beckets Run	15	8	51	380	38	277	27	203	16	117	10	77	5	38
Beckets Run	16	3	29	29	22	22	17	17	11	11	7	7	4	4
Beckets Run	17	4	45	73	32	54	22	38	12	22	8	15	4	8
Beckets Run	18	1	13	13	9	9	6	6	3	3	2	2	1	1
Beckets Run	19	2	91	101	66	73	48	53	30	32	22	24	13	14
Beckets Run	20	0	0	175	0	127	0	91	0	55	0	38	0	21
Beckets Run	21	5	50	218	36	159	25	116	14	68	9	47	5	25
Beckets Run	22	0	0	565	0	418	0	311	0	180	0	119	0	61
Beckets Run	23	18	72	622	52	462	36	344	21	200	13	132	7	67
Beckets Run	24	19	14	14	12	12	9	9	6	6	5	5	3	3
Beckets Run	25	20	72	85	52	62	38	45	22	26	15	18	7	9
Beckets Run	26	21	6	6	5	5	4	4	2	2	2	2	1	1
Beckets Run	27	22	35	41	25	30	18	21	11	12	7	7	3	4
Beckets Run	28	0	0	126	0	92	0	66	0	37	0	25	0	13
Beckets Run	29	23	29	150	21	109	15	78	8	45	5	30	2	15
Beckets Run	30	0	0	755	0	561	0	418	0	243	0	161	0	82
Beckets Run	31	24	31	774	23	577	17	430	11	252	7	166	4	85
Belle Bridge Stream	1	196	13	13	10	10	7	7	4	4	3	3	1	1
Belle Bridge Stream	2	197	61	74	43	53	30	37	18	21	11	14	6	7
Belle Bridge Stream	3	198	29	29	21	21	15	15	9	9	6	6	3	3
Belle Bridge Stream	4	199	46	74	34	54	25	39	15	23	11	16	6	9
Belle Bridge Stream	5	0	0	148	0	107	0	76	0	45	0	30	0	16
Bunola Run	1	52	33	33	27	27	21	21	14	14	10	10	6	6
Bunola Run	2	53	41	73	30	56	21	42	13	27	9	18	5	10

CHESTER ENVIRONMENTAL

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Bunola Run	3	54	51	122	37	92	26	68	16	42	11	29	6	16
Bunola Run	4	55	79	79	60	60	45	45	27	27	18	18	9	9
Bunola Run	5	56	67	143	48	107	34	77	20	45	13	30	7	15
Bunola Run	6	0	0	260	0	197	0	143	0	85	0	58	0	30
Bunola Run	7	57	24	280	17	212	13	154	8	92	5	62	3	33
Bunola Run	8	58	16	16	13	13	10	10	6	6	4	4	2	2
Bunola Run	9	59	14	31	10	23	7	17	4	10	3	7	1	3
Bunola Run	10	0	0	306	0	230	0	168	0	101	0	68	0	36
Bunola Run	11	60	14	314	11	236	9	173	7	105	6	71	4	38
Coal Valley Run	1	208	42	42	33	33	27	27	19	19	14	14	10	10
Coal Valley Run	2	209	51	90	39	70	29	56	20	38	14	28	9	19
Coal Valley Run	3	210	155	235	121	185	95	145	67	99	53	78	37	54
Coal Valley Run	4	211	36	36	30	30	25	25	18	18	14	14	9	9
Coal Valley Run	5	212	98	132	78	107	63	86	45	62	36	49	26	35
Coal Valley Run	6	0	0	366	0	292	0	230	0	162	0	127	0	89
Coal Valley Run	7	213	16	379	12	301	9	238	5	166	4	130	2	91
Coal Valley Run	8	214	48	48	41	41	33	33	24	24	19	19	13	13
Coal Valley Run	9	215	31	77	24	63	19	50	13	37	10	29	7	20
Coal Valley Run	10	0	0	448	0	359	0	284	0	197	0	153	0	110
Coal Valley Run	11	216	53	491	41	391	30	309	20	213	14	164	9	117
Coal Valley Run	12	217	70	70	56	56	45	45	32	32	24	24	17	17
Coal Valley Run	13	218	37	105	27	82	20	64	12	43	8	32	5	21
Coal Valley Run	14	0	0	578	0	460	0	357	0	244	0	190	0	137
Coal Valley Run	15	219	36	610	25	483	17	374	10	254	7	196	3	140
Coal Valley Run	16	221	61	61	47	47	35	35	21	21	14	14	8	8
Coal Valley Run	17	222	38	96	27	72	19	53	11	32	7	21	4	11
Coal Valley Run	18	0	0	677	0	535	0	413	0	279	0	216	0	150
Coal Valley Run	19	223	78	740	58	583	44	449	28	302	21	234	14	161

CHESTER ENVIRONMENTAL

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Coal Valley Run	20	224	14	14	11	11	9	9	5	5	4	4	2	2
Coal Valley Run	21	225	75	88	57	67	42	50	27	32	21	24	13	15
Coal Valley Run	22	226	58	145	40	106	29	77	17	47	11	33	5	19
Coal Valley Run	23	227	64	201	46	148	33	108	20	65	14	46	8	26
Coal Valley Run	24	228	68	68	49	49	34	34	19	19	12	12	6	6
Coal Valley Run	25	229	40	104	30	77	22	55	14	32	10	21	7	11
Coal Valley Run	26	0	0	925	0	714	0	546	0	361	0	278	0	186
Coal Valley Run	27	230	10	928	8	716	7	548	6	362	5	280	4	188
Coal Valley Run	28	0	0	1,014	0	780	0	596	0	391	0	300	0	198
Courain Hill Stream	1	201	18	18	14	14	10	10	6	6	4	4	2	2
Courain Hill Stream	2	202	109	125	79	91	57	66	36	41	26	29	16	17
Courain Hill Stream	3	203	14	14	11	11	9	9	6	6	4	4	3	3
Courain Hill Stream	4	204	54	68	39	50	29	37	18	23	12	16	8	10
Courain Hill Stream	5	0	0	192	0	140	0	103	0	64	0	45	0	27
Courain Hill Stream	6	205	32	219	24	161	18	119	11	74	7	52	4	31
Crooked Run	1	362	49	49	41	41	34	34	25	25	20	20	14	14
Crooked Run	2	363	205	249	163	198	130	159	94	116	75	94	53	67
Crooked Run	3	364	209	434	166	345	131	275	91	199	73	156	53	118
Crooked Run	4	365	128	128	101	101	79	79	55	55	42	42	30	30
Crooked Run	5	366	100	213	78	170	61	135	43	94	34	74	23	51
Crooked Run	6	0	0	642	0	509	0	409	0	293	0	229	0	169
Crooked Run	7	367	211	807	167	639	131	510	96	363	75	284	53	212
Crooked Run	8	370	214	214	175	175	144	144	106	106	85	85	62	62
Crooked Run	9	371	39	253	32	207	27	171	20	126	17	102	13	75
Crooked Run	10	368	43	43	33	33	26	26	16	16	11	11	6	6
Crooked Run	11	369	107	147	87	117	71	93	52	67	42	52	31	37
Crooked Run	12	0	0	399	0	324	0	264	0	191	0	154	0	111
Crooked Run	13	372	65	464	53	377	43	307	32	223	26	179	19	130

CHESTER ENVIRONMENTAL

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Crooked Run	14	0	0	1,066	0	860	0	691	0	531	0	443	0	324
Crooked Run	15	373	52	1,103	43	891	36	717	26	553	22	458	16	335
Crooked Run	16	374	15	15	13	13	11	11	8	8	6	6	4	4
Crooked Run	17	375	138	152	113	124	93	102	70	77	57	63	42	46
Crooked Run	18	376	124	262	102	215	84	177	62	134	51	111	38	83
Crooked Run	19	0	0	1,345	0	1,095	0	885	0	686	0	558	0	407
Crooked Run	20	377	103	1,408	85	1,147	71	929	54	721	44	587	32	427
Curry Hollow Run	1	233	127	127	110	110	96	96	78	78	66	66	52	52
Curry Hollow Run	2	234	177	303	140	249	111	206	78	156	63	129	44	96
Curry Hollow Run	3	235	191	465	150	381	117	309	83	232	66	187	46	136
Curry Hollow Run	4	236	80	80	65	65	53	53	38	38	30	30	21	21
Curry Hollow Run	5	237	66	141	53	113	41	90	29	67	23	52	16	38
Curry Hollow Run	6	0	0	599	0	486	0	393	0	297	0	239	0	173
Curry Hollow Run	7	238	39	631	31	509	24	412	17	311	13	249	9	181
Homestead Run	1	269	159	159	132	132	110	110	82	82	67	67	50	50
Homestead Run	2	270	171	313	140	257	114	211	85	161	69	133	51	98
Homestead Run	3	271	148	429	120	355	97	291	72	219	59	178	43	134
Homestead Run	4	272	164	164	130	130	102	102	71	71	54	54	37	37
Homestead Run	5	273	127	275	102	219	82	175	59	129	48	100	35	72
Homestead Run	6	274	299	535	243	430	198	347	145	267	119	212	87	157
Homestead Run	7	275	115	624	94	506	77	413	56	312	46	251	34	186
Homestead Run	8	0	0	1,052	0	861	0	700	0	531	0	426	0	320
Homestead Run	9	276	218	1,200	177	982	144	799	110	604	88	487	63	366
Homestead Run	10	277	28	1,208	24	989	21	805	16	609	14	492	11	370
Kelly Run	1	40	14	14	11	11	8	8	5	5	4	4	2	2
Kelly Run	2	41	68	81	49	59	35	42	21	25	14	16	7	9
Kelly Run	3	42	10	10	7	7	5	5	3	3	2	2	1	1
Kelly Run	4	43	65	74	48	54	34	38	20	23	14	15	8	8

CHESTER ENVIRONMENTAL

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Kelly Run	5	0	0	155	0	113	0	81	0	47	0	31	0	17
Kelly Run	6	44	75	228	54	165	39	117	23	68	15	45	7	24
Kelly Run	7	45	51	269	37	197	25	140	14	81	9	53	5	28
Kelly Run	8	46	81	81	59	59	42	42	24	24	15	15	8	8
Kelly Run	9	47	38	116	27	85	19	61	11	34	7	22	4	12
Kelly Run	10	0	0	372	0	275	0	196	0	114	0	74	0	40
Kelly Run	11	48	90	457	66	339	46	242	28	141	19	93	11	50
Kelly Run	12	49	29	29	22	22	17	17	11	11	7	7	4	4
Kelly Run	13	50	34	62	25	46	18	34	10	21	7	14	4	8
Kelly Run	14	0	0	502	0	375	0	270	0	158	0	105	0	56
Kelly Run	15	51	122	593	89	447	65	326	38	192	25	128	13	69
Lobbs Run	1	156	38	38	27	27	19	19	11	11	7	7	4	4
Lobbs Run	2	157	21	58	15	42	11	30	6	17	4	11	3	6
Lobbs Run	3	158	28	28	21	21	15	15	9	9	6	6	3	3
Lobbs Run	4	159	26	53	19	39	14	29	8	17	6	12	3	6
Lobbs Run	5	0	0	109	0	78	0	56	0	33	0	22	0	11
Lobbs Run	6	160	54	160	38	115	26	81	15	47	10	31	5	16
Lobbs Run	7	161	20	20	16	16	12	12	7	7	5	5	2	2
Lobbs Run	8	162	33	53	25	39	17	27	10	16	7	10	3	5
Lobbs Run	9	0	0	213	0	153	0	108	0	63	0	41	0	21
Lobbs Run	10	163	51	257	35	186	24	131	12	74	7	48	3	24
Lobbs Run	11	381	9	9	7	7	5	5	3	3	2	2	1	1
Lobbs Run	12	380	31	40	21	28	15	20	9	12	6	7	3	4
Lobbs Run	13	0	0	292	0	212	0	150	0	85	0	55	0	27
Lobbs Run	14	164	27	312	19	228	14	162	7	92	5	59	2	29
Lobbs Run	15	165	8	8	6	6	5	5	3	3	2	2	1	1
Lobbs Run	16	166	22	30	16	22	12	15	7	9	4	6	2	3
Lobbs Run	17	0	0	337	0	247	0	177	0	101	0	65	0	31

CHESTER ENVIRONMENTAL

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Lobbs Run	18	167	28	358	20	263	13	190	7	108	5	69	2	33
Lobbs Run	19	168	24	24	18	18	13	13	8	8	5	5	2	2
Lobbs Run	20	379	40	63	28	46	20	33	11	19	8	12	4	6
Lobbs Run	21	384	11	11	9	9	7	7	4	4	3	3	2	2
Lobbs Run	22	385	50	59	36	43	26	31	15	18	10	12	5	7
Lobbs Run	23	0	0	457	0	339	0	247	0	143	0	92	0	46
Lobbs Run	24	169	79	519	58	387	41	284	24	164	16	107	8	53
Lobbs Run	25	170	42	42	32	32	23	23	14	14	9	9	4	4
Lobbs Run	26	171	34	74	25	56	18	41	10	24	7	16	4	8
Lobbs Run	27	0	0	567	0	426	0	318	0	185	0	121	0	61
Lobbs Run	28	172	48	599	34	452	25	339	14	198	9	129	5	65
Lobbs Run	29	173	18	18	15	15	12	12	8	8	6	6	4	4
Lobbs Run	30	174	31	49	24	38	18	30	12	20	9	15	6	10
Lobbs Run	31	175	33	33	25	25	19	19	12	12	8	8	5	5
Lobbs Run	32	176	29	59	22	46	17	34	10	21	7	15	4	9
Lobbs Run	33	0	0	107	0	85	0	64	0	42	0	30	0	19
Lobbs Run	34	177	80	182	57	140	40	104	23	64	16	45	9	27
Lobbs Run	35	178	14	14	11	11	8	8	5	5	3	3	2	2
Lobbs Run	36	179	19	33	14	24	10	17	5	10	4	7	2	4
Lobbs Run	37	0	0	210	0	162	0	120	0	74	0	52	0	30
Lobbs Run	38	180	11	217	8	169	6	124	3	77	2	53	1	31
Lobbs Run	39	181	28	28	22	22	16	16	10	10	6	6	3	3
Lobbs Run	40	182	30	58	21	43	15	31	9	18	6	12	3	6
Lobbs Run	41	0	0	271	0	209	0	153	0	94	0	65	0	37
Lobbs Run	42	183	35	304	25	232	18	170	10	104	7	71	4	40
Lobbs Run	43	0	0	850	0	649	0	496	0	293	0	195	0	101
Lobbs Run	44	184	59	904	43	689	30	525	17	310	12	206	6	107
Lobbs Run	45	185	24	24	19	19	16	16	11	11	9	9	5	5

CHESTER ENVIRONMENTAL

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Lobbs Run	46	186	19	42	13	32	9	25	5	16	3	12	2	7
Lobbs Run	47	0	0	925	0	707	0	538	0	319	0	213	0	111
Lobbs Run	48	187	89	981	70	755	55	575	40	345	31	233	22	125
Mill Run	1	66	30	30	22	22	16	16	9	9	6	6	3	3
Mill Run	2	67	57	85	41	62	28	44	16	25	11	16	5	8
Mill Run	3	64	108	108	79	79	55	55	31	31	19	19	10	10
Mill Run	4	65	60	163	44	120	31	85	18	49	12	31	7	16
Mill Run	5	0	0	244	0	179	0	129	0	74	0	47	0	25
Mill Run	6	68	120	353	85	257	58	185	33	106	21	67	10	34
Mill Run	7	69	17	17	13	13	10	10	7	7	5	5	3	3
Mill Run	8	70	29	45	21	34	15	25	9	15	6	10	3	6
Mill Run	9	0	0	395	0	288	0	210	0	121	0	77	0	39
Mill Run	10	71	54	444	38	324	26	236	15	136	10	86	5	44
Mill Run	11	72	45	45	33	33	24	24	14	14	9	9	5	5
Mill Run	12	73	54	98	39	71	28	50	17	29	11	19	6	10
Mill Run	13	0	0	535	0	391	0	284	0	165	0	106	0	54
Mill Run	14	74	62	584	45	429	31	312	18	182	11	116	6	60
Mill Run	15	75	24	24	20	20	15	15	10	10	8	8	5	5
Mill Run	16	76	27	51	19	38	13	28	7	17	5	12	2	7
Mill Run	17	77	15	15	12	12	9	9	6	6	4	4	3	3
Mill Run	18	78	23	38	16	28	11	20	6	12	4	8	2	4
Mill Run	19	0	0	89	0	66	0	48	0	29	0	20	0	11
Mill Run	20	79	45	132	31	96	22	69	13	41	8	27	4	14
Mill Run	21	0	0	693	0	508	0	373	0	220	0	142	0	71
Mill Run	22	80	82	772	59	566	43	414	25	243	16	157	8	79
Mill Run	23	81	27	27	21	21	16	16	10	10	7	7	4	4
Mill Run	24	82	61	85	43	61	31	43	17	24	11	16	6	9
Mill Run	25	0	0	845	0	619	0	453	0	266	0	172	0	87

CHESTER ENVIRONMENTAL

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Mill Run	26	83	67	901	48	661	34	484	19	285	13	184	7	93
Mill Run	27	84	14	14	11	11	8	8	5	5	4	4	2	2
Mill Run	28	85	19	33	14	25	10	18	6	11	4	7	2	4
Mill Run	29	86	8	8	7	7	5	5	4	4	2	2	1	1
Mill Run	30	87	23	32	17	24	12	17	7	10	4	6	2	3
Mill Run	31	0	0	65	0	49	0	35	0	21	0	14	0	7
Mill Run	32	88	75	139	53	102	39	72	23	41	15	26	8	13
Mill Run	33	0	0	1,012	0	744	0	546	0	323	0	209	0	106
Mill Run	34	89	26	1,026	20	755	15	555	9	329	6	214	4	108
River Hill Stream	1	36	29	29	22	22	17	17	10	10	6	6	4	4
River Hill Stream	2	37	34	64	24	46	17	33	10	20	7	13	5	8
River Hill Stream	3	38	64	126	46	90	33	64	19	37	12	24	7	15
Smiths Run	1	94	17	17	13	13	10	10	6	6	4	4	2	2
Smiths Run	2	95	36	52	27	39	21	29	13	18	10	14	7	8
Sunfish Run	1	25	10	10	8	8	5	5	3	3	2	2	1	1
Sunfish Run	2	26	88	93	64	67	46	48	26	28	17	18	9	9
Sunfish Run	3	27	65	148	47	107	33	75	19	44	12	29	6	15
Sunfish Run	4	28	20	20	15	15	11	11	6	6	4	4	2	2
Sunfish Run	5	29	35	54	24	38	17	27	10	15	6	9	2	4
Sunfish Run	6	0	0	201	0	144	0	101	0	57	0	38	0	19
Sunfish Run	7	30	58	258	41	184	29	128	17	74	11	48	5	23
Sunfish Run	8	31	32	32	24	24	18	18	11	11	7	7	4	4
Sunfish Run	9	32	48	79	34	58	24	42	14	24	10	16	5	8
Sunfish Run	10	0	0	330	0	240	0	168	0	96	0	64	0	32
Sunfish Run	11	33	9	334	7	244	6	171	4	98	3	65	2	32
Streets Run	1	278	104	104	90	90	77	77	58	58	47	47	34	34
Streets Run	2	279	163	254	132	201	106	155	77	127	62	105	44	78
Streets Run	3	280	330	330	263	263	211	211	150	150	120	120	86	86

CHESTER ENVIRONMENTAL

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Streets Run	4	281	133	443	110	357	90	289	68	210	55	171	41	126
Streets Run	5	0	0	773	0	620	0	500	0	360	0	287	0	211
Streets Run	6	282	219	935	175	751	141	605	101	434	82	352	59	257
Streets Run	7	283	145	145	118	118	97	97	71	71	57	57	41	41
Streets Run	8	284	90	220	72	180	58	146	42	108	34	88	24	64
Streets Run	9	0	0	1,144	0	919	0	742	0	531	0	439	0	318
Streets Run	10	285	238	1,302	195	1,051	160	850	120	617	97	508	71	373
Streets Run	11	286	296	1,479	235	1,194	187	964	132	700	105	572	75	424
Streets Run	12	287	463	463	396	396	339	339	264	264	225	225	172	172
Streets Run	13	288	214	641	174	538	143	455	106	352	86	293	63	222
Streets Run	14	0	0	2,025	0	1,663	0	1,365	0	1,042	0	850	0	640
Streets Run	15	289	49	2,065	36	1,693	26	1,387	15	1,056	10	859	6	645
Streets Run	16	290	103	103	86	86	71	71	53	53	44	44	32	32
Streets Run	17	291	204	296	164	244	132	199	97	147	79	121	56	88
Streets Run	18	292	237	237	196	196	162	162	121	121	98	98	73	73
Streets Run	19	293	84	312	66	255	52	209	36	154	28	124	20	93
Streets Run	20	0	0	606	0	497	0	405	0	298	0	242	0	180
Streets Run	21	294	113	703	85	570	64	459	42	332	32	267	21	197
Streets Run	22	0	0	2,763	0	2,254	0	1,840	0	1,381	0	1,120	0	834
Streets Run	23	295	59	2,802	44	2,285	32	1,863	21	1,396	14	1,131	9	840
Streets Run	24	296	377	377	318	318	269	269	212	212	175	175	131	131
Streets Run	25	297	249	581	203	488	166	408	124	312	101	255	74	195
Streets Run	26	0	0	3,233	0	2,650	0	2,171	0	1,633	0	1,324	0	998
Streets Run	27	298	50	3,259	40	2,671	32	2,188	23	1,645	18	1,333	12	1,005
Streets Run	28	299	39	39	32	32	27	27	20	20	16	16	11	11
Streets Run	29	300	141	179	114	145	93	118	69	87	56	71	40	52
Streets Run	30	301	173	319	138	260	110	217	81	158	64	125	45	90
Streets Run	31	0	0	3,501	0	2,858	0	2,338	0	1,753	0	1,418	0	1,073

CHESTER ENVIRONMENTAL

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Streets Run	32	302	79	3,548	61	2,895	46	2,368	31	1,772	23	1,432	15	1,082
Streets Run	33	303	26	26	20	20	15	15	9	9	6	6	4	4
Streets Run	34	304	34	58	26	44	20	33	13	22	10	16	7	10
Streets Run	35	0	0	3,584	0	2,923	0	2,389	0	1,786	0	1,442	0	1,089
Streets Run	36	305	120	3,667	88	2,987	65	2,437	41	1,816	29	1,462	18	1,099
Streets Run	37	306	60	60	49	49	39	39	27	27	21	21	15	15
Streets Run	38	307	142	195	111	153	86	120	62	85	48	66	33	46
Streets Run	39	308	88	88	72	72	59	59	43	43	35	35	25	25
Streets Run	40	309	84	165	63	132	47	104	31	73	23	56	15	39
Streets Run	41	0	0	359	0	284	0	224	0	157	0	122	0	85
Streets Run	42	310	87	437	65	342	48	266	30	185	22	143	14	97
Streets Run	43	0	0	3,955	0	3,210	0	2,611	0	1,933	0	1,548	0	1,157
Streets Run	44	311	80	3,987	64	3,237	50	2,633	35	1,948	28	1,560	20	1,166
Streets Run	45	312	56	56	40	40	29	29	16	16	10	10	6	6
Streets Run	46	313	37	84	29	64	23	49	16	30	12	21	8	14
Streets Run	47	314	137	137	111	111	91	91	66	66	53	53	39	39
Streets Run	48	315	92	218	73	176	58	142	41	103	33	85	23	62
Streets Run	49	316	186	380	142	301	110	242	76	174	59	138	40	97
Streets Run	50	317	108	477	79	373	57	294	36	207	25	160	15	111
Streets Run	51	0	0	4,379	0	3,529	0	2,861	0	2,101	0	1,671	0	1,242
Streets Run	52	318	80	4,404	67	3,550	56	2,878	42	2,114	35	1,683	26	1,252
Thompson Run	1	240	830	830	693	693	580	580	437	437	364	364	272	272
Thompson Run	2	241	560	1,351	454	1,114	369	936	282	698	226	574	163	435
Thompson Run	3	242	181	1,507	141	1,239	108	1,025	77	762	60	622	42	469
Thompson Run	4	243	85	85	69	69	56	56	41	41	33	33	24	24
Thompson Run	5	244	22	104	16	84	12	67	7	47	5	36	3	27
Thompson Run	6	246	14	14	12	12	10	10	7	7	5	5	4	4
Thompson Run	7	245	29	43	23	34	18	27	12	19	10	15	7	10

CHESTER ENVIRONMENTAL

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Thompson Run	8	0	0	144	0	115	0	91	0	64	0	51	0	37
Thompson Run	9	247	32	174	23	136	16	106	9	73	6	56	4	41
Thompson Run	10	248	139	270	112	213	90	176	64	128	52	102	37	75
Thompson Run	11	0	0	1,776	0	1,452	0	1,192	0	882	0	717	0	537
Thompson Run	12	249	80	1,826	65	1,492	53	1,223	38	905	31	736	22	550
Thompson Run	13	250	49	49	39	39	31	31	21	21	16	16	10	10
Thompson Run	14	251	46	94	34	72	25	55	16	36	12	27	7	17
Thompson Run	15	0	0	1,900	0	1,550	0	1,264	0	934	0	757	0	564
Thompson Run	16	252	106	1,959	86	1,597	68	1,301	49	962	39	778	28	578
Thompson Run	17	253	22	22	18	18	14	14	9	9	6	6	3	3
Thompson Run	18	254	36	59	28	46	21	34	14	23	10	16	7	10
Thompson Run	19	255	65	65	53	53	43	43	31	31	25	25	18	18
Thompson Run	20	256	54	115	42	92	33	73	23	53	17	42	12	30
Thompson Run	21	0	0	174	0	137	0	108	0	76	0	58	0	40
Thompson Run	22	257	20	192	15	150	11	117	6	82	4	62	2	42
Thompson Run	23	0	0	2,105	0	1,709	0	1,388	0	1,022	0	819	0	606
Thompson Run	24	258	321	2,306	261	1,871	213	1,521	161	1,122	129	896	93	662
Thompson Run	25	259	98	98	81	81	67	67	50	50	41	41	30	30
Thompson Run	26	260	261	348	215	287	176	236	136	181	109	147	79	107
Thompson Run	27	0	0	2,513	0	2,041	0	1,664	0	1,231	0	982	0	726
Thompson Run	28	261	101	2,548	85	2,072	72	1,691	56	1,252	47	999	35	739
Thompson Run	29	262	359	2,709	302	2,211	254	1,811	197	1,347	163	1,079	122	815
Fallen Timber Run	1	97	16	16	12	12	8	8	5	5	3	3	2	2
Fallen Timber Run	2	98	50	64	35	46	25	33	15	19	10	12	5	6
Fallen Timber Run	3	99	21	21	17	17	13	13	8	8	5	5	3	3
Fallen Timber Run	4	100	32	52	24	40	17	29	11	18	7	12	4	6
Fallen Timber Run	5	0	0	116	0	85	0	61	0	36	0	24	0	13
Fallen Timber Run	6	101	93	207	66	151	48	108	29	62	19	41	10	21

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Fallen Timber Run	7	102	23	23	17	17	13	13	8	8	6	6	4	4
Fallen Timber Run	8	103	36	58	25	43	18	30	11	18	7	12	3	6
Fallen Timber Run	9	0	0	265	0	193	0	138	0	80	0	52	0	27
Fallen Timber Run	10	104	50	306	36	224	26	161	16	94	11	61	6	32
Fallen Timber Run	11	105	19	19	15	15	11	11	7	7	5	5	3	3
Fallen Timber Run	12	106	58	76	43	56	30	41	18	25	12	17	7	10
Fallen Timber Run	13	0	0	375	0	276	0	200	0	117	0	77	0	42
Fallen Timber Run	14	107	79	432	61	320	47	237	32	142	25	96	17	54
Fallen Timber Run	15	110	6	6	5	5	4	4	2	2	2	2	1	1
Fallen Timber Run	16	111	19	26	14	19	10	13	5	7	3	5	2	2
Fallen Timber Run	17	108	26	26	20	20	15	15	10	10	7	7	3	3
Fallen Timber Run	18	109	103	127	75	93	55	68	33	41	24	29	14	17
Fallen Timber Run	19	0	0	153	0	112	0	81	0	49	0	34	0	19
Fallen Timber Run	20	112	86	234	61	171	44	123	25	73	16	50	9	27
Fallen Timber Run	21	0	0	647	0	471	0	356	0	212	0	143	0	79
Fallen Timber Run	22	113	27	659	22	483	18	366	13	219	11	148	8	83
Fallen Timber Run	23	114	59	59	44	44	31	31	19	19	13	13	7	7
Fallen Timber Run	24	115	58	116	42	84	30	60	18	35	11	23	6	12
Fallen Timber Run	25	116	14	14	11	11	8	8	5	5	4	4	2	2
Fallen Timber Run	26	117	212	222	178	185	149	154	115	118	96	98	71	72
Fallen Timber Run	27	0	0	931	0	720	0	552	0	352	0	254	0	163
Fallen Timber Run	28	118	76	982	58	762	44	584	28	375	20	272	13	174
Fallen Timber Run	29	122	296	296	246	246	205	205	153	153	128	128	95	95
Fallen Timber Run	30	382	59	351	42	287	30	234	19	171	13	139	7	101
Fallen Timber Run	31	0	0	1,303	0	1,039	0	804	0	546	0	410	0	271
Fallen Timber Run	32	119	78	1,366	58	1,087	43	839	27	568	20	427	13	282
Fallen Timber Run	33	120	43	43	32	32	23	23	14	14	9	9	5	5
Fallen Timber Run	34	121	71	113	49	81	36	57	21	32	14	21	7	11

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Fallen Timber Run	35	0	0	1,469	0	1,162	0	894	0	599	0	447	0	292
Fallen Timber Run	36	123	57	1,502	45	1,189	35	915	23	614	18	459	12	300
Fallen Timber Run	37	124	30	30	23	23	18	18	11	11	8	8	5	5
Fallen Timber Run	38	125	36	64	27	51	21	38	13	25	10	18	6	11
Fallen Timber Run	39	0	0	1,538	0	1,218	0	938	0	629	0	471	0	307
Fallen Timber Run	40	126	56	1,567	46	1,241	37	958	28	644	23	484	17	317
Fallen Timber Run	41	127	48	48	39	39	31	31	21	21	15	15	10	10
Fallen Timber Run	42	128	40	83	32	68	26	56	19	39	15	29	11	19
Fallen Timber Run	43	0	0	1,609	0	1,276	0	986	0	664	0	503	0	331
Fallen Timber Run	44	129	23	1,613	20	1,280	25	990	20	667	17	505	14	333
West Run	1	319	92	92	77	77	64	64	48	48	38	38	28	28
West Run	2	320	86	172	71	141	58	116	43	87	35	72	26	54
West Run	3	321	58	58	45	45	35	35	23	23	17	17	12	12
West Run	4	322	16	71	12	56	9	43	6	29	4	22	3	14
West Run	5	0	0	240	0	195	0	157	0	117	0	93	0	68
West Run	6	323	49	277	40	225	32	182	23	134	19	108	14	80
West Run	7	324	215	425	176	347	144	284	111	220	89	178	65	134
West Run	8	325	105	105	81	81	62	62	42	42	32	32	22	22
West Run	9	326	85	174	69	140	56	113	41	80	34	63	24	45
West Run	10	0	0	582	0	472	0	381	0	300	0	240	0	177
West Run	11	327	165	694	133	564	107	467	78	359	64	288	46	215
West Run	12	328	45	712	38	581	33	486	25	373	22	299	16	225
Wylie Run	1	131	41	41	32	32	24	24	16	16	12	12	7	7
Wylie Run	2	132	103	144	75	107	54	78	32	48	22	33	13	21
Wylie Run	3	133	24	24	19	19	14	14	9	9	7	7	4	4
Wylie Run	4	134	49	74	36	54	26	40	16	25	11	18	7	10
Wylie Run	5	135	61	128	45	97	33	72	21	45	14	31	8	18
Wylie Run	6	0	0	267	0	204	0	149	0	92	0	64	0	38

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Wylie Run	7	136	81	345	59	261	42	189	25	115	16	80	9	47
Wylie Run	8	137	49	383	36	290	25	212	15	129	10	89	5	52
Wylie Run	9	140	20	20	15	15	11	11	6	6	4	4	2	2
Wylie Run	10	141	50	67	36	48	26	33	15	19	9	12	4	6
Wylie Run	11	138	80	80	62	62	48	48	32	32	23	23	15	15
Wylie Run	12	139	86	160	64	123	48	94	31	61	23	45	15	29
Wylie Run	13	0	0	227	0	169	0	126	0	79	0	56	0	34
Wylie Run	14	142	34	255	24	190	17	142	10	88	6	62	3	37
Wylie Run	15	143	24	24	18	18	14	14	8	8	6	6	3	3
Wylie Run	16	144	51	73	36	54	25	39	15	23	10	15	5	8
Wylie Run	17	145	50	120	35	87	25	63	15	36	10	24	5	13
Wylie Run	18	0	0	374	0	278	0	204	0	124	0	85	0	49
Wylie Run	19	146	14	382	11	284	8	210	5	128	3	87	2	50
Wylie Run	20	386	49	49	37	37	27	27	16	16	10	10	5	5
Wylie Run	21	387	40	89	29	65	21	47	12	27	8	18	4	9
Wylie Run	22	0	0	449	0	336	0	251	0	152	0	104	0	59
Wylie Run	23	147	35	477	26	357	18	266	10	162	7	110	3	62
Wylie Run	24	150	25	25	19	19	14	14	9	9	6	6	3	3
Wylie Run	25	151	55	79	40	57	29	41	16	23	11	15	5	7
Wylie Run	26	148	17	17	14	14	11	11	7	7	5	5	3	3
Wylie Run	27	149	33	50	24	38	17	28	10	17	6	12	4	6
Wylie Run	28	0	0	591	0	439	0	327	0	199	0	135	0	75
Wylie Run	29	152	66	649	49	481	35	358	21	218	15	148	9	82
Wylie Run	30	0	0	1,032	0	771	0	558	0	344	0	234	0	131
Wylie Run	31	153	124	1,099	98	825	78	603	55	378	44	260	31	149
Wylie Run	32	154	23	1,106	19	831	17	609	13	384	11	264	8	152
Mile 24 Stream	1	91	13	13	10	10	8	8	5	5	3	3	2	2
Mile 24 Stream	2	92	51	63	38	47	27	34	17	21	12	14	7	8

Table B–3
Summary of Modeled Runoff and Discharge
Six Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Mile 5 Stream	1	378	15	15	12	12	9	9	6	6	4	4	2	2
Mile 5 Stream	2	388	40	52	28	37	20	29	11	17	8	12	4	6

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Table B–4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Mile 22 Stream	1	193	41	41	31	31	23	23	14	14	10	10	5	5
Mile 22 Stream	2	194	111	151	86	114	68	89	44	58	36	45	23	27
Mile 23.5 Stream	1	220	19	19	12	12	10	10	6	6	5	5	3	3
Mile 23.5 Stream	2	190	163	176	130	142	105	114	74	80	58	62	40	42
Mile 23.5 Stream	3	191	71	221	58	178	48	146	35	104	28	82	20	58
Mile 9.7 Stream	1	356	377	377	307	307	256	256	191	191	155	155	140	140
Mile 9.7 Stream	2	357	227	602	177	483	143	397	102	291	83	237	56	176
Mile 9.7 Stream	3	358	207	765	171	619	142	513	105	377	87	305	62	228
Becks Run	1	331	418	418	395	395	321	321	236	236	190	190	136	136
Becks Run	2	332	342	722	278	654	228	537	165	393	136	326	95	224
Becks Run	3	333	351	351	301	301	254	254	192	192	197	197	145	145
Becks Run	4	334	410	679	293	585	246	490	180	366	144	335	105	248
Becks Run	5	0	0	1,376	0	1,198	0	997	0	741	0	618	0	472
Becks Run	6	335	144	1,511	111	1,294	86	1,073	56	789	47	658	28	495
Becks Run	7	336	244	244	199	199	165	165	124	124	123	123	90	90
Becks Run	8	337	180	412	145	338	119	280	86	207	70	194	50	131
Becks Run	9	0	0	1,835	0	1,532	0	1,273	0	928	0	781	0	589
Becks Run	10	338	87	1,900	69	1,581	54	1,311	38	953	29	800	19	601
Beckets Run	1	11	6	6	4	4	3	3	1	1	2	2	0	0
Beckets Run	2	12	33	38	23	26	17	19	9	9	5	6	1	1
Beckets Run	3	13	47	84	33	59	24	42	12	21	7	13	2	3
Beckets Run	4	14	50	50	38	38	29	29	18	18	12	12	5	5
Beckets Run	5	15	61	111	44	81	32	59	17	33	11	21	3	7
Beckets Run	6	0	0	194	0	139	0	100	0	52	0	33	0	10
Beckets Run	7	16	38	227	27	164	19	119	10	62	7	40	3	12
Beckets Run	8	9	11	11	9	9	6	6	3	3	2	2	1	1
Beckets Run	9	10	35	46	25	33	18	23	10	12	6	8	2	2
Beckets Run	10	0	0	271	0	196	0	142	0	74	0	48	0	14

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Table B–4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Beckets Run	11	17	33	296	24	215	18	158	9	83	6	53	3	17
Beckets Run	12	6	19	19	15	15	12	12	9	9	7	7	5	5
Beckets Run	13	7	58	72	42	54	30	39	16	23	11	16	4	8
Beckets Run	14	0	0	361	0	264	0	193	0	103	0	67	0	23
Beckets Run	15	8	53	399	39	293	28	217	15	118	10	77	4	27
Beckets Run	16	3	33	33	25	25	18	18	12	12	8	8	2	2
Beckets Run	17	4	43	76	31	55	22	40	12	22	9	16	3	5
Beckets Run	18	1	14	14	10	10	7	7	2	2	1	1	1	1
Beckets Run	19	2	95	107	71	79	54	59	33	34	24	25	13	14
Beckets Run	20	0	0	181	0	133	0	98	0	56	0	39	0	18
Beckets Run	21	5	52	229	35	166	25	122	15	71	9	49	3	20
Beckets Run	22	0	0	601	0	440	0	329	0	183	0	121	0	44
Beckets Run	23	18	70	661	50	486	36	363	22	204	14	135	5	49
Beckets Run	24	19	20	20	15	15	11	11	7	7	5	5	3	3
Beckets Run	25	20	74	89	53	65	39	48	21	27	14	18	5	8
Beckets Run	26	21	8	8	6	6	4	4	2	2	1	1	1	1
Beckets Run	27	22	36	43	26	31	19	22	10	12	7	7	3	3
Beckets Run	28	0	0	132	0	96	0	70	0	38	0	24	0	11
Beckets Run	29	23	31	158	21	115	14	83	8	46	5	30	2	12
Beckets Run	30	0	0	801	0	594	0	443	0	249	0	164	0	61
Beckets Run	31	24	33	820	24	610	18	456	11	258	7	170	4	63
Belle Bridge Stream	1	196	14	14	10	10	8	8	4	4	3	3	1	1
Belle Bridge Stream	2	197	62	76	45	55	33	40	18	22	12	14	4	5
Belle Bridge Stream	3	198	31	31	22	22	16	16	8	8	4	4	5	5
Belle Bridge Stream	4	199	49	78	34	56	25	41	18	24	13	16	8	12
Belle Bridge Stream	5	0	0	153	0	110	0	80	0	46	0	29	0	16
Bunola Run	1	52	41	41	32	32	25	25	15	15	11	11	6	6
Bunola Run	2	53	40	80	30	62	22	47	13	27	9	20	5	10

Table B–4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Bunola Run	3	54	51	131	38	100	28	75	16	43	11	30	6	15
Bunola Run	4	55	85	85	64	64	47	47	28	28	18	18	8	8
Bunola Run	5	56	67	152	49	112	35	80	19	46	12	30	5	12
Bunola Run	6	0	0	282	0	208	0	152	0	87	0	60	0	28
Bunola Run	7	57	25	303	18	225	14	164	8	94	6	65	3	30
Bunola Run	8	58	20	20	14	14	11	11	7	7	4	4	2	2
Bunola Run	9	59	15	34	10	24	8	18	4	10	3	6	1	2
Bunola Run	10	0	0	328	0	245	0	180	0	103	0	70	0	32
Bunola Run	11	60	21	336	18	252	17	186	13	107	10	74	7	35
Coal Valley Run	1	208	58	58	48	48	39	39	27	27	21	21	15	15
Coal Valley Run	2	209	62	118	48	94	41	72	28	54	22	42	14	29
Coal Valley Run	3	210	182	279	146	230	118	189	84	138	66	108	45	75
Coal Valley Run	4	211	55	55	45	45	37	37	26	26	21	21	15	15
Coal Valley Run	5	212	143	185	116	157	95	131	60	87	49	70	34	49
Coal Valley Run	6	0	0	443	0	362	0	305	0	221	0	176	0	123
Coal Valley Run	7	213	16	458	12	373	9	314	5	226	4	180	2	120
Coal Valley Run	8	214	76	76	62	62	51	51	36	36	29	29	21	21
Coal Valley Run	9	215	43	110	34	90	28	73	19	52	15	41	11	32
Coal Valley Run	10	0	0	551	0	452	0	368	0	265	0	211	0	145
Coal Valley Run	11	216	58	601	45	491	35	396	24	283	18	224	12	154
Coal Valley Run	12	217	100	100	80	80	65	65	47	47	37	37	33	33
Coal Valley Run	13	218	37	138	27	107	20	84	12	58	8	45	4	37
Coal Valley Run	14	0	0	712	0	575	0	462	0	320	0	251	0	177
Coal Valley Run	15	219	35	746	25	600	17	479	10	330	7	258	2	178
Coal Valley Run	16	221	68	68	51	51	37	37	23	23	15	15	5	5
Coal Valley Run	17	222	39	106	28	78	18	55	11	34	7	23	3	7
Coal Valley Run	18	0	0	834	0	663	0	525	0	360	0	277	0	185
Coal Valley Run	19	223	84	904	64	716	49	565	32	384	25	294	15	197

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Table B–4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Coal Valley Run	20	224	17	17	13	13	10	10	6	6	4	4	2	2
Coal Valley Run	21	225	82	98	62	75	48	57	31	36	23	26	15	16
Coal Valley Run	22	226	60	156	41	112	29	83	17	51	11	36	3	19
Coal Valley Run	23	227	64	214	47	158	34	116	20	70	15	50	7	25
Coal Valley Run	24	228	67	67	47	47	32	32	19	19	12	12	4	4
Coal Valley Run	25	229	43	106	33	78	25	56	16	33	11	22	7	8
Coal Valley Run	26	0	0	1,105	0	861	0	672	0	448	0	339	0	222
Coal Valley Run	27	230	20	1,108	17	864	15	675	11	450	9	340	9	224
Coal Valley Run	28	0	0	1,207	0	934	0	727	0	482	0	361	0	232
Courain Hill Stream	1	201	20	20	15	15	11	11	6	6	5	5	2	2
Courain Hill Stream	2	202	115	134	81	95	60	70	39	45	29	33	15	17
Courain Hill Stream	3	203	18	18	14	14	10	10	6	6	5	5	3	3
Courain Hill Stream	4	204	55	73	41	55	30	41	18	24	14	19	8	10
Courain Hill Stream	5	0	0	207	0	150	0	110	0	69	0	52	0	27
Courain Hill Stream	6	205	33	236	25	172	18	128	11	79	9	60	5	30
Crooked Run	1	362	82	82	67	67	56	56	41	41	34	34	24	24
Crooked Run	2	363	251	333	205	272	167	223	118	159	94	127	67	92
Crooked Run	3	364	303	540	246	439	199	358	144	263	114	211	70	156
Crooked Run	4	365	178	178	144	144	132	132	94	94	75	75	52	52
Crooked Run	5	366	117	282	94	227	75	205	54	132	42	117	29	81
Crooked Run	6	0	0	822	0	665	0	562	0	389	0	327	0	231
Crooked Run	7	367	253	1,013	198	814	160	681	118	478	92	397	62	274
Crooked Run	8	370	332	332	275	275	262	262	192	192	156	156	111	111
Crooked Run	9	371	64	395	62	325	51	313	38	229	31	187	22	133
Crooked Run	10	368	50	50	37	37	27	27	18	18	12	12	5	5
Crooked Run	11	369	170	206	139	166	114	133	82	95	59	68	42	47
Crooked Run	12	0	0	586	0	491	0	447	0	325	0	255	0	179
Crooked Run	13	372	104	690	85	575	69	516	45	370	36	291	26	205

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Table B–4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Crooked Run	14	0	0	1,318	0	1,068	0	886	0	640	0	528	0	411
Crooked Run	15	373	83	1,347	80	1,092	66	905	49	655	39	540	28	424
Crooked Run	16	374	24	24	20	20	16	16	12	12	10	10	9	9
Crooked Run	17	375	177	200	147	167	122	138	89	101	74	83	52	61
Crooked Run	18	376	199	352	144	295	121	245	88	178	71	144	51	110
Crooked Run	19	0	0	1,575	0	1,292	0	1,060	0	813	0	671	0	515
Crooked Run	20	377	142	1,640	118	1,347	98	1,114	71	857	57	708	42	540
Curry Hollow Run	1	233	294	294	252	252	216	216	167	167	140	140	130	130
Curry Hollow Run	2	234	212	497	170	416	138	348	95	258	77	212	54	170
Curry Hollow Run	3	235	225	699	181	577	146	479	100	352	81	284	56	210
Curry Hollow Run	4	236	122	122	99	99	82	82	71	71	57	57	41	41
Curry Hollow Run	5	237	95	197	76	160	61	131	44	107	35	86	24	62
Curry Hollow Run	6	0	0	857	0	704	0	582	0	427	0	342	0	257
Curry Hollow Run	7	238	54	891	43	731	35	604	25	442	20	354	13	265
Homestead Run	1	269	261	261	219	219	213	213	158	158	129	129	93	93
Homestead Run	2	270	220	461	181	383	150	355	109	262	89	217	64	152
Homestead Run	3	271	186	612	153	507	127	451	92	331	76	274	53	192
Homestead Run	4	272	226	226	183	183	147	147	119	119	95	95	68	68
Homestead Run	5	273	198	372	161	303	130	246	94	196	68	157	48	114
Homestead Run	6	274	482	700	389	571	321	473	210	365	169	301	118	231
Homestead Run	7	275	156	820	127	670	107	558	77	430	61	354	44	269
Homestead Run	8	0	0	1,424	0	1,173	0	976	0	732	0	592	0	452
Homestead Run	9	276	271	1,595	222	1,313	182	1,093	135	812	106	661	75	506
Homestead Run	10	277	53	1,603	45	1,320	47	1,100	36	817	30	666	22	510
Kelly Run	1	40	16	16	12	12	9	9	5	5	4	4	2	2
Kelly Run	2	41	70	85	49	60	36	43	21	26	14	17	6	8
Kelly Run	3	42	11	11	8	8	6	6	3	3	1	1	1	1
Kelly Run	4	43	64	74	47	55	35	41	22	24	15	16	8	9

Table B–4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Kelly Run	5	0	0	160	0	115	0	84	0	50	0	33	0	16
Kelly Run	6	44	76	236	55	170	40	122	22	69	14	45	5	20
Kelly Run	7	45	50	277	36	202	25	146	15	84	10	55	3	23
Kelly Run	8	46	85	85	58	58	41	41	24	24	16	16	7	7
Kelly Run	9	47	39	123	27	85	19	60	11	35	8	23	3	10
Kelly Run	10	0	0	389	0	281	0	204	0	119	0	78	0	33
Kelly Run	11	48	91	477	68	347	50	253	28	146	19	97	10	43
Kelly Run	12	49	33	33	25	25	19	19	11	11	8	8	3	3
Kelly Run	13	50	34	67	25	50	18	37	10	21	7	14	3	7
Kelly Run	14	0	0	526	0	386	0	283	0	163	0	109	0	49
Kelly Run	15	51	123	623	91	462	66	342	35	197	24	131	13	61
Lobbs Run	1	156	38	38	27	27	20	20	11	11	7	7	3	3
Lobbs Run	2	157	22	60	15	42	11	30	6	17	4	10	4	7
Lobbs Run	3	158	31	31	22	22	17	17	10	10	6	6	3	3
Lobbs Run	4	159	26	57	19	41	14	31	8	17	6	12	3	5
Lobbs Run	5	0	0	114	0	82	0	60	0	34	0	22	0	11
Lobbs Run	6	160	54	167	39	120	28	88	15	48	8	29	8	19
Lobbs Run	7	161	23	23	17	17	12	12	7	7	5	5	1	1
Lobbs Run	8	162	34	55	25	40	18	28	10	14	6	10	2	3
Lobbs Run	9	0	0	221	0	159	0	115	0	62	0	39	0	21
Lobbs Run	10	163	49	269	35	193	25	140	12	74	5	43	6	26
Lobbs Run	11	381	11	11	8	8	6	6	3	3	2	2	1	1
Lobbs Run	12	380	30	40	22	29	15	20	8	10	6	7	2	2
Lobbs Run	13	0	0	305	0	220	0	159	0	84	0	51	0	28
Lobbs Run	14	164	28	328	20	237	14	173	7	91	4	55	1	29
Lobbs Run	15	165	9	9	7	7	5	5	3	3	2	2	1	1
Lobbs Run	16	166	22	31	16	22	11	16	7	9	4	6	1	2
Lobbs Run	17	0	0	355	0	257	0	187	0	100	0	61	0	31

CHESTER ENVIRONMENTAL

Table B–4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Lobbs Run	18	167	28	378	20	274	14	202	8	107	5	65	1	32
Lobbs Run	19	168	26	26	19	19	14	14	7	7	5	5	2	2
Lobbs Run	20	379	39	65	28	47	20	33	11	18	7	11	3	5
Lobbs Run	21	384	14	14	10	10	8	8	5	5	3	3	1	1
Lobbs Run	22	385	49	62	36	46	26	33	16	20	10	13	4	5
Lobbs Run	23	0	0	481	0	353	0	263	0	144	0	89	0	41
Lobbs Run	24	169	81	544	59	403	42	302	24	166	16	104	7	48
Lobbs Run	25	170	47	47	35	35	25	25	14	14	9	9	3	3
Lobbs Run	26	171	33	80	24	58	18	43	11	24	7	16	4	7
Lobbs Run	27	0	0	594	0	446	0	339	0	188	0	120	0	55
Lobbs Run	28	172	47	627	34	473	24	361	14	202	10	129	4	59
Lobbs Run	29	173	26	26	21	21	17	17	12	12	9	9	7	7
Lobbs Run	30	174	36	59	28	48	22	39	15	26	11	20	8	14
Lobbs Run	31	175	35	35	27	27	20	20	11	11	8	8	5	5
Lobbs Run	32	176	31	64	23	49	17	37	11	22	8	15	4	9
Lobbs Run	33	0	0	122	0	94	0	73	0	46	0	33	0	22
Lobbs Run	34	177	79	200	57	151	41	113	23	69	18	51	7	29
Lobbs Run	35	178	16	16	12	12	9	9	5	5	4	4	2	2
Lobbs Run	36	179	19	34	14	25	10	18	5	10	3	6	1	3
Lobbs Run	37	0	0	231	0	175	0	131	0	79	0	57	0	31
Lobbs Run	38	180	11	240	8	183	6	137	3	82	2	59	1	31
Lobbs Run	39	181	32	32	23	23	17	17	10	10	7	7	3	3
Lobbs Run	40	182	30	61	21	44	16	32	9	18	6	12	2	5
Lobbs Run	41	0	0	299	0	224	0	169	0	100	0	70	0	35
Lobbs Run	42	183	34	331	25	248	18	187	11	110	7	77	3	38
Lobbs Run	43	0	0	904	0	679	0	532	0	300	0	197	0	90
Lobbs Run	44	184	58	958	42	720	30	562	18	318	12	209	5	95
Lobbs Run	45	185	35	35	26	26	20	20	13	13	10	10	6	6

CHESTER ENVIRONMENTAL

Table B–4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Lobbs Run	46	186	18	51	13	38	9	29	5	17	4	13	1	6
Lobbs Run	47	0	0	981	0	739	0	576	0	328	0	216	0	99
Lobbs Run	48	187	105	1,038	84	788	68	614	48	355	38	238	26	114
Mill Run	1	66	32	32	24	24	17	17	9	9	5	5	2	2
Mill Run	2	67	56	88	40	63	29	44	15	24	10	15	4	6
Mill Run	3	64	110	110	79	79	55	55	29	29	19	19	7	7
Mill Run	4	65	62	170	43	121	31	85	19	47	13	31	6	12
Mill Run	5	0	0	255	0	184	0	130	0	71	0	46	0	18
Mill Run	6	68	122	371	87	268	63	192	33	104	21	67	6	24
Mill Run	7	69	21	21	16	16	12	12	8	8	6	6	3	3
Mill Run	8	70	29	50	21	36	15	27	8	16	6	11	2	5
Mill Run	9	0	0	414	0	300	0	219	0	118	0	76	0	28
Mill Run	10	71	53	466	38	338	27	246	15	132	10	85	4	31
Mill Run	11	72	47	47	34	34	25	25	13	13	9	9	4	4
Mill Run	12	73	54	101	39	73	28	52	17	30	11	20	4	8
Mill Run	13	0	0	563	0	408	0	297	0	162	0	105	0	39
Mill Run	14	74	61	616	44	447	31	328	17	179	11	115	4	43
Mill Run	15	75	31	31	24	24	19	19	12	12	9	9	5	5
Mill Run	16	76	27	57	19	42	14	32	7	19	5	13	1	6
Mill Run	17	77	18	18	14	14	11	11	7	7	5	5	3	3
Mill Run	18	78	23	40	16	29	12	21	6	12	4	8	1	4
Mill Run	19	0	0	97	0	71	0	53	0	30	0	20	0	9
Mill Run	20	79	46	142	32	103	24	76	13	42	8	27	2	10
Mill Run	21	0	0	737	0	533	0	395	0	219	0	140	0	51
Mill Run	22	80	84	819	61	594	44	439	25	242	16	156	6	57
Mill Run	23	81	31	31	23	23	17	17	10	10	7	7	3	3
Mill Run	24	82	61	89	43	63	31	45	16	24	9	15	2	4
Mill Run	25	0	0	895	0	648	0	480	0	265	0	169	0	61

CHESTER ENVIRONMENTAL

Table B-4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Mill Run	26	83	67	954	49	692	35	513	19	284	13	182	5	66
Mill Run	27	84	17	17	13	13	10	10	6	6	4	4	1	1
Mill Run	28	85	21	37	15	28	10	19	6	11	4	8	1	2
Mill Run	29	86	10	10	8	8	6	6	4	4	3	3	1	1
Mill Run	30	87	23	34	17	25	12	18	6	10	4	6	2	2
Mill Run	31	0	0	70	0	52	0	37	0	21	0	14	0	5
Mill Run	32	88	77	145	56	107	40	75	22	41	15	26	6	10
Mill Run	33	0	0	1,071	0	778	0	579	0	324	0	208	0	76
Mill Run	34	89	28	1,085	21	789	15	588	9	330	7	212	4	78
River Hill Stream	1	36	33	33	23	23	17	17	10	10	5	5	6	6
River Hill Stream	2	37	34	67	25	48	18	35	10	21	7	12	4	9
River Hill Stream	3	38	64	130	46	92	33	67	17	37	11	22	4	12
Smiths Run	1	94	19	19	14	14	11	11	6	6	4	4	2	2
Smiths Run	2	95	40	58	30	44	24	33	15	21	12	16	7	9
Sunfish Run	1	25	12	12	8	8	6	6	2	2	1	1	1	1
Sunfish Run	2	26	88	97	65	70	47	50	26	27	17	18	7	8
Sunfish Run	3	27	66	152	48	112	33	80	18	43	11	28	4	12
Sunfish Run	4	28	21	21	16	16	11	11	7	7	3	3	3	3
Sunfish Run	5	29	35	55	25	39	18	28	9	14	6	8	1	4
Sunfish Run	6	0	0	207	0	149	0	107	0	57	0	36	0	15
Sunfish Run	7	30	60	267	43	192	29	135	17	74	11	47	3	18
Sunfish Run	8	31	35	35	25	25	19	19	11	11	7	7	4	4
Sunfish Run	9	32	49	84	34	58	26	44	14	25	10	16	4	8
Sunfish Run	10	0	0	344	0	248	0	177	0	97	0	62	0	25
Sunfish Run	11	33	13	349	11	252	9	179	6	99	5	64	3	26
Streets Run	1	278	169	169	137	137	118	118	90	90	73	73	54	54
Streets Run	2	279	244	413	201	336	189	290	137	212	112	173	79	131
Streets Run	3	280	504	504	403	403	329	329	237	237	189	189	132	132

CHESTER ENVIRONMENTAL

Table B–4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Streets Run	4	281	183	678	149	547	125	449	91	326	73	261	53	181
Streets Run	5	0	0	1,182	0	951	0	778	0	564	0	450	0	309
Streets Run	6	282	327	1,405	261	1,129	192	928	139	680	112	544	80	375
Streets Run	7	283	224	224	214	214	176	176	128	128	104	104	74	74
Streets Run	8	284	111	322	91	301	75	248	53	179	43	147	30	101
Streets Run	9	0	0	1,725	0	1,354	0	1,115	0	820	0	668	0	463
Streets Run	10	285	322	1,929	263	1,523	221	1,264	159	928	127	757	93	535
Streets Run	11	286	442	2,144	359	1,696	292	1,404	206	1,022	164	831	115	592
Streets Run	12	287	900	900	748	748	628	628	417	417	340	340	245	245
Streets Run	13	288	287	1,158	233	959	195	803	142	547	113	446	82	326
Streets Run	14	0	0	2,733	0	2,202	0	1,841	0	1,366	0	1,123	0	873
Streets Run	15	289	50	2,772	36	2,232	26	1,863	14	1,379	11	1,133	5	876
Streets Run	16	290	172	172	144	144	119	119	109	109	89	89	65	65
Streets Run	17	291	256	420	205	341	168	284	121	213	100	186	70	134
Streets Run	18	292	387	387	324	324	269	269	240	240	195	195	141	141
Streets Run	19	293	112	482	81	401	65	332	47	286	37	232	26	167
Streets Run	20	0	0	895	0	738	0	616	0	499	0	418	0	301
Streets Run	21	294	121	1,003	93	818	72	678	46	538	38	448	23	318
Streets Run	22	0	0	3,538	0	2,918	0	2,423	0	1,862	0	1,542	0	1,152
Streets Run	23	295	63	3,577	48	2,949	37	2,448	24	1,878	20	1,554	12	1,157
Streets Run	24	296	513	513	426	426	360	360	274	274	223	223	162	162
Streets Run	25	297	321	816	265	672	217	557	159	408	130	339	93	239
Streets Run	26	0	0	4,065	0	3,350	0	2,803	0	2,174	0	1,800	0	1,332
Streets Run	27	298	72	4,091	64	3,372	52	2,821	37	2,186	30	1,810	21	1,338
Streets Run	28	299	64	64	52	52	44	44	33	33	27	27	24	24
Streets Run	29	300	184	243	150	202	125	168	89	122	72	99	52	75
Streets Run	30	301	207	424	167	352	136	290	98	220	77	176	54	126
Streets Run	31	0	0	4,362	0	3,580	0	2,999	0	2,310	0	1,910	0	1,409

Table B–4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Streets Run	32	302	98	4,410	75	3,622	61	3,033	42	2,330	32	1,925	21	1,417
Streets Run	33	303	29	29	22	22	17	17	11	11	7	7	7	7
Streets Run	34	304	39	68	30	52	24	40	16	26	12	18	8	15
Streets Run	35	0	0	4,447	0	3,655	0	3,059	0	2,345	0	1,935	0	1,424
Streets Run	36	305	128	4,529	96	3,723	74	3,111	46	2,374	34	1,955	21	1,431
Streets Run	37	306	87	87	69	69	56	56	41	41	33	33	29	29
Streets Run	38	307	164	249	130	196	104	158	74	114	57	89	38	67
Streets Run	39	308	139	139	114	114	110	110	82	82	66	66	47	47
Streets Run	40	309	92	226	70	180	55	157	35	116	27	92	16	63
Streets Run	41	0	0	474	0	376	0	315	0	225	0	179	0	123
Streets Run	42	310	90	558	68	439	51	362	35	258	26	204	15	137
Streets Run	43	0	0	4,824	0	3,982	0	3,308	0	2,493	0	2,045	0	1,483
Streets Run	44	311	121	4,862	96	4,013	78	3,333	56	2,510	45	2,058	31	1,491
Streets Run	45	312	56	56	39	39	28	28	16	16	8	8	9	9
Streets Run	46	313	50	88	40	68	32	51	22	34	21	25	15	21
Streets Run	47	314	237	237	194	194	160	160	116	116	93	93	67	67
Streets Run	48	315	139	346	111	281	91	231	65	168	52	135	37	91
Streets Run	49	316	211	538	165	432	130	350	88	237	74	203	47	138
Streets Run	50	317	114	643	85	510	60	404	40	265	29	228	15	150
Streets Run	51	0	0	5,352	0	4,397	0	3,593	0	2,667	0	2,177	0	1,563
Streets Run	52	318	136	5,381	99	4,422	84	3,615	61	2,681	50	2,189	36	1,572
Thompson Run	1	240	1,458	1,458	1,201	1,201	995	995	657	657	531	531	378	378
Thompson Run	2	241	698	2,156	564	1,765	480	1,459	346	990	275	800	194	567
Thompson Run	3	242	216	2,349	172	1,918	133	1,576	96	1,079	75	869	50	611
Thompson Run	4	243	130	130	108	108	88	88	76	76	61	61	44	44
Thompson Run	5	244	23	153	17	124	13	101	8	82	6	65	4	46
Thompson Run	6	246	22	22	18	18	15	15	11	11	9	9	8	8
Thompson Run	7	245	40	62	32	50	26	41	22	32	18	27	12	19

Table B–4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Thompson Run	8	0	0	204	0	164	0	135	0	107	0	85	0	59
Thompson Run	9	247	32	236	24	187	17	152	9	116	5	90	6	64
Thompson Run	10	248	222	364	181	293	148	239	106	163	85	139	60	109
Thompson Run	11	0	0	2,668	0	2,177	0	1,788	0	1,241	0	1,006	0	716
Thompson Run	12	249	134	2,733	109	2,230	89	1,831	65	1,272	52	1,032	37	734
Thompson Run	13	250	66	66	52	52	41	41	27	27	21	21	15	15
Thompson Run	14	251	48	112	36	86	27	68	18	45	14	35	8	22
Thompson Run	15	0	0	2,828	0	2,301	0	1,887	0	1,308	0	1,057	0	749
Thompson Run	16	252	173	2,901	139	2,359	113	1,934	82	1,341	66	1,084	47	768
Thompson Run	17	253	28	28	21	21	16	16	10	10	6	6	3	3
Thompson Run	18	254	44	67	34	52	27	40	18	25	13	18	8	11
Thompson Run	19	255	97	97	91	91	73	73	54	54	43	43	31	31
Thompson Run	20	256	68	159	53	139	40	113	28	80	22	62	15	45
Thompson Run	21	0	0	226	0	190	0	152	0	104	0	78	0	55
Thompson Run	22	257	20	244	15	205	11	163	7	110	5	83	2	57
Thompson Run	23	0	0	3,083	0	2,507	0	2,049	0	1,413	0	1,136	0	801
Thompson Run	24	258	402	3,313	329	2,696	271	2,206	202	1,527	161	1,229	112	868
Thompson Run	25	259	162	162	135	135	111	111	102	102	83	83	61	61
Thompson Run	26	260	329	448	271	385	231	329	167	265	133	216	94	155
Thompson Run	27	0	0	3,552	0	2,897	0	2,375	0	1,652	0	1,332	0	945
Thompson Run	28	261	196	3,590	163	2,929	136	2,404	101	1,675	82	1,352	59	960
Thompson Run	29	262	498	3,769	415	3,084	345	2,539	256	1,780	212	1,442	154	1,031
Fallen Timber Run	1	97	18	18	12	12	9	9	5	5	2	2	2	2
Fallen Timber Run	2	98	50	68	36	48	27	35	15	19	10	12	4	6
Fallen Timber Run	3	99	25	25	18	18	14	14	8	8	5	5	2	2
Fallen Timber Run	4	100	34	56	24	42	18	31	10	18	7	12	4	6
Fallen Timber Run	5	0	0	123	0	88	0	65	0	37	0	24	0	12
Fallen Timber Run	6	101	92	215	68	155	50	113	30	65	20	42	9	20

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Table B–4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Fallen Timber Run	7	102	26	26	20	20	15	15	11	11	8	8	5	5
Fallen Timber Run	8	103	36	60	26	44	18	31	11	19	7	13	2	6
Fallen Timber Run	9	0	0	272	0	198	0	143	0	84	0	54	0	24
Fallen Timber Run	10	104	51	315	38	230	27	168	15	98	10	64	5	29
Fallen Timber Run	11	105	21	21	16	16	12	12	7	7	5	5	3	3
Fallen Timber Run	12	106	58	79	43	59	32	44	18	25	12	17	7	9
Fallen Timber Run	13	0	0	388	0	286	0	210	0	122	0	80	0	38
Fallen Timber Run	14	107	96	450	72	335	57	250	38	148	30	101	21	52
Fallen Timber Run	15	110	7	7	6	6	4	4	2	2	1	1	0	0
Fallen Timber Run	16	111	19	26	13	19	9	13	5	7	4	5	1	1
Fallen Timber Run	17	108	31	31	23	23	17	17	10	10	6	6	2	2
Fallen Timber Run	18	109	104	133	77	99	56	72	36	45	27	31	13	14
Fallen Timber Run	19	0	0	159	0	116	0	85	0	53	0	35	0	15
Fallen Timber Run	20	112	87	243	63	178	46	130	26	78	17	52	8	22
Fallen Timber Run	21	0	0	680	0	496	0	379	0	223	0	151	0	74
Fallen Timber Run	22	113	42	695	35	507	29	391	21	232	17	158	16	80
Fallen Timber Run	23	114	60	60	44	44	32	32	20	20	14	14	7	7
Fallen Timber Run	24	115	59	117	42	85	30	61	16	35	12	25	4	10
Fallen Timber Run	25	116	17	17	13	13	9	9	5	5	3	3	1	1
Fallen Timber Run	26	117	290	295	242	245	201	205	150	151	124	126	90	90
Fallen Timber Run	27	0	0	1,003	0	784	0	615	0	397	0	294	0	178
Fallen Timber Run	28	118	88	1,057	65	830	52	651	36	422	28	314	17	189
Fallen Timber Run	29	122	519	519	429	429	355	355	260	260	209	209	133	133
Fallen Timber Run	30	382	59	578	43	472	32	387	18	278	14	223	7	140
Fallen Timber Run	31	0	0	1,447	0	1,186	0	932	0	663	0	511	0	324
Fallen Timber Run	32	119	83	1,521	63	1,238	48	971	30	689	22	530	14	335
Fallen Timber Run	33	120	45	45	33	33	24	24	13	13	8	8	4	4
Fallen Timber Run	34	121	70	114	51	82	36	58	20	31	14	22	5	8

Table B–4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Fallen Timber Run	35	0	0	1,634	0	1,318	0	1,028	0	720	0	551	0	342
Fallen Timber Run	36	123	73	1,677	60	1,347	48	1,052	34	737	26	565	18	351
Fallen Timber Run	37	124	36	36	28	28	21	21	13	13	9	9	5	5
Fallen Timber Run	38	125	39	74	31	56	24	43	16	27	12	20	8	12
Fallen Timber Run	39	0	0	1,724	0	1,380	0	1,078	0	756	0	579	0	359
Fallen Timber Run	40	126	75	1,759	61	1,405	50	1,099	37	774	29	593	21	371
Fallen Timber Run	41	127	62	62	50	50	38	38	24	24	18	18	10	10
Fallen Timber Run	42	128	49	110	39	86	32	69	24	47	19	37	13	24
Fallen Timber Run	43	0	0	1,811	0	1,443	0	1,131	0	799	0	613	0	386
Fallen Timber Run	44	129	65	1,816	54	1,446	45	1,133	36	802	31	615	25	389
West Run	1	319	155	155	129	129	108	108	80	80	66	66	60	60
West Run	2	320	152	263	124	220	102	184	75	138	60	113	43	94
West Run	3	321	74	74	58	58	46	46	31	31	27	27	19	19
West Run	4	322	19	91	15	71	11	56	8	37	6	29	4	23
West Run	5	0	0	344	0	283	0	235	0	170	0	143	0	112
West Run	6	323	81	397	67	329	54	272	40	198	31	165	22	127
West Run	7	324	269	587	221	485	188	403	135	296	109	245	76	189
West Run	8	325	134	134	116	116	92	92	67	67	52	52	35	35
West Run	9	326	106	226	88	199	73	161	53	120	43	95	30	65
West Run	10	0	0	752	0	618	0	502	0	372	0	302	0	238
West Run	11	327	207	872	167	714	138	578	100	430	81	358	58	276
West Run	12	328	72	891	60	730	51	599	38	449	31	371	23	285
Wylie Run	1	131	51	51	40	40	31	31	20	20	16	16	12	12
Wylie Run	2	132	105	151	78	113	56	85	33	52	36	50	12	23
Wylie Run	3	133	30	30	23	23	18	18	11	11	8	8	5	5
Wylie Run	4	134	52	80	37	58	27	44	18	28	26	33	7	11
Wylie Run	5	135	65	142	49	107	36	80	21	49	23	54	9	19
Wylie Run	6	0	0	288	0	218	0	162	0	99	0	104	0	42

Table B–4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

Stream Name	MODEL ID	WATERSHED ID	RUNOFF AND DISCHARGE (CFS)											
			100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
			RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Wylie Run	7	136	82	370	60	278	43	205	24	122	65	166	8	49
Wylie Run	8	137	50	411	37	310	26	229	15	137	24	187	5	54
Wylie Run	9	140	22	22	16	16	11	11	7	7	4	4	1	1
Wylie Run	10	141	49	69	35	49	25	33	13	18	58	61	3	4
Wylie Run	11	138	101	101	79	79	62	62	42	42	32	32	25	25
Wylie Run	12	139	92	187	68	148	52	114	36	76	89	118	16	41
Wylie Run	13	0	0	255	0	192	0	144	0	91	0	179	0	43
Wylie Run	14	142	34	285	25	216	18	160	10	101	18	194	3	46
Wylie Run	15	143	26	26	20	20	15	15	9	9	6	6	2	2
Wylie Run	16	144	49	76	36	56	26	40	16	24	35	39	5	7
Wylie Run	17	145	48	123	35	91	25	65	15	38	36	73	4	11
Wylie Run	18	0	0	408	0	305	0	220	0	136	0	267	0	53
Wylie Run	19	146	15	417	11	313	8	227	5	140	5	271	1	54
Wylie Run	20	386	54	54	38	38	27	27	16	16	10	10	4	4
Wylie Run	21	387	42	95	28	66	20	47	12	27	19	28	3	8
Wylie Run	22	0	0	491	0	373	0	273	0	167	0	297	0	60
Wylie Run	23	147	36	522	26	396	18	290	10	177	19	311	3	63
Wylie Run	24	150	29	29	22	22	16	16	9	9	5	5	2	2
Wylie Run	25	151	56	83	40	60	29	42	16	22	53	56	3	5
Wylie Run	26	148	21	21	17	17	13	13	8	8	6	6	3	3
Wylie Run	27	149	33	54	24	41	18	30	10	17	22	27	4	6
Wylie Run	28	0	0	643	0	486	0	358	0	215	0	382	0	72
Wylie Run	29	152	68	704	50	530	37	391	22	235	51	414	9	79
Wylie Run	30	0	0	1,114	0	837	0	613	0	368	0	579	0	129
Wylie Run	31	153	179	1,186	145	896	117	660	84	407	91	611	45	150
Wylie Run	32	154	48	1,193	40	902	34	665	25	413	34	614	15	155
Mile 24 Stream	1	91	15	15	12	12	9	9	5	5	3	3	1	1
Mile 24 Stream	2	92	52	66	39	49	29	36	18	23	13	16	7	8

Table B–4
Summary of Modeled Runoff and Discharge
Three Hour Storm Duration

			RUNOFF AND DISCHARGE (CFS)											
	MODEL	WATERSHED	100 YEAR		50 YEAR		25 YEAR		10 YEAR		5 YEAR		2 YEAR	
Stream Name	ID	ID	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE	RUNOFF	DISCHARGE
Mile 5 Stream	1	378	20	20	17	17	13	13	8	8	9	9	5	5
Mile 5 Stream	2	388	39	58	28	40	20	30	11	18	7	15	3	7

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Table B–5
Comparison of Current and Future
Modeled Stream Discharges
50 Year Frequency Twenty–Four Hour Storm Duration

Stream Name	Model ID	Watershed ID	Discharge (cfs) Current	Future
Mile 22 Stream	1	193	42	45
Mile 22 Stream	2	194	364	364
Mile 23.5 Stream	1	220	13	15
Mile 23.5 Stream	2	190	313	325
Mile 23.5 Stream	3	191	346	358
Mile 9.7 Stream	1	356	270	301
Mile 9.7 Stream	2	357	681	837
Mile 9.7 Stream	3	358	826	1,012
Becks Run	1	331	315	361
Becks Run	2	332	712	842
Becks Run	3	333	205	206
Becks Run	4	334	567	590
Becks Run	5	0	1,279	1,432
Becks Run	6	335	1,553	1,743
Becks Run	7	336	170	177
Becks Run	8	337	483	500
Becks Run	9	0	1,965	2,191
Becks Run	10	338	2,062	2,293
Beckets Run	1	11	6	6
Beckets Run	2	12	105	112
Beckets Run	3	13	239	262
Beckets Run	4	14	51	52
Beckets Run	5	15	237	278
Beckets Run	6	0	476	540
Beckets Run	7	16	527	607
Beckets Run	8	9	12	14
Beckets Run	9	10	135	158
Beckets Run	10	0	638	739
Beckets Run	11	17	678	780
Beckets Run	12	6	15	16
Beckets Run	13	7	287	318
Beckets Run	14	0	892	1,022
Beckets Run	15	8	950	1,081
Beckets Run	16	3	34	47
Beckets Run	17	4	142	202
Beckets Run	18	1	16	23
Beckets Run	19	2	305	383
Beckets Run	20	0	447	585
Beckets Run	21	5	518	671
Beckets Run	22	0	1,437	1,720
Beckets Run	23	18	1,536	1,837
Beckets Run	24	19	16	16
Beckets Run	25	20	317	336
Beckets Run	26	21	8	8
Beckets Run	27	22	147	151
Beckets Run	28	0	464	487
Beckets Run	29	23	507	531
Beckets Run	30	0	1,930	2,277
Beckets Run	31	24	1,949	2,295
Belle Bridge Stream	1	196	16	21
Belle Bridge Stream	2	197	243	276
Belle Bridge Stream	3	198	36	51
Belle Bridge Stream	4	199	124	149
Belle Bridge Stream	5	0	366	426
Bunola Run	1	52	40	40
Bunola Run	2	53	181	171
Bunola Run	3	54	324	297
Bunola Run	4	55	98	95
Bunola Run	5	56	325	317
Bunola Run	6	0	648	614
Bunola Run	7	57	694	658
Bunola Run	8	58	19	18
Bunola Run	9	59	75	80
Bunola Run	10	0	756	719
Bunola Run	11	60	767	730
Coal Valley Run	1	208	47	52
Coal Valley Run	2	209	123	141
Coal Valley Run	3	210	409	482
Coal Valley Run	4	211	41	42
Coal Valley Run	5	212	217	223
Coal Valley Run	6	0	625	705
Coal Valley Run	7	213	645	725
Coal Valley Run	8	214	55	57
Coal Valley Run	9	215	114	119
Coal Valley Run	10	0	745	828
Coal Valley Run	11	216	800	882
Coal Valley Run	12	217	80	93
Coal Valley Run	13	218	169	203
Coal Valley Run	14	0	936	1,041
Coal Valley Run	15	219	996	1,101

Table B–5
Comparison of Current and Future
Modeled Stream Discharges
50 Year Frequency Twenty–Four Hour Storm Duration

Stream Name	Model ID	Watershed ID	Discharge (cfs) Current	Future
Coal Valley Run	16	221	72	114
Coal Valley Run	17	222	169	259
Coal Valley Run	18	0	1,122	1,310
Coal Valley Run	19	223	1,245	1,436
Coal Valley Run	20	224	17	20
Coal Valley Run	21	225	220	301
Coal Valley Run	22	226	451	612
Coal Valley Run	23	227	565	757
Coal Valley Run	24	228	88	137
Coal Valley Run	25	229	191	262
Coal Valley Run	26	0	1,767	2,171
Coal Valley Run	27	230	1,770	2,173
Coal Valley Run	28	0	1,919	2,386
Courain Hill Stream	1	201	21	29
Courain Hill Stream	2	202	370	464
Courain Hill Stream	3	203	17	19
Courain Hill Stream	4	204	158	161
Courain Hill Stream	5	0	519	624
Courain Hill Stream	6	205	563	671
Crooked Run	1	362	54	63
Crooked Run	2	363	431	550
Crooked Run	3	364	711	909
Crooked Run	4	365	153	202
Crooked Run	5	366	351	441
Crooked Run	6	0	1,053	1,349
Crooked Run	7	367	1,356	1,681
Crooked Run	8	370	246	258
Crooked Run	9	371	295	308
Crooked Run	10	368	51	72
Crooked Run	11	369	222	258
Crooked Run	12	0	10	10
Crooked Run	13	372	112	120
Crooked Run	14	0	1,398	1,778
Crooked Run	15	373	1,419	1,813
Crooked Run	16	374	17	19
Crooked Run	17	375	272	293
Crooked Run	18	376	451	489
Crooked Run	19	0	1,781	2,248
Crooked Run	20	377	1,838	2,302
Curry Hollow Run	1	233	133	135
Curry Hollow Run	2	234	551	659
Curry Hollow Run	3	235	921	1,105
Curry Hollow Run	4	236	92	114
Curry Hollow Run	5	237	207	250
Curry Hollow Run	6	0	1,118	1,356
Curry Hollow Run	7	238	1,168	1,414
Homestead Run	1	269	178	181
Homestead Run	2	270	479	511
Homestead Run	3	271	701	783
Homestead Run	4	272	194	231
Homestead Run	5	273	367	426
Homestead Run	6	274	699	812
Homestead Run	7	275	841	964
Homestead Run	8	0	1,523	1,717
Homestead Run	9	276	1,741	1,960
Homestead Run	10	277	1,747	1,966
Kelly Run	1	40	16	17
Kelly Run	2	41	275	276
Kelly Run	3	42	12	12
Kelly Run	4	43	199	202
Kelly Run	5	0	468	479
Kelly Run	6	44	691	707
Kelly Run	7	45	755	780
Kelly Run	8	46	104	108
Kelly Run	9	47	187	194
Kelly Run	10	0	932	961
Kelly Run	11	48	1,109	1,119
Kelly Run	12	49	34	34
Kelly Run	13	50	136	126
Kelly Run	14	0	1,169	1,183
Kelly Run	15	51	1,298	1,305
Lobbs Run	1	156	48	79
Lobbs Run	2	157	82	125
Lobbs Run	3	158	33	36
Lobbs Run	4	159	147	165
Lobbs Run	5	0	228	289
Lobbs Run	6	160	345	451
Lobbs Run	7	161	24	31
Lobbs Run	8	162	179	211
Lobbs Run	9	0	512	655

Table B-5
Comparison of Current and Future
Modeled Stream Discharges
50 Year Frequency Twenty-Four Hour Storm Duration

Stream Name	Model ID	Watershed ID	Discharge (cfs) Current	Future
Lobbs Run	10	163	591	765
Lobbs Run	11	381	11	13
Lobbs Run	12	380	112	129
Lobbs Run	13	0	682	868
Lobbs Run	14	164	713	901
Lobbs Run	15	165	9	11
Lobbs Run	16	166	106	125
Lobbs Run	17	0	772	978
Lobbs Run	18	167	798	1,013
Lobbs Run	19	168	29	34
Lobbs Run	20	379	152	173
Lobbs Run	21	384	13	15
Lobbs Run	22	385	285	350
Lobbs Run	23	0	1,056	1,369
Lobbs Run	24	169	1,181	1,495
Lobbs Run	25	170	51	57
Lobbs Run	26	171	133	136
Lobbs Run	27	0	1,290	1,611
Lobbs Run	28	172	1,341	1,665
Lobbs Run	29	173	20	20
Lobbs Run	30	174	85	91
Lobbs Run	31	175	41	49
Lobbs Run	32	176	94	104
Lobbs Run	33	0	179	195
Lobbs Run	34	177	399	472
Lobbs Run	35	178	17	21
Lobbs Run	36	179	65	75
Lobbs Run	37	0	460	548
Lobbs Run	38	180	476	570
Lobbs Run	39	181	33	36
Lobbs Run	40	182	124	131
Lobbs Run	41	0	592	701
Lobbs Run	42	183	663	770
Lobbs Run	43	0	1,921	2,324
Lobbs Run	44	184	2,021	2,421
Lobbs Run	45	185	27	24
Lobbs Run	46	186	83	89
Lobbs Run	47	0	2,050	2,452
Lobbs Run	48	187	2,132	2,540
Mill Run	1	66	37	39
Mill Run	2	67	172	180
Mill Run	3	64	140	162
Mill Run	4	65	242	288
Mill Run	5	0	414	467
Mill Run	6	68	583	686
Mill Run	7	69	20	19
Mill Run	8	70	129	142
Mill Run	9	0	683	811
Mill Run	10	71	783	936
Mill Run	11	72	57	77
Mill Run	12	73	296	362
Mill Run	13	0	1,035	1,252
Mill Run	14	74	1,130	1,347
Mill Run	15	75	28	28
Mill Run	16	76	107	125
Mill Run	17	77	18	21
Mill Run	18	78	81	95
Mill Run	19	0	188	220
Mill Run	20	79	307	349
Mill Run	21	0	1,407	1,672
Mill Run	22	80	1,564	1,845
Mill Run	23	81	32	36
Mill Run	24	82	358	394
Mill Run	25	0	1,778	2,063
Mill Run	26	83	1,879	2,160
Mill Run	27	84	16	19
Mill Run	28	85	52	60
Mill Run	29	86	10	12
Mill Run	30	87	63	72
Mill Run	31	0	115	131
Mill Run	32	88	370	379
Mill Run	33	0	2,151	2,490
Mill Run	34	89	2,171	2,509
River Hill Stream	1	36	36	43
River Hill Stream	2	37	138	169
River Hill Stream	3	38	440	506
Smiths Run	1	94	21	36
Smiths Run	2	95	148	193
Sunfish Run	1	25	12	18
Sunfish Run	2	26	485	520

Table B–5
Comparison of Current and Future
Modeled Stream Discharges
50 Year Frequency Twenty–Four Hour Storm Duration

Stream Name	Model ID	Watershed ID	Discharge (cfs) Current	Future
Sunfish Run	3	27	581	617
Sunfish Run	4	28	24	24
Sunfish Run	5	29	151	151
Sunfish Run	6	0	716	752
Sunfish Run	7	30	855	881
Sunfish Run	8	31	41	41
Sunfish Run	9	32	200	210
Sunfish Run	10	0	993	1,023
Sunfish Run	11	33	998	1,027
Streets Run	1	278	111	128
Streets Run	2	279	282	310
Streets Run	3	280	392	442
Streets Run	4	281	565	626
Streets Run	5	0	940	1,043
Streets Run	6	282	1,168	1,308
Streets Run	7	283	168	171
Streets Run	8	284	344	356
Streets Run	9	0	1,478	1,641
Streets Run	10	285	1,736	1,933
Streets Run	11	286	1,988	2,215
Streets Run	12	287	494	467
Streets Run	13	288	794	744
Streets Run	14	0	2,710	2,907
Streets Run	15	289	2,761	2,958
Streets Run	16	290	114	116
Streets Run	17	291	541	574
Streets Run	18	292	265	278
Streets Run	19	293	424	460
Streets Run	20	0	964	1,034
Streets Run	21	294	1,175	1,271
Streets Run	22	0	3,936	4,221
Streets Run	23	295	3,984	4,271
Streets Run	24	296	406	413
Streets Run	25	297	788	766
Streets Run	26	0	4,470	4,781
Streets Run	27	298	4,490	4,803
Streets Run	28	299	44	45
Streets Run	29	300	290	316
Streets Run	30	301	672	768
Streets Run	31	0	4,920	5,301
Streets Run	32	302	4,976	5,356
Streets Run	33	303	32	45
Streets Run	34	304	131	162
Streets Run	35	0	5,024	5,407
Streets Run	36	305	5,145	5,536
Streets Run	37	306	70	87
Streets Run	38	307	473	578
Streets Run	39	308	101	106
Streets Run	40	309	366	463
Streets Run	41	0	837	1,041
Streets Run	42	310	1,001	1,222
Streets Run	43	0	5,609	6,020
Streets Run	44	311	5,644	6,055
Streets Run	45	312	70	101
Streets Run	46	313	107	146
Streets Run	47	314	158	166
Streets Run	48	315	289	316
Streets Run	49	316	646	835
Streets Run	50	317	875	1,097
Streets Run	51	0	6,328	6,819
Streets Run	52	318	6,351	6,843
Thompson Run	1	240	927	883
Thompson Run	2	241	1,852	2,038
Thompson Run	3	242	2,126	2,451
Thompson Run	4	243	98	117
Thompson Run	5	244	127	165
Thompson Run	6	246	16	17
Thompson Run	7	245	58	68
Thompson Run	8	0	182	233
Thompson Run	9	247	263	370
Thompson Run	10	248	435	599
Thompson Run	11	0	2,545	3,024
Thompson Run	12	249	2,607	3,101
Thompson Run	13	250	57	71
Thompson Run	14	251	222	282
Thompson Run	15	0	2,755	3,299
Thompson Run	16	252	2,826	3,384
Thompson Run	17	253	27	29
Thompson Run	18	254	112	136
Thompson Run	19	255	76	85

Table B–5
Comparison of Current and Future
Modeled Stream Discharges
50 Year Frequency Twenty–Four Hour Storm Duration

Stream Name	Model ID	Watershed ID	Discharge (cfs) Current	Future
Thompson Run	20	256	184	212
Thompson Run	21	0	296	348
Thompson Run	22	257	329	381
Thompson Run	23	0	3,061	3,689
Thompson Run	24	258	3,347	4,005
Thompson Run	25	259	109	113
Thompson Run	26	260	643	672
Thompson Run	27	0	3,621	4,292
Thompson Run	28	261	3,653	4,325
Thompson Run	29	262	3,816	4,506
Fallen Timber Run	1	97	20	23
Fallen Timber Run	2	98	199	238
Fallen Timber Run	3	99	25	29
Fallen Timber Run	4	100	81	87
Fallen Timber Run	5	0	277	325
Fallen Timber Run	6	101	557	627
Fallen Timber Run	7	102	28	33
Fallen Timber Run	8	103	153	172
Fallen Timber Run	9	0	706	789
Fallen Timber Run	10	104	780	878
Fallen Timber Run	11	105	23	26
Fallen Timber Run	12	106	216	223
Fallen Timber Run	13	0	960	1,069
Fallen Timber Run	14	107	1,057	1,161
Fallen Timber Run	15	110	7	9
Fallen Timber Run	16	111	53	59
Fallen Timber Run	17	108	31	38
Fallen Timber Run	18	109	315	392
Fallen Timber Run	19	0	364	451
Fallen Timber Run	20	112	548	672
Fallen Timber Run	21	0	1,570	1,813
Fallen Timber Run	22	113	1,584	1,832
Fallen Timber Run	23	114	76	76
Fallen Timber Run	24	115	315	316
Fallen Timber Run	25	116	17	17
Fallen Timber Run	26	117	355	308
Fallen Timber Run	27	0	2,111	2,367
Fallen Timber Run	28	118	2,196	2,453
Fallen Timber Run	29	122	333	356
Fallen Timber Run	30	382	485	520
Fallen Timber Run	31	0	2,673	2,940
Fallen Timber Run	32	119	2,771	3,030
Fallen Timber Run	33	120	55	61
Fallen Timber Run	34	121	307	324
Fallen Timber Run	35	0	2,971	3,230
Fallen Timber Run	36	123	3,005	3,263
Fallen Timber Run	37	124	35	42
Fallen Timber Run	38	125	107	125
Fallen Timber Run	39	0	3,045	3,304
Fallen Timber Run	40	126	3,068	3,328
Fallen Timber Run	41	127	56	54
Fallen Timber Run	42	128	160	169
Fallen Timber Run	43	0	3,116	3,374
Fallen Timber Run	44	129	3,123	3,383
West Run	1	319	103	104
West Run	2	320	217	226
West Run	3	321	68	81
West Run	4	322	87	104
West Run	5	0	303	329
West Run	6	323	357	391
West Run	7	324	719	805
West Run	8	325	127	162
West Run	9	326	277	323
West Run	10	0	996	1,128
West Run	11	327	1,224	1,369
West Run	12	328	1,237	1,382
Wylie Run	1	131	49	55
Wylie Run	2	132	275	331
Wylie Run	3	133	28	36
Wylie Run	4	134	151	181
Wylie Run	5	135	248	296
Wylie Run	6	0	523	627
Wylie Run	7	136	726	857
Wylie Run	8	137	774	924
Wylie Run	9	140	25	30
Wylie Run	10	141	284	331
Wylie Run	11	138	96	119
Wylie Run	12	139	428	499
Wylie Run	13	0	711	830
Wylie Run	14	142	775	870

Table B–5
Comparison of Current and Future
Modeled Stream Discharges
50 Year Frequency Twenty–Four Hour Storm Duration

Stream Name	Model ID	Watershed ID	Discharge (cfs) Current	Future	Stream Name	Model ID	Watershed ID	Discharge (cfs) Current	Future
Wylie Run	15	143	28	33	Wylie Run	26	148	20	18
Wylie Run	16	144	172	193	Wylie Run	27	149	103	100
Wylie Run	17	145	302	344	Wylie Run	28	0	1,803	2,041
Wylie Run	18	0	1,077	1,226	Wylie Run	29	152	1,920	2,155
Wylie Run	19	146	1,091	1,242	Wylie Run	30	0	2,666	3,059
Wylie Run	20	386	145	150	Wylie Run	31	153	2,755	3,148
Wylie Run	21	387	399	407	Wylie Run	32	154	2,760	3,153
Wylie Run	22	0	1,480	1,635	Mile 24 Stream	1	91	15	19
Wylie Run	23	147	1,525	1,685	Mile 24 Stream	2	92	153	166
Wylie Run	24	150	29	36	Mile 5 Stream	1	378	19	18
Wylie Run	25	151	279	333	Mile 5 Stream	2	388	131	152

APPENDIX D
MODEL STORMWATER MANAGEMENT ORDINANCE PROVISIONS

MODEL STORMWATER MANAGEMENT PROVISIONS FOR MUNICIPAL SUBDIVISION/LAND DEVELOPMENT ORDINANCE

Article ____, Stormwater Management

Section 101 - General Provisions

A. Purpose

These regulations have the following general purposes and objectives:

1. To assure safe management of stormwater runoff resulting from land alteration and disturbance activities in accordance with watershed stormwater management plans adopted pursuant to the Pennsylvania Storm Water Management Act (Act 167 of 1978, as amended).

2. To utilize and preserve the existing natural drainage systems and to preserve the flood-carrying capacity of streams.

3. To encourage natural infiltration of rainfall to preserve groundwater supplies and stream flows.

4. To provide for adequate maintenance of all permanent stormwater management structures in the municipality.

E. Liability Disclaimer

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

2. The granting of a permit which includes any stormwater 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.

Section 102 - Stormwater Management Performance Standards

A. Stormwater Management Districts

1. For purposes of stormwater management, the municipality of _____ is divided into the following stormwater management districts:

   (Note: List each DER-designated watershed in the municipality.)

   One or more of these districts may be further subdivided into subareas which have similar hydrological characteristics and drain to a common point.

2. The location and boundaries of the watershed(s) and subareas are shown on the "Municipal Stormwater Management District Map" which is hereby adopted as a part of this section.

   (Note: Map can be included as an appendix to the ordinance or copies made available in the municipal offices.)

B. General Standards

1. All proposed stormwater control measures shall be evaluated according to the following performance standard:

   a. Any landowner and 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 shall include such actions as are required:

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

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

2. The stormwater management plan for the development site shall consider all the stormwater runoff flowing over the site.

3. No discharge of toxic materials shall be permitted into any stormwater management system. Where required by federal and state regulation, the landowner or developer shall be responsible for obtaining and NPDES permit for stormwater discharges.

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C. Watershed Standards: Designated Monongahela River Stormwater Management Watershed

(Note: Municipalities that include more than one DER designated watersheds will need to add provisions following this section for other designated watersheds)

1. The stormwater performance standards contained in this section are intended to implement the standards and criteria contained in the Monongahela River Stormwater Management Plan, adopted and approved in accordance with the Pennsylvania Storm Water Management Act. If there is any discrepancy between the provisions of this section and the standards and criteria of the plan, or if the watershed plan is subsequently amended, then the standards/criteria of the current watershed plan shall govern.

2. Storm Frequencies. Stormwater management facilities on all development sites shall control the peak stormwater discharge for the 2-, 10-, 25- and 100-year storm frequencies. The SCS 24-hour, Type II Rainfall Distribution shall be used for analyzing stormwater runoff for both pre- and post-development conditions. The 24-hour total rainfall for these storm frequencies in the watershed are:

Storm Frequency	Rainfall Depth (inches)
2-year	2.50
10-year	3.61
25-year	4.31
100-year	5.71

3. Calculation Methods

   a. Development Sites: For the purpose of computing peak flow rates and runoff hydrographs from development sites, calculations shall be performed using one of the following: SCS publications, Technical Release (TR) 55 or 20, HEC I, Penn State Runoff Model (PSRM) or Modified Rational Method.

   b. Stormwater Collection/Conveyance Facilities: For the purposes of designing storm sewers, open swales and other stormwater runoff collection and conveyance facilities, the Rational Method shall be applied. Rainfall intensities for design should be obtained from the Pennsylvania Department of Transportation rainfall charts.

   c. Routing of hydrographs through detention / retention facilities for the purpose of designing those facilities shall be accomplished using the Modified-Puls Method or other

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recognized reservoir routing method subject to the approval of the municipality and county.

d. Predevelopment Conditions: Predevelopment conditions shall be assumed to be those which exist on any site at the time of adoption of the Monongahela River Stormwater Management Plan. Hydrologic conditions for all areas with pervious cover (i.e., fields, woods, lawn areas, pastures, cropland, etc.) shall be assumed to be in "good" condition, and the lowest recommended SCS runoff curve number (CN) shall be applied for all pervious land uses within the respective range for each land use and hydrologic soil group.

4. Release Rate Percentage

a. Definition. The release rate percentage defines the percentage of the pre-development peak rate of runoff that can be discharged from an outfall on the site after development. It applies uniformly to all land development or alterations within a subarea. A listing of the release rate percentage by subarea appears in Appendix __ of this ordinance; the subareas are delineated on the Release Rate Percentage Maps.

b. Procedure for Use

(1) Identify the specific subarea in which the development site is located from the watershed map and obtain the subarea release rate percentage from Appendix __ and the appropriate Release Rate Percentage Map.

(2) Compute the pre- and post-development runoff hydrographs for each stormwater outfall on the development site using an acceptable calculation method for the 2-, 10-, 25- and 100-year storms. Apply no on-site detention for stormwater management but include any techniques to minimize impervious surfaces and/or increase the time of concentration for stormwater runoff flowing from the development site. If the post-development peak runoff rate and the runoff volume are less than or equal to the predevelopment peak runoff rate and volume, then additional stormwater control shall not be required at that outfall.

If the post-development peak runoff rate and volume are greater than the predevelopment peak runoff rate and volume, then stormwater detention shall be required. The capacity of the detention facility shall be calculated by be calculated multiplying the subarea release rate percentage by the predevelopment rate of runoff from

the development site to determine the maximum allowable release rate from any detention facility for the four prescribed storm events.

5. No Harm Evaluation

a. An applicant may seek to exceed the otherwise applicable subarea release rate percentage by performing the "No Harm Evaluation". This evaluation requires an independent engineering analysis to demonstrate that other reasonable options exist to prevent the occurrence of increased stormwater runoff discharge rates and/or velocities or that measures can be provided to prevent increased stormwater discharge rates and/or velocities from increasing flood elevations and accelerating erosion at all downstream points in the watershed.

b. A "No Harm Evaluation" will be considered only in the following instances:

1. In the Monongahela River Watershed: only in instances where the discharge to a stream channel from the development site occurs directly to the Monongahela River, an adequately sized storm or combined sewer which discharges directly into the Monongahela River, or through a properly sized and designed regional stormwater detention facility.

(Note: Municipalities that include more than one DER designated watersheds will need to add conditions where the No-Harm Option is appropriate in each watershed)

c. The analysis for the no-harm evaluation shall be submitted to the municipal engineer and Allegheny County Planning Department for review and approval.

d. The "No Harm Evaluation" shall be prepared by a registered engineer who is experienced in hydrology and hydraulics. The "No Harm Evaluation" analysis shall be completed using the following procedure:

e. The analysis shall be completed using the Penn State Runoff Model (PSRM) in the following manner:

1. Develop the runoff hydrograph(s) for the design storms of the site and areas tributary to it using the PSRM for pre-development conditions using the land use characterizations contained in the

Monongahela River Watershed Stormwater Management Plan.

2. Develop the post-development discharge hydrograph from the proposed site using the PSRM. If no management or controls are proposed, this would be equivalent to the runoff hydrograph under the post-development conditions. If some management or controls are proposed, then the runoff hydrograph under post-development conditions should be modified to reflect their effects on the rate, volume and timing of discharges.

3. Subtract the runoff hydrograph ordinates under pre-development conditions (step 1) from the discharge hydrograph ordinates (step 2), maintaining the time scales of both hydrographs for one-to-one correspondence.

4. Obtain the PSRM for the existing conditions for the Monongahela River Watershed from the County.

5. Locate the subbasin(s) in which the proposed development is located and into which the discharge hydrograph enters. If more than one subbasin receives this incremental flow, divide the flow accordingly.

6. Add the incremental increase computed in step 3 to the runoff hydrograph of the subbasin(s) identified in step 5.

7. Route the adjusted runoff hydrograph through the Monongahela River Watershed PSRM and note any increase in peak flows which would occur in downstream subbasins. If no increase is noted, then the "No-Harm" has been demonstrated. If no increase is observed in peak flows, the increased potential for erosion and/or sedimentation in downstream channels resulting from any change in the flood hydrograph predicted by the model shall be evaluated. If no increased potential can be demonstrated by appropriated technical means, then the "No-Harm" exemption may be requested.

8. If an increase in peak flow is observed in any of the downstream subbasins or increased potential

for erosion and/or sedimentation is indicated, the "No-Harm" exemption shall not be granted.

Section 103 - Design criteria for stormwater management controls

A. General criteria

1. Applicants may select runoff control techniques, or a combination of techniques, which are most suitable to control stormwater runoff from the development site. All controls shall be subject to approval of the municipal engineer. The municipal engineer may request specific information on design and/or operating features of the proposed stormwater controls in order to determine their suitability and adequacy in terms of the standards of this ordinance.

2. The applicant should consider the effect of the proposed stormwater management techniques on any special soil conditions or geological hazards which may exist on the development site. In the event such conditions are identified on the site, the municipal engineer may require in-depth studies by a competent geotechnical engineer. Not all stormwater control methods may be advisable or allowable at a particular development site.

3. In developing a stormwater management plan for a particular site, stormwater controls shall be selected according to the following order of preference:

   a. infiltration of runoff on-site

   b. flow attenuation by use of open vegetated swales and natural depressions

   c. stormwater detention/retention structures

4. Infiltration practices shall be used to the extent practicable to reduce volume increases and promote groundwater recharge. A combination of successive practices may be used to achieve the applicable minimum control requirements. Justification shall be provided by the applicant for rejecting each of the preferred practices based on actual site conditions.

B. Criteria for infiltration systems

1. Infiltration systems shall be sized and designed based upon local soil and ground water conditions.

2. Infiltration systems greater than three (3) feet deep shall be located at least ten (10) feet from basement walls.

3. Infiltration systems shall not be used to handle runoff from commercial or industrial working or parking areas. This prohibition does not extend to roof areas which are demonstrated to be suitably protected from the effects of the commercial/industrial activities.

4. Infiltration systems may not receive runoff until the entire drainage area to the system has received final stabilization.

5. The stormwater infiltration facility design shall provide an overflow system with measures to provide a non-erosive velocity of flow along its length and at the outfall.

C. Criteria for flow attenuation facilities

1. If flow attenuation facilities are employed to assist in the control of peak rates of discharge, their effects must be quantified using the SCS Technical Release (TR) 55 Urban Hydrology for Small Watersheds or other approved method. The effects of the flow attenuation facilities on travel time should be reflected in the calculations.

2. Flow attenuation facilities such as swales and natural depressions should be properly graded to ensure positive drainage and avoid prolonged ponding of water.

3. Swales shall be properly vegetatively stabilized or otherwise lined to prevent erosion.

4. Swales shall be designed according to the recommendations contained in the Commonwealth of Pennsylvania Erosion and Sediment Pollution Control Program Manual.

D. Criteria for stormwater detention facilities

1. If detention facilities are utilized for the development site, the facility(ies) shall be designed such that post-development peak runoff rates from the developed site are controlled to those rates defined by the subarea release rate percentage for the 2-, 10-, 25, and 100-year storm frequencies.

2. All detention facilities shall be equipped with outlet structures to provide discharge control for the four (4) designated storm frequencies. Provisions shall also be made to safely pass the post-development 100-year storm runoff without damaging (i.e., impairing the continued function of the facilities). Should any stormwater management facilities qualify as a dam under PA DER Chapter 105, the facility shall be designed in accordance with those regulations and meet the regulations concerning dam safety.

3. Shared-storage facilities which provide detention of runoff for more than one development site within a single subarea may are encouraged wherever feasible and provided such facilities meet the criteria contained in this section. In addition, runoff from the development sites involved shall be conveyed to the facility in a manner that avoids adverse impacts (such as flooding or erosion) to channels and properties located between the development site and the shared-storage facilities.

4. Where detention facilities will be utilized, multiple use facilities, such as wetlands, lakes, ballfields or similar recreational/open space uses are encouraged wherever feasible, subject to the approval of the municipality and Pennsylvania Department of Environmental Resources' Chapter 105 regulations.

5. Other considerations which should be incorporated into the design of the detention facilities include:

   a. Inflow and outflow structures shall be designed and installed to prevent erosion and bottoms of impoundment type structures should be protected from soil erosion.

   b. Control and removal of debris both in the storage structure and in all inlet or outlet devices shall be a design consideration.

   c. Inflow and outflow structures, pumping stations, and other structures shall be designed and protected to minimize safety hazards.

   d. The water depth at the perimeter of a storage pond should be limited to that which is safe for children. This is especially necessary if bank slopes are steep or if ponds are full and recirculating in dry periods. Restriction of access (fence, walls, etc.) may be necessary depending on the location of the facility.

   e. Side slope of storage ponds shall not exceed a ration of two-and-one-half to one (2.5:1) horizontal to vertical dimension.

   f. Landscaping shall be provided for the facility which harmonizes with the surrounding area.

   g. Facility shall be located to facilitate maintenance, considering the frequency and type of equipment that will be required.

E. Criteria for collection/conveyance facilities

(Note: The municipality should review the specific requirements of this section for consistency with its existing requirements and local preferences. Specific design and construction details suggested here may be modified upon

recommendation of the municipal engineer in order to reflect the municipality's current standard practices, local conditions and preferences.)

1. All stormwater runoff collection or conveyance facilities, whether storm sewers or other open or closed channels, shall be designed in accordance with the following basic standards:

   a. All sites shall be graded to provide drainage away from and around the structure in order to prevent any potential flooding damage.

   b. Lots located on the high side of streets shall extend roof and french drains to the curb line storm sewer (if applicable). Low side lots shall extend roof and french drains to a stormwater collection/conveyance/control system or natural watercourse in accordance with the approved stormwater management plan for the development site.

   c. Collection/conveyance facilities should not be installed parallel and close to the top or bottom of a major embankment to avoid the possibility of failing or causing the embankment to fail.

   d. All collection/conveyance facilities shall be designed to convey the 25-year storm peak flow rate from the contributing drainage area and to carry it to the nearest suitable outlet such as a stormwater control facility, curbed street, storm sewer or natural watercourse.

   e. Where drainage swales or open channels are used, they shall be suitably lined to prevent erosion and designed to avoid excessive velocities.

2. Wherever storm sewers are proposed to be utilized, they shall comply with the following criteria:

   a. Where practical, designed to traverse under seeded and planted areas. If constructed within ten (10) feet of road paving, walks or other surfaced areas, drains shall have a narrow trench and maximum compaction of backfill to prevent settlement of the superimposed surface or development.

   b. Preferably installed after excavating and filling in the area to be traversed is completed, unless the drain is installed in the original ground with a minimum of three (3) feet cover and/or adequate protection during the fill construction.

   c. Designed: (1) with cradle when traversing fill areas of indeterminate stability, (2) with anchors when gradient exceeds

twenty (20) percent, and (3) with encasement or special backfill requirements when traversing under a paved area.

d. Designed to adequately handle the anticipated stormwater flow and be economical to construct and maintain. The minimum pipe size shall be fifteen (15) inches in diameter.

e. Drain pipe, trenching, bedding and backfilling requirements shall conform to the requirements of the municipality and/or applicable PennDOT Specifications, Form 408.

f. All corrugated metal pipe shall be polymer coated, and with asbestos bonding and paved inverts where prone to erode. Pipe within a municipal right-of-way shall be reinforced concrete pipe with a minimum diameter of 15 inches.

g. Storm inlets and structures shall be designed to be adequate, safe, self-cleaning and unobtrusive and consistent with municipal standards.

h. Appropriate grates shall be designed for all catch basins, stormwater inlets and other entrance appurtenances.

i. Manholes shall be designed so that the top shall be at finished grade and sloped to conform to the slope of the finished grade. Top castings of structures located in roads or parking areas shall be machined or installed to preclude "rattling."

j. Where proposed sewer connects with an existing storm sewer system, the applicant shall demonstrate that sufficient capacity exists in the downstream system to handle the additional flow.

k. Storm sewer outfalls shall be equipped with energy dissipation devices to prevent erosion and conform with applicable requirements of the Pennsylvania DER for stream encroachments (Chapter 105 of Pennsylvania DER Rules and Regulations).

Section 104 - Erosion and sedimentation controls

A. An erosion/sedimentation plan shall be prepared for each development site in accordance with the Pennsylvania Erosion/Sedimentation Regulations (25 PA Code, Chapter 102) and the standards and guidelines of the County Conservation District.

(Note: If the municipality has a grading or other ordinance which contains its erosion/sedimentation provisions, then it should be referenced here.)

B. Proposed erosion/sedimentation measures shall be submitted with the stormwater management plan.

Section 105 - Maintenance of stormwater management controls

A. Maintenance responsibilities

1. The maintenance plan for stormwater management facilities located on the development site shall establish responsibilities for the continuing operation and maintenance of all proposed stormwater control facilities, consistent with the following principals:

   a. If a development consists of structures or lots which are to be separately owned and in which streets, sewers and other public improvements are to be dedicated to the municipality, stormwater control facilities should also be dedicated to and maintained by the municipality.

   b. If a development site is to be maintained in 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 should be the responsibility of the owner or private management entity.

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

B. Maintenance agreement for privately owned stormwater facilities

1. Prior to final approval of the site's stormwater management plan the applicant and municipality shall execute a maintenance agreement covering all stormwater control facilities which are to be privately owned. The maintenance agreement shall be recorded with the final subdivision/land development plan for the site. The agreement shall stipulate that:

   a. All facilities shall be maintained in accordance with the approved maintenance schedule and in a safe and attractive manner.

   b. Easements and or rights-of-way shall be conveyed to the municipality to assure access for periodic inspections by the municipality and maintenance if required.

c. The name, address and telephone number of the person or company responsible for maintenance activities shall be filed with the municipality. In the event of a change, new information will be submitted to the municipality within ten (10) days of the change.

d. If the facility owner fails to maintain the stormwater control facilities, the municipality may perform the necessary maintenance work or corrective work following due notice by the municipality to the facility owner to correct the problem(s). The facility owner shall reimburse the municipality for all costs.

2. Other items may be included in the agreement where determined necessary to guarantee the satisfactory maintenance of all facilities.

C. Municipal stormwater maintenance fund

(Note: This provision illustrates one way a municipality could establish a special fund to finance its maintenance and inspection activities for stormwater retention/detention facilities. It is an optional provision of the ordinance. If a municipality is interested in establishing such a fund, it is recommended that it consult with its solicitor for legal requirements and procedures.)

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

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

   b. If the storage facility is to be owned and maintained by the municipality, the deposit shall cover the estimated costs for maintenance and inspections for ten (10) years. The municipal engineer will establish the estimated costs utilizing information submitted by the applicant.

   c. The amount of the deposit to the fund shall be converted to present worth of the annual series values. The municipal engineer shall determine the present worth equivalents which shall be subject to the approval of the governing body.

2. If a storage facility is proposed that also serves as a recreation facility (e.g., ballfield, lake), the municipality may reduce or waive the amount

of the maintenance fund deposit based upon the value of the land for public recreation purposes.

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

Section 106 - Stormwater plan requirements

A. General requirements

1. No final subdivision/land development plan be approved, no permit authorizing construction issued, or any earth moving or land disturbance activity initiated until the final stormwater management plan for the development site is approved in accordance with the provisions of this ordinance.

B. Exemptions for small developments

1. At the time of application, the municipality shall determine if the subdivision/land development qualifies as a "small development" and, therefore, is eligible for a simplified stormwater plan submission. For the purposes of this ordinance, a small development is any subdivision or land development which results in (or will result when fully constructed) the creation of 5,000 or less square feet of impervious surface area.

2. Applications for small developments shall include a plan which describes the type and location of proposed on-site stormwater management techniques or the proposed connection to an existing storm sewer system. The plan should show accurately site boundaries, five-foot interval contours, locations of watershed and/or subarea boundaries on the site (if applicable) and any watercourses, floodplains, or existing drainage facilities or structures located on the site. The municipality reserves the right to require that the plan be prepared by a registered professional engineer, surveyor or landscape architect.

3. The municipal engineer shall review and approve the proposed provisions for stormwater management in accordance with the standards and requirements of this ordinance.

C. Stormwater plan contents

1. General Format: The stormwater plan shall be drawn to a scale of not less than 1 inch = 200 feet. All sheets shall contain a title block with;

Name and address of applicant and engineer, scale, north arrow, legend and date of preparation.

2. Existing and Proposed Features: The plan shall show the following:

   a. Watershed location - Provide a key map showing the location of the development site within the watershed(s) and watershed subarea(s). On all site drawings, show the boundaries of the watershed(s) and subarea(s) as they are located on the development site and identify watershed names(s) and subarea number(s).

   b. Floodplain boundaries - Identify 100-year floodplains on the development site (as appropriate) based on the municipal Flood Insurance Study maps.

   c. Natural features - Show all bodies of water (natural or artificial), watercourses (permanent and intermittent), swales, wetlands and other natural drainage courses on the development site, or which will be affected by runoff form the development.

   d. Soils - Provide an overlay showing soil types and boundaries within the development site (consult county, SCS and U.S. Geological Survey for information).

   e. Contours - Show existing and final contours at intervals of two (2) feet; in areas with slopes greater than fifteen (15) percent, five (5) foot contour intervals may be used.

   f. Land cover - Show existing and final land cover classifications as necessary to support and illustrate the runoff calculations performed.

   g. Drainage area delineations - Show the boundaries of the drainage areas employed in the runoff calculations performed.

   h. Stormwater management controls - Show any existing stormwater management or drainage controls and/or structures, such as sanitary and storm sewers, swales, culverts, etc. which are located on the development site, or which are located off-site but will be affected by runoff from the development.

3. Professional certification: The stormwater management plan (including all calculations) shall be prepared and sealed by a registered professional engineer, surveyor or landscape architect with training and expertise in hydrology and hydraulics. Documentation of qualifications may be required by the municipality.

4. Runoff calculations: Calculations for determining pre- and post-development discharge rates and for designing proposed stormwater control facilities must be submitted with the stormwater management plan. All calculations shall be prepared using the methods and data prescribed by Section 102 of this Article.

5. Stormwater controls: All proposed stormwater runoff control measures must be shown on the plan including methods for collecting, conveying and storing stormwater runoff on-site, which are to be used both during and after construction. Erosion and sedimentation controls shall be shown in accordance with Section 104 of this Article. The plan shall provide information on the exact type, location, sizing, design and construction of all proposed facilities and relationship to the existing watershed drainage system.

   a. If the development is to be constructed in stages, the applicant must demonstrate that stormwater facilities will be installed to manage stormwater runoff safely during each stage of development.

   b. A schedule for the installation of all temporary and permanent stormwater control measures and devices shall be submitted.

   c. If appropriate, a justification should be submitted as to why any preferred stormwater management techniques, as listed in Section 103, are not proposed for use.

6. Easements, rights-of-way, deed restrictions: All existing and proposed easements and rights-or-way for drainage and/or access to stormwater control facilities shall be shown along with any areas subject to special deed restrictions relative to or affecting stormwater management on the development site.

7. Other permits/approvals: A list of any approvals/permits relative to stormwater management that will be required from other governmental agencies (Pennsylvania DER Chapter 105 and 106 permits and/or NPDES permit) and anticipated dates of submission/receipt should be included with the stormwater plan submission. Copies of permit applications may be requested by the municipality where they may be helpful for the plan review.

8. Maintenance program: The proposed maintenance plan for all stormwater control facilities shall:

   a. Identify the proposed ownership entity (e.g., municipality, property owner, private corporation, homeowner's association, or other entity).

b. Identify the type of maintenance, probable frequencies, personnel and equipment requirements and estimated annual maintenance costs.

c. Identify method of financing continuing operation and maintenance if the facility is to be owned by other than a governmental agency.

d. Include copies of any legal agreements required to implement the maintenance program and, if applicable, copies of the maintenance agreement as required by Section 105 of this Article.

9. Financial guarantees: Submit financial guarantees in accordance with the provisions of Section 111 of this Article.

Section 107 - Plan review procedures

A. Pre-application phase

1. Before submitting the stormwater plan, applicants are urged to consult with the municipality, County Planning Department and County Conservation District on the applicable regulations and techniques for safely managing from the development site. These agencies may also be helpful in providing necessary data for the stormwater management plan.

2. Applicants are encouraged to submit a sketch plan with a narrative description of the proposed stormwater management controls for general guidance and discussion with the municipality and other agencies.

3. The pre-application phase is not mandatory; any review comments provided by the municipality or other agencies are advisory only and do not constitute any legally binding action on the part of the municipality or any county agency.

B. Stormwater plan reviews

1. Submission of plans: Stormwater plan applications shall be submitted with the preliminary and final subdivision/land development applications.

2. Notification of affected municipalities: The municipality shall notify municipalities upstream and downstream of the development site, which may be affected by the stormwater runoff and proposed controls for the site. Copies of the plans will be made available to the municipalities upon request. Comments received from any affected

municipality will be considered by the municipal engineer and county agencies in their reviews.

3. County planning review:

   a. The municipality shall forward a copy of the stormwater plan, along with all runoff calculations, shall be forwarded to the Allegheny County Planning Department. A report of the findings will be returned to the municipality within 30 days.

   b. If the Department determines that the plan fails to comply with the watershed standards and criteria or that a possibility exists for harmful downstream impacts from the development site, the applicant will be advised so that proposed stormwater management controls can be modified. The municipal engineer shall not approve the development site's stormwater management plan until it receives a positive review from the County Planning Department.

4. Municipal engineer's review: The municipal engineer shall approve or disapprove the stormwater management plan based on the requirements of the municipal ordinances, the standards and criteria of the watershed plan and good engineering practice. The engineer shall submit a written report, along with supporting documentation, stating their reasons for approval or disapproval.

5. Status of the engineer's determination: The approval/disapproval of the site's stormwater management plan by the municipal engineer shall be considered final. The governing body shall not reverse the engineer's determination by approving or disapproving the site's stormwater management plan or any specific control measure in contradiction to the engineer's action. The governing body may request modifications or alternative approaches to the stormwater management controls, provided these are agreed to by the municipal engineer and the applicant's engineer.

(Notes: 1) If the municipal Planning Commission has the final authority for approving plans, then this section should be changed as appropriate; 2) The applicant's engineer must concur with the requested modifications because he/she is certifying the development's stormwater management system.)

7. Permits required from other governmental agencies: Where the proposed development requires an obstruction permit from the Pennsylvania DER or an erosion/sedimentation permit from the County Conservation District, final stormwater management plan approval shall be granted subject to the receipt of such permits. No building permit shall be issued, nor construction started, until the permits are received and copies filed with the municipality.

Section 108 - Status of the stormwater plan after final approval

A. Upon final stormwater plan approval and receipt of all necessary permits, the applicant may commence to install or implement the approved stormwater management controls.

B. If site development or building construction does not begin within two years of the date of final approval of the stormwater management plan, then before doing so, the applicant shall resubmit the stormwater management plan to verify that no condition has changed within the watershed that would affect the feasibility or effectiveness of the previously approved stormwater management controls. Further, if for any reason development activities are suspended for two years or more, then the same requirement for resubmission of the stormwater management plan shall apply.

Section 109 - Stormwater plan modifications

A. If the request for a plan modification is initiated before construction begins, the stormwater plan must be resubmitted and reviewed according to the procedures contained in Section 107 above.

B. If the request for a plan modification is initiated after construction is underway, the municipal engineer shall have the authority to approve or disapprove the modification based on field inspection provided: (1) the requested changes in stormwater controls do not result in any modifications to other approved municipal land use/development requirements (e.g., building setbacks, yards, etc.) and (2) the performance standards in Section 102 are met. Notification of the engineer's action shall be sent to the governing body which may issue a stay of the plan modification within five (5) days and require the permittee to resubmit the plan modification for full stormwater plan review in accordance with Section 107 above.

Section 110 - Inspections of stormwater management controls

(Note: This section outlines an ideal schedule for inspecting stormwater controls during construction. However, the recommendations may have to be tailored to each municipality's needs and resources.)

A. The municipal engineer or a designated representative shall inspect the construction of the temporary and permanent stormwater management system for the development site. The permittee shall notify the engineer 48 hours in advance of the completion of the following key development phases:

1. At the completion of preliminary site preparation including stripping of vegetation, stockpiling of topsoil and construction of temporary stormwater management and erosion control facilities.

2. At the completion of rough grading but prior to placing topsoil, permanent drainage or other site development improvements and ground covers.

3. During construction of the permanent stormwater facilities at such times as specified by the municipal engineer.

4. Completion of permanent stormwater management facilities including established ground covers and plantings.

5. Completion of final grading, vegetative control measures or other site restoration work done in accordance with the approved plan and permit.

B. No work shall commence on any subsequent phase until the preceding one has been inspected and approved. If there are deficiencies in any phase, the municipal engineer shall issue a written description of the required corrections and stipulate the time by which they must be made.

C. If during construction, the contractor or permittee identifies and site condition, such as subsurface soil conditions, alterations in surface or subsurface drainage which could affect the feasibility of the approved stormwater facilities, he/she shall notify the municipal engineer within 24 hours of the discovery of such condition and request a field inspection. The municipal engineer shall determine if the condition requires a stormwater plan modification.

D. In cases where stormwater facilities are to be installed in areas of landslide-prone soils or other special site conditions exist, the municipality may require special precautions such as soil tests and core borings, full-time inspectors and/or similar measures. All costs of any such measures shall be borne by the permittee.

Section 111 - Financial guarantees and dedication of public improvements

(Note: If these provisions are already included in another article of the subdivision/land development ordinance, they can simply be referenced here.)

A. Guarantee of completion: A completion guarantee in the form of a bond, cash deposit, certified check or other negotiable securities acceptable to the municipality, shall be filed. The guarantee shall cover all streets, sanitary sewers, stormwater management facilities, water systems, fire hydrants, sidewalks and other required improvements; it shall be in the amount and form prescribed by the Municipal Planning Code (Section 509).

B. Release of completion guarantee: The procedures for requesting and obtaining a release of the completion guarantee shall be in a manner prescribed by the Municipalities Planning Code (Section 510).

C. Default of completion guarantee: If improvements are not installed in accordance with the approved final plan, the governing body may enforce any corporate bond or other security by appropriate legal and equitable remedies. If proceeds of such bond or other security are insufficient to pay the cost of installing or making repairs or corrections to all the improvements covered by said security, the governing body may at its option install part of such improvements in all or part of the development and may institute appropriate legal or equitable action to recover the monies necessary to complete the remainder of the improvements. All proceeds, whether resulting from the security or from the security or from any legal or equitable action brought against the developer, or both, shall be used solely for the installation of the improvements covered by such security and not for any other municipal purpose.

D. Dedication of public improvements:

1. When streets, sanitary sewers, stormwater management facilities, water lines or other required improvements in the development have been completed in accordance with the final approved plan, such improvements shall be deemed private until such time as they have been offered for dedication to the municipality and accepted by separate ordinance or resolution or until they have been condemned for use as a public facility.

2. Prior to acceptance of any improvements or facilities, the municipal engineer shall inspect it to ensure that it is constructed in accordance with the approved plan and is functioning properly. In the case of any stormwater control facility, it must be free of sediment and debris.

3. The owner shall submit as-built plans for all facilities proposed for dedication.

E. Maintenance guarantee: Prior to acceptance of any improvements or facilities, the applicant shall provide a financial security to secure the structural integrity and functioning of the improvements. The security shall: (1) be in the form of a bond, cash, certified check or other negotiable securities acceptable to the municipality, (2) be for a term of 18 months, and (3) be in an amount equal to 15 percent of the actual cost of the improvements and facilities so dedicated.

Section 112 - Fee Schedule

The municipal governing body may adopt by resolution from time to time a reasonable schedule of fees to cover the cost of plan reviews, inspections and other activities necessary to administer the provisions of this ordinance. All fees shall be set in accordance with the applicable provisions of the Municipalities Planning Code and any dispute over the fee amount shall be resolved in the manner prescribed by the Planning Code.

Section 113 - Enforcement procedures and remedies

(Note: This section is drafted to be consistent with the Planning Code for enforcing a municipal subdivision and land development ordinance. If the municipality adopts a separate, single-purpose stormwater management ordinance, then this section should be modified as appropriate to meet the provisions of the municipal codes.)

A. Right of entry: Upon presentation of proper credentials, duly authorized representatives of the municipality may enter at reasonable times upon any property to investigate or ascertain the condition of the subject property in regard to an aspect regulated by this ordinance.

B. Notification: In the event that the applicant, developer, owner or his/her agent fails to comply with the requirements of this ordinance or fails to conform to the requirements of any permit, a written notice of violation shall be issued. Such notification shall set forth the nature of the violations(s) and establish a time limit for correction of the violation(s). Upon failure to comply within the time specified, unless otherwise extended by the municipality, the applicant, developer, owner or his/her agent shall be subject to the enforcement remedies of this ordinance.

C. Preventive remedies:

1. In addition to other remedies, the municipality may institute and maintain appropriate actions by law or in equity to restrain, correct or abate a violation, to prevent unlawful construction, to recover damages and to prevent illegal occupancy of a building or premises.

2. In accordance with the Planning Code (Sec. 515.1), the municipality may refuse to issue any permit or grant approval to further improve or develop any property which has been developed in violation of this chapter.

D. Enforcement remedies

1. Any person, who has violated or permitted the violation of the provisions of this Ordinance shall, upon being found liable therefor in a civil enforcement proceeding commenced by the municipality, pay a fine of not less than $50.00 and not more than $500.00 plus court costs, including reasonable attorney fees incurred by the municipality. No judgement shall commence or be imposed, levied or be payable until the date of the determination of a violation by the district justice.

2. If the defendant neither pays nor timely appeals the judgement, the municipality may enforce the judgement pursuant to applicable rules of civil procedure.

3. Each day that a violation continues shall constitute a separate violation unless the district justice further determines that there was a good faith basis for the person violating the ordinance to have believed that there was no such violation. In such case there shall be deemed to have been only one such violation until the fifth day following the date of the district justice's determination of a violation; thereafter each day that a violation continues shall constitute a separate violation.

4. All judgements, costs and reasonable attorney fees collected for the violation of this Ordinance shall be paid over to the municipality.

5. The court of common pleas, upon petition, may grant an order of stay, upon cause shown, tolling the per diem fine pending a final adjudication of the violation and judgement.

6. Nothing contained in this section shall be construed or interpreted to grant to any person or entity other than the municipality the right to commence any action for enforcement pursuant to this section.

E. Additional remedies: In addition to the above remedies, the municipality may also seek remedies and penalties under applicable Pennsylvania statutes, or regulations adopted pursuant thereto, including but not limited to the Storm Water Management Act (32 P.S. Section 693.1-693.27) and the Erosion and Sedimentation Regulations (25 Pennsylvania Code, Chapter 102). Any activity conducted in violation of this ordinance or any Pennsylvania approved watershed stormwater management plan may be declared a public nuisance by the municipality and abatable as such.

Section 114 - Definitions

Act: The Storm Water Management Act (Act of October 4, 1978, P.L. 864 No. 167; 32 P.S. Sections 680.1-680.17, as amended by Act of May 24, 1984, No. 63).

Applicant: A landowner or developer who has filed an application for development including his/her heirs, successors and assigns.

Channel: A perceptible natural or artificial waterway which periodically or continuously contains moving water or which forms a connecting link between two bodies of water. It has a definite bed and banks which confine the water.

Conservation District: The Allegheny County Conservation District.

County: Allegheny County, Pennsylvania

Culvert: A closed conduit for the free passage of surface drainage under a highway, railroad, canal or other embankment.

Design criteria: (1) Engineering guidelines specifying construction details and materials. (2) Objectives, results, or limits which must be met by a facility, structure, or process in performance of its intended functions.

Design storm: (see storm frequency)

Detention: The slowing, dampening or attenuating of runoff flows entering the natural drainage pattern or storm drainage system by temporarily holding water on a surface area in a detention basin or within the drainage system.

Detention pond: A pond or reservoir, usually small, constructed to impound or retard surface runoff temporarily.

Developer: The person, persons, or any corporation, partnership, association, or other entity or any responsible person therein or agent therefor that undertakes the activities associated with changes in land use. The term "developer" is intended to include by not necessarily be limited to the term "subdivider", "owner", and "builder" even though the individuals involved in successive stages of a project may vary.

Development: Any activity, construction, alteration, change in land use or practice that affects stormwater runoff characteristics.

Discharge: The flow or rate of flow from a canal, conduit, channel or other hydraulic structure.

Drainage: (1) In general, the removal of surface water from a given area. Commonly applied to surface water and ground water.

Drainage Area: (1) The area of a drainage basin or watershed, expressed in acres, square miles, or other unit of area. Also called catchment area, watershed, river basin. (2) The area served by a sewer system receiving storm and surface water, or by a watercourse.

Encroachment: Any structure or activity which in any manner changes, expands or diminishes, the course, current or cross section of any watercourse, floodway or body of water.

Erosion: Wearing away of the lands by running water, glaciers, winds and waves.

Erosion control: The application of measures to reduce erosion of land surfaces.

Ground Cover: Materials covering the ground surface,

Ground Water: Subsurface water occupying the saturation zone, from which wells and springs are fed.

Ground Water Recharge: Replenishment of ground water naturally by precipitation or runoff or artificially by spreading or injection.

Impervious: Not allowing or allowing only with great difficulty the movement of water; impermeable.

Infiltration: (1) The flow or movement of water through the interstices or pores of a soil or other porous medium. (2) The absorption of liquid by the soil.

Land Development: Any of the following activities:

> (1) the improvement of one lot or two or more contiguous lots, tracts or parcels or land for any purpose involving: (a) a group of two or more residential or non-residential buildings, whether proposed initially or cumulatively, or a single non-residential building on a lot or lots regardless of the number of occupants or tenure; or (b) the division or allocation of land or space, whether initially or cumulatively, between or among two or more existing or prospective occupants by means or, or for the purpose of streets, common areas, leaseholds, condominiums, building groups or other features;
>
> (2) a subdivision of land.

Land Disturbance: Any activity involving the changing, grading, transportation, fill and any other activity which causes land to be exposed to the danger of erosion.

Maintenance: The upkeep necessary for efficient operation of physical properties.

Municipality: (name of municipality)

Natural Stormwater Runoff Regime: A watershed where natural surface configurations, runoff characteristics and defined drainage conveyances have attained the conditions of equilibrium.

Outfall: (1) The point, location or structure where drainage discharges from a sewer, drain or other conduit. (2) The conduit leading to the ultimate discharge point.

Outlet Control Structure: The means of controlling the relationship between the headwater elevation and the discharge, placed at the outlet or downstream end of any structure through which water may flow.

Performance Standard: A standard which establishes an end result or outcome which is to be achieved but does not prescribe specific means for achieving it.

Peak Flow: Maximum flow.

Pennsylvania DER: Pennsylvania Department of Environmental Resources.

Release Rate Percentage: The watershed factor determined by comparing the maximum rate of runoff from a subbasin to the contributing rate of runoff to the watershed peak rate at specific points of interest.

Retention Pond: A basin, usually enclosed by artificial dikes, that is used to retard stormwater runoff by temporarily storing the runoff and releasing it at a predetermined rate.

Return Period: The average interval in years over which an event of a given magnitude can be expected to recur.

Runoff: That part of precipitation which flows over the land.

Runoff Characteristics: The surface components of any watershed which affect the rate, amount, and direction of stormwater runoff. These may include but are not limited to: vegetation, soils, slopes and man-made landscape alterations.

SCS: U.S. Department of Agriculture Soil Conservation Service.

Sediment: Mineral or organic solid material that is being transported or has been moved from its site of origin by air, water or ice and has come to rest.

Sedimentation: The process by which Mineral or organic matter is accumulated or deposited by moving water, wind or gravity.

Storage Facility: (See detention pond and retention pond).

Storm Frequency: The average interval in years over which a storm event of a given precipitation volume can be expected to occur.

Storm Sewer: A sewer that carries intercepted surface runoff, street water and other drainage but excludes domestic sewage and industrial waste.

Stormwater: That portion of precipitation which runs over the land.

Stormwater Collection System: Natural or man-made structures that collect and transport stormwater through or from a drainage area to the point of final outlet including, but not limited to, any of the following: conduits and appurtenant features, canals, channels, ditches, streams, culverts, streets, and pumping stations.

Stormwater Management Plan: The plan for managing stormwater runoff adopted by Allegheny County as required by the Storm Water Management Act.

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 10 acres, not involving any new street or easement of access or any residential dwelling shall be exempted.

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

Watercourse: Any channel for conveyance of surface water having a defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

Watershed: The entire region or area drained by a river or other body of water whether natural or artificial. A "designated watershed" is an area delineated by the Pennsylvania DER and approved by the Environmental Quality Board for which counties are required to develop watershed stormwater management plans.

Watershed Stormwater Management Plan: The plan for managing stormwater runoff throughout a designated watershed adopted by Allegheny County as required by the Pennsylvania Storm Water Management Act.

MODEL STORMWATER MANAGEMENT PROVISIONS FOR THE MUNICIPAL ZONING ORDINANCE

(Note: The following section should be added to the Supplementary Provisions of the municipality's existing zoning ordinance. This provision assures that stormwater management standards apply to all types of land uses in the municipality)

Section _____, Stormwater Management

A. All uses or lots in all zoning districts shall comply with the applicable requirements and standards for managing stormwater runoff in accordance with the municipal subdivision and land development ordinance.

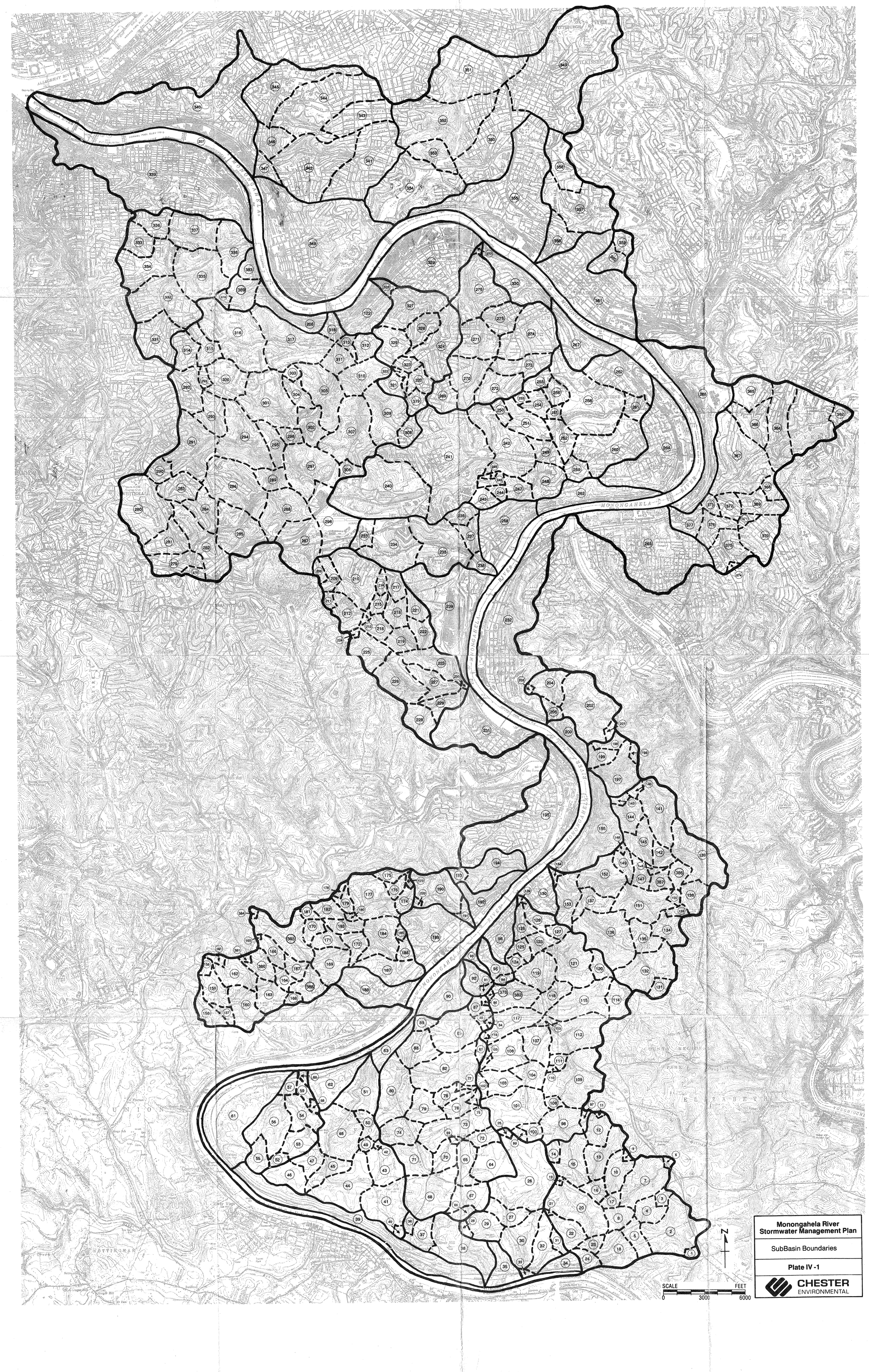
(Note: The following language should be included if the municipality permits any of the following land use activities under its zoning district regulations.)

B. Agricultural activities, nurseries and forestry management operations, where permitted by this ordinance, shall be required to provide for the safe management of stormwater runoff in accordance with the requirements of the subdivision/land development ordinance. However, the submission and approval of a stormwater management plan shall be waived when:

1. agricultural activities are operated in accordance with a conservation plan or erosion and sedimentation control plan approved by the Allegheny County Conservation District;

2. forestry management operations are following Pennsylvania DER management practices contained in its publication Soil Erosion and Sedimentation Control Guidelines for Forestry and are operating under an erosion and sedimentation control plan.

C. Strip mining where permitted by this ordinance shall have a plan for control of erosion and sedimentation and stormwater runoff which is approved by the Pennsylvania DER. If the strip mining operation is located within a watershed(s) for which a stormwater management plan has bee approved in accordance with the requirements of the Storm Water Management Act, then the erosion/sedimentation plan and any permanent stormwater runoff controls shall be consistent with the standards and criteria of the watershed stormwater management plan. A copy of the state-approved erosion/sedimentation plan shall be filed with the municipality prior to commencing mining operations.


Monongahela River
Stormwater Management Plan
SubBasin Boundaries
Plate IV -1
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PORT VUE
ELIZABETH
WHITEHALL
BALDWIN
UNION
NOTTINGHAM
ALLEGHENY RIVER
MONONGAHELA RIVER
YOUGHIOGHENY RIVER