ACT 167

STORMWATER MANAGEMENT PLAN

FOR THE

RIDLEY CREEK WATERSHED

VOLUME I

EXECUTIVE SUMMARY

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The Delaware County Planning Department also says a special thank you to the consultant team of Walter B. Satterthwaite Associates, Inc. and Green International, Inc. for their guidance, insights, patience, and inspiration offered throughout the plan preparation, update, and adoption effort.

RESOLUTION OF THE COUNCIL
OF THE COUNTY OF DELAWARE
WITH RESPECT TO THE
RIDLEY CREEK STORMWATER MANAGEMENT PLAN

WHEREAS, the County has prepared and updated the Act 167 Stormwater Management Plan for the Ridley Creek Watershed, pursuant to the Pennsylvania Stormwater Management Act, Act 167, as amended; and

WHEREAS, the plan presents the standards and criteria that have been determined to be essential for effective control of stormwater flows from existing and new development in the Delaware County portion of the watershed; and

WHEREAS, the plan also presents recommended methods for implementing these standards and criteria on a municipal level; and

WHEREAS, a public hearing was held on December 8, 1987 for the purpose of seeking public comments on this plan pursuant to the publishing of the notice of public hearing on November 24, 1987 in the Delaware County Daily Times; and

WHEREAS, County adoption of the plan is desired and required for effective implementation of this watershed plan.

NOW, THEREFORE, BE IT RESOLVED by the Council of the County of Delaware that the Act 167 Stormwater Management Plan for the Ridley Creek Watershed, comprised of Volume I Executive Summary and Volume II Ridley Creek Stormwater Management Study and Addendum, including all text, tables, and figures, is hereby adopted.

RESOLVED, this 15th day of June, 1988.

Joyce A. Lamont
County Clerk

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INTRODUCTION

On October 4, 1978, the Pennsylvania General Assembly enacted Act 167, the Pennsylvania Stormwater Management Act. The policies and purposes of this Act are:

1) to encourage stormwater planning and management on a watershed basis which is consistent with sound water and land use practices;

2) to authorize a comprehensive program of stormwater management to preserve and restore natural runoff patterns and the flood carrying capacities of streams and to protect and conserve groundwaters and groundwater recharge areas; and

3) to encourage local administration and management of stormwater.

This legislation requires all counties to prepare and adopt a comprehensive stormwater management plan for every designated watershed, pursuant to guidelines promulgated by the Pennsylvania Department of Environmental Resources (DER), in consultation with the municipalities located within each watershed. Because these guidelines were in draft form only in 1982 when the plan preparation was begun, the stormwater management plan for the Ridley Creek watershed was originally prepared as a "pilot" Act 167 Plan. On May 14, 1985, the Stormwater Management Guidelines were approved by the General Assembly, clearing the way for the adoption of the Ridley Creek watershed plan as an official Act 167 watershed stormwater management plan.

Since the upper part of the watershed lies in Chester County, DER encouraged both counties to participate in the preparation of a joint watershed plan. However, with Chester County's decision not to participate in this study in an official capacity, it was not feasible to perform detailed planning for the Chester County portion of the watershed. Consequently, the resources and efforts for this study have been focused toward development of a stormwater management plan which addresses the problems and concerns of Delaware County.

The original plan's preparation was administered by the Delaware County Planning Department (DCPD), in conjunction with DER. The consultant team of Walter B. Satterthwaite Associates, Inc. of West Chester, Pennsylvania, and Green International, Inc. of Sewickley, Pennsylvania, was hired to assist the County in developing a detailed scope of study for the project, to perform the technical and institutional analyses, and to develop an implementation plan.

Following the approval of the Stormwater Management Guidelines, a project to update the plan in preparation for its adoption by Delaware County Council was initiated in 1986. The update involved review and updating of the technical and institutional analyses as well as presentation of the plan to officials in the affected municipalities. The endorsement of the twelve municipalities within the watershed is considered to be a key factor in the adoption of the plan.

In conjunction with this planning effort, the County established a watershed advisory committee open to municipal officials, the County Conservation District, and other interested parties. The role of this committee was to advise the County throughout the planning process, to evaluate policy and project alternatives, to coordinate this watershed stormwater plan with other municipal plans and programs, and to review this plan prior to adoption by the County. Advisory committee/public meetings were held during the course of the study to describe the progress that had been made and to solicit public input and support for the plan.

Within six months following County adoption and DER approval, the Act requires that municipalities in the watershed adopt or amend and implement such ordinances and regulations as are necessary to regulate stormwater management facilities in a manner consistent with the plan.

<u>Presentation Format</u>

The Act 167 stormwater management plan for the Delaware County portion of the Ridley Creek watershed consists of two reports:

- Volume I - Executive Summary

  This document essentially contains the summary and conclusions of the original watershed planning effort as well as the update for the watershed. As such, it presents the stormwater management standards and criteria that have been determined to be essential for effective control of storm flows in the Delaware County portion of the watershed. A brief discussion of the recommended methods for implementing these standards and criteria on a municipal level is also presented.

- Volume II - Ridley Creek Stormwater Management Study and Addendum

  The specific details of the technical program (e.g., modeling data and results) are contained in this document. The intent of this volume is to describe the technical and institutional evaluation from which the standards and criteria for stormwater management in the Delaware County portion of the Ridley Creek watershed were developed. In addition, Volume II also presents the steps that need to be taken to actually use the technical results that are presented in the standards and criteria.

This approach was taken in order to assure that the recommended standards and criteria for stormwater management could be easily reviewed independently from the bulk of the technical report. The overall plan, however, consists of both documents, and the reader is encouraged to review Volume II in order to better understand and evaluate the standards and criteria. The major chapters of the study (Volume II) are:

- Introduction and Summary of Study Approach
- Rationale and Legal Framework for Stormwater Management
- Existing and Projected Future Watershed Characteristics
- Technical Approach for Watershed Stormwater Management
- Stormwater Management Techniques
- Existing Institutional/Regulatory Systems
- Municipal Regulatory Approaches to Stormwater Management

As an outgrowth of the plan update effort, an addendum to Volume II was prepared which contains the results of the revised land use modeling, municipal ordinance revisions, and other minor revisions to Volume II's text consistent with these changes.

Terminology

Throughout the text of the plan, several key technical terms and phrases are used repeatedly which deserve definition so that the non-technical reader can gain a better understanding of the standards and criteria, other recommendations presented, and the technical basis for those conclusions.

The primary objectives of the technical investigation were to establish the existing stormwater runoff characteristics of the Ridley Creek watershed and to assess the impact of anticipated future development on these existing characteristics. Stormwater runoff is the excess water resulting from a precipitation event which exceeds the amount that can percolate (infiltrate) or be absorbed into the ground. That water flows over the surface of the ground, collects in channels and conduits, and is carried by receiving streams. The rate of runoff, or flow rate, reaching a point in a stream channel or leaving a development site is an expression of the volume of water passing that point in a defined time interval. Unless otherwise noted, flow or rate of runoff will be given in terms of cubic feet per second (cfs).

The rate of runoff passing a point during and after a storm event varies with time. Typically, the flow rate starts from zero on an upland site or from a relatively small flow in a stream, which is called normal flow or baseflow. The rate of runoff, or flow, increases either gradually or rapidly with passing time, reaches a maximum or peak rate, and then gradually decreases to the original or baseflow rate. A record of the flow rate leaving a site or passing a point in a stream channel with respect to time is called a hydrograph. A hydrograph can be displayed as a graph of flow rate vs. elapsed time or simply as a listing of flow rates at respective times of occurrence.

For the purposes of designing hydraulic structures, including stormwater management facilities, design storm events are used. Design storms are statistically determined rainfall events having a specific distribution of rainfall amounts (inches of precipitation) over specific time intervals with an associated frequency or likelihood of occurrence developed from recorded events. The frequency is typically expressed as a return period such as the 25-year storm. A 25-year storm is expected to occur once in every 25 years, on the average, or has a four percent probability of occurring in any given year. Design storms provide a uniform basis for calculation and comparison of resulting flow rates from any portion of a watershed or from any development site. A design hydrograph with an associated design peak runoff rate resulting at a point of interest can be calculated for use in the design of stormwater management facilities, including storm sewers, detention basins, open channels, etc.

Design storms allow for a direct comparison of the hydrographs and peak runoff leaving a site under existing and planned future conditions. A primary purpose of stormwater management facilities is to control the flow rate at which runoff is allowed to leave a development site, or discharge rate, in order to take reasonable steps to protect downstream areas. The level to which the discharge rate must be controlled after development, in order to demonstrate that reasonable steps have been taken to protect against downstream damage, can be calculated using a release rate percentage. Release rate percentages are values which are determined as a result of the overall watershed storm runoff analysis that is performed to develop a watershed plan to be effective in assisting land developers to take the necessary reasonable steps to protect downstream areas from damages caused by storm runoff. The release rate percentage prescribes the allowable post-development peak discharge as a fraction of the pre-development peak runoff rate. Control of the post-development discharge rate typically involves the use of detention storage facilities to accommodate the increased volume and rates of runoff that usually accompany land development. It is generally the increased rate of runoff leaving a site which increases the potential damage downstream. Control of the rate of discharge can be accomplished with facilities on each development site or at downstream locations (e.g., in distributed storage detention facilities which control the stormwater runoff from more than one development site).

The land development process normally generates an increase in impervious cover and an improvement in surface drainage. Therefore, during any rainfall event, the resulting increase in the volume of runoff must be recognized as a decrease in the volume that percolates, or infiltrates, through the soil to join shallow or deep groundwaters. Shallow groundwater in the Ridley Creek watershed moves slowly towards the main stem and tributary channels to become normal flow or baseflow. Decreased infiltration of stormwater reduces the volume of shallow groundwater that is available to become baseflow in streams. Infiltration or groundwater recharge projects can be designed to capture stormwater runoff and induce its percolation into the shallow groundwater system to augment the baseflow of Ridley Creek and its tributaries.

LEGAL FRAMEWORK FOR STORMWATER MANAGEMENT

In 1978, Pennsylvania embarked on a new era of stormwater management and flood control with the passage of the Stormwater Management Act (Act 167), its companion bill, the Floodplain Management Act (Act 166), and the subsequent Dam Safety and Encroachments Act (Act 325). Unlike existing common law, which generally provides remedies after damages occur unless the action is addressable in equity, the thrust of the new acts is to prevent future problems.[1] Together they provide a comprehensive approach to watershed planning, stormwater management, and flood prevention.

In addition to these three primary acts, there are three other related statutory or administrative bodies of law: the erosion and sedimentation regulations adopted pursuant to the Clean Streams Law, the Municipalities Planning Code (Act 247, as amended), and the municipal (i.e., city, borough, township, home rule) codes. These laws provide important powers and mandates required by local governments to imple-

1 Although common law can also provide preventive measures through equity, each matter would be treated on a case-by-case basis, thus not assuring the application of uniform standards as provided by the Act. Consequently, the Act is more effective in its preventive approach with the establishment of uniform standards.

ment a comprehensive stormwater management program. In combination with the principal stormwater statutes, they define the legal framework for stormwater management in Pennsylvania.

The Stormwater Management Act provides the primary powers for stormwater planning and management. Its basic premise is that those whose activities generate additional runoff (or increase the velocity or change direction of storm runoff) should be responsible for managing the runoff so that reasonable measures are taken to protect other persons or property. Simply shifting the storm runoff burden to downstream property owners and the public is no longer acceptable. The Act emphasizes the prevention of new problems or the aggravation of existing ones; it does not mandate the elimination of existing stormwater related problems. However, the basic standards established by the Act help to ensure that existing problems are not aggravated. Also, current stormwater problems, along with proposed solutions, must be considered during the development of the comprehensive watershed plan.

Section 5 of the Act directs counties to prepare stormwater management plans for watersheds (designated by DER with assistance from the counties) and describes the required contents of these watershed plans. Section 5(c) mandates a watershed-wide approach to stormwater management to ensure that activities in one municipality do not adversely affect other municipalities in the watershed and in other drainage basins to which the particular watershed is tributary. It also requires that stormwater plans be consistent with other local, county, regional, and state environmental and land use plans.

This Act 167 stormwater management plan for the Ridley Creek watershed has been evaluated for consistency with a wide variety of existing land use plans and environmental programs and has been found to be compatible with and to complement the following:

- the National Flood Insurance Program
- the COWAMP/208 Water Quality Management Plan
- the Coastal Zone Management Program (CZM)
- Pennsylvania's Environmental Master Plan
- the State Water Plan
- Delaware County environmental plans
- the Delaware County Land Use Plan 2000: Update and Revision
- municipal comprehensive plans and ordinances

A detailed description of the compatibility of this plan with those listed above is presented in Chapter VI of Volume II.

An equally important section of Act 167 is Section 13. This section, which became effective upon the passage of the

Act on October 4, 1978, defines the basic standards for stormwater management in Pennsylvania. These standards essentially expand and broaden (redefine) prior common law drainage rules.[2] Section 13 states:

> 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.

Section 13's principal measure of sound stormwater management is to take <u>reasonable</u> steps to protect health and property from possible injury; subsections (1) and (2) prescribe the alternatives for meeting this basic objective. Further, when Section 13 is read in conjunction with other portions of the Act, it is clear that the intent of the Act is to apply the "reasonable step standard" to persons and property <u>downstream</u> of the development site. In other words, Section 13 is not spatially limited; it applies not only as the runoff leaves the site but also as far downstream as its impact can reasonably be determined. For this reason, it is important that county stormwater plans consider the watershed-wide impacts of runoff.

It is important to note that Section 13(1) uses the terminology maximum <u>rate</u> of runoff and not volume. This implies that total volume of runoff may increase after development, but any increased volume must be detained and discharged over time so that the pre-development maximum rate of flow will not be exceeded. A standard that did not permit any increase in volume could limit the use of many sites in that it could require that additional runoff be permanently stored or recharged on-site.

Section 13(2) is also worth special mention. Its purpose is to make the statutory standard more flexible. It permits changes in runoff characteristics and rates, <u>pro-</u>

2 Common law rules will still apply to all development occurring prior to October 4, 1978.

vided that reasonable measures are taken to protect downstream areas from storm runoff damages. The watershed plans will be critical in deciding when Section 13(2) may be exercised. They should identify areas where increased runoff rates will not adversely affect downstream areas or may even be beneficial for the overall runoff conditions in a watershed. In fact, until a watershed plan is adopted, it may not be practical for land developers to utilize this provision. A detailed hydrological and engineering analysis of the watershed may be necessary to determine the results of increasing the maximum rate of runoff, so for small developments this work may be too costly.

TECHNICAL APPROACH

The technical approach selected for this comprehensive watershed stormwater plan was structured to respond to Act 167 and DER draft guidelines for stormwater management planning. As stated previously, Sections 5 and 13 of the Act establish the basic standard that the maximum rate of runoff is no greater after development than prior to development activities or that reasonable steps are taken to protect downstream areas. Specific standards and criteria for achieving this stormwater management objective in the Delaware County portion of the Ridley Creek watershed were developed in a logical manner as a part of this watershed plan.

The technical program that led to the identification of the standards and criteria for the watershed involved the collection of data describing existing and future land uses, soils, slopes, stream channel characteristics, floodplains, water obstructions, and stormwater or flood related problems in the Delaware County portion of the watershed. From that data base, a "model" of watershed stormwater runoff flows reflecting these physical characteristics and conditions was developed using the Penn State Runoff Model (PSRM).[3]

Design storm events of 2-, 10-, 25-, and 100-year return periods were evaluated using the model to establish the base or existing stormwater runoff conditions for the watershed. The impacts of projected future development on the stormwater runoff characteristics of the watershed were then determined for the same rainfall events, using the calibrated model. Various management schemes for controlling the anticipated increases in stormwater runoff resulting from projected development were evaluated so that

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3 Lakatos, David F. (Walter B. Satterthwaite Associates, Inc.) and Aron, Gert (The Pennsylvania State University), "Penn State Runoff Model-User's Manual," June, 1981 Version, Institute for Research on Land and Water Resources, The Pennsylvania State University, University Park, Pennsylvania, June, 1981.

appropriate (technically feasible and implementable) stormwater management techniques for the Ridley Creek watershed could be defined.

The analysis of existing and future stormwater runoff conditions was initiated by dividing the watershed into 63 subwatersheds or "subareas," as shown on Plate 1 in the pocket of the back cover. The stormwater runoff flow contributions from each of these subareas were evaluated for their potential to generate peak runoff rates at various downstream points of interest. The key results of the technical work program are listed below. These results and conclusions are based on the unique configuration of the surface streams within this particular watershed as well as the specific land use characteristics that were considered. The reader is encouraged to examine Volume II for the background material on which these important conclusions were based.

- Effective stormwater management within the Delaware County portion of the Ridley Creek watershed requires the definition of criteria for controlling the peak stormwater runoff rates that would result from the 2- through 25-year design rainfall events.

- The ability to provide for safe routing of the stormwater runoff flows generated by the 100-year rainfall event through all proposed on-site stormwater management facilities is required. However, contrary to the existing practice in many communities in the County, the analyses performed indicate that specific control of the 100-year event is not needed in the Delaware County portion of the Ridley Creek watershed to maintain existing storm runoff flow rates on the main stem.

- Specific peak runoff release rate percentages are designated for the subareas within the Delaware County portion of the Ridley Creek watershed.

- Special site conditions are presented and described under which parties involved in new land development may apply alternative management criteria (i.e., "direct discharge" and the "downstream impact evaluation") to effectively reduce the impact of their site improvements. This aspect of the plan provides the desired flexibility of approach that can be used by a municipality in order to effectively implement this plan.

- Proper maintenance of stormwater management facilities, which is essential for the protection of downstream property from stormwater runoff impacts, was identified as a critical element of an effective stormwater management plan for the watershed.

- The important benefits that could be gained from the use of on-site infiltration of rainfall on new development sites in the upper region of the Delaware County portion of the watershed were identified. This resulted from an evaluation of baseflow conditions in the watershed, specifically as it affects the water supply for the basin's municipalities.

- The potential for the effective use of large-scale, regional distributed storage detention facilities for runoff control from large-scale events (e.g. 100-year storms) for more than one subarea is limited in the Delaware County portion of the watershed, given its configuration and location relative to the entire watershed. Some potential, however, does exist, and the basis for the identification of these areas is presented. Smaller distributed storage facilities, e.g., for use in providing "shared storage" for more than one development site within a single subarea, can be used in conformance with the watershed plan.

- In order to provide for an increase in usable watershed water resources, the feasibility of developing a regional baseflow augmentation system using groundwater recharge of stormwater is presented. This unique aspect of this plan was, again, evaluated as a result of the identified water supply needs for the Media Water Authority. In that stormwater runoff can be, in effect, a benefit to a watershed (as opposed to being viewed <u>only</u> as a detrimental factor), the framework for the wise use of this resource is presented.

In the update of the technical analysis, the original 1982 Ridley Creek watershed digitized data base was converted to a new digitization program format for use on an IBM AT personal computer. Land use changes which have occurred in the watershed since 1982 were reflected in the updated digitized data base using land use information provided by the Delaware County Planning Department. The PSRM input sequences were then updated to reflect the associated changes in impervious cover percentages and other runoff characteristics so that both existing and future condition models could be rerun for the design storm events.

The results of the updated modeling runs revealed no significant new impacts to cause a change in the conclusions reached in the original study or the recommended standards and criteria for stormwater management. The individual subarea release rates were reviewed using the updated modeling output. New release rates have been calculated and are presented on Plate 1. The new modeling results can be found in the Addendum to Volume II.

STANDARDS AND CRITERIA FOR STORMWATER MANAGEMENT

A required product of an Act 167 watershed stormwater management plan is a set of standards and criteria for the control of stormwater runoff from existing and new development. These are necessary to minimize dangers to property and life and to carry out the purposes of the Act.[4] The standards and criteria represent the minimum requirements for adequate control of stormwater runoff in the Ridley Creek watershed and thereby are the primary implementation element of the plan. Consequently, they need to be reflected in the municipal ordinances in order to comply with the watershed plan and thus the Act. The municipal regulatory approaches for incorporating these standards and criteria into a municipality's existing ordinance framework are discussed in more detail in Chapter VII of Volume II of the plan.

DER has designated Ridley Creek as a high quality stream from a water quality standpoint. As such, discharges to the stream from "point" sources such as wastewater treatment plants are subject to the highest level of effluent quality restrictions. In the future, the Department may require permits for all stormwater runoff discharges and, therefore, may apply some yet undefined effluent limitations to those discharges.

In complying with the standards and criteria of this watershed plan, it should be clear that developers are in no way relieved of their obligation to comply with the requirements of the Clean Streams Law and associated regulations including Chapter 102.[5]

The safety of the public shall be considered at all times in the design of stormwater collection and control facilities and provided for to the satisfaction of the municipal engineer. Except as otherwise provided for by municicipal ordinances, the standards and specifications of the Pennsylvania Department of Transportation shall be used in the construction of stormwater collection system components.

The standards and criteria for stormwater management are based on the technical approach used for the watershed study and can be considered to be either:

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4 Section 5(b)(11), P.L. 864, No. 167, Stormwater Management Act.

5 Title 25, Chapter 102, Erosion and Sedimentation Control, Rules and Regulations of the Pennsylvania Department of Environmental Resources.

- technical factors affecting stormwater runoff,
- performance standards for stormwater management, or
- maintenance of stormwater management facilities.

Technical Factors Affecting Stormwater Runoff

Definition of Existing Conditions

Existing or pre-development conditions shall be defined as those conditions which are present on any site prior to the date of adoption of this plan by the County. These existing conditions shall be used in defining those development activities which are subject to the standards and criteria as well as for stormwater runoff calculation purposes.

Development

When applying the standards and criteria developed in this watershed-level stormwater management plan, the term "development" shall be defined as any improvement of one lot or two or more contiguous lots, tracts, or parcels of land for any purpose (including the expansion of, or addition to, existing improvements) resulting in the creation of an additional 7,500 or more square feet of impervious land area. Therefore, any improvement that does not create 7,500 square feet of additional impervious land area shall be exempt from the standards and criteria of the watershed plan. However, persons making such improvements must still adhere to the provisions of Sections 5 and 13 of Act 167. The manner in which stormwater runoff is allowed to be discharged from land improvements with less than 7,500 square feet of additional impervious land area shall be reviewed by the municipal engineer, who shall have the responsibility for defining performance standards to be implemented on these sites in conformance with the intent of this plan and the provisions of Act 167.

Design Storms

For the purpose of analysis of stormwater runoff in pre- and post-development conditions, as well as for the design of runoff control facilities in the watershed (with the exception of storm sewer collection systems), the Soil Conservation Service's (SCS) 24-hour, Type II Rainfall Distribution shall be used. Use of this method for rainfall distribution is inherent when SCS methods are employed. The Type II distribution shall also be applied when other appropriate methods are used for developing design hydrographs.

The design storm frequencies that have been determined to be appropriate for stormwater management purposes in the Delaware County portion of the Ridley Creek watershed are presented in Table I-1 below. The 24-hour total runoff depths for these return periods, as determined from the "Pennsylvania Rainfall Manual,"[6] are also listed in this table.

TABLE I-1

24-Hour Rainfall Depths for Selected Return Periods in the Ridley Creek Watershed

Return Period	Depth in Inches
2-year	2.92
10-year	4.68
25-year	5.54
100-year	6.85

Calculation of Peak Stormwater Runoff Rates

The peak stormwater runoff rate from a development site is defined as the maximum flow rate of stormwater generated from the site area and leaving the boundaries of the site through any stormwater runoff outfall. Peak stormwater runoff rates, generated for both existing (pre-development) and future (post-development) conditions using the 2-, 10-, 25-, or 100-year design rainfall events presented in Table I-1, shall be defined for each outfall from a land development site. Outfalls may include distinct points, e.g., stream channels or storm sewers, and dispersed runoff areas. Various engineering methods are available for determining these peak stormwater runoff rates. One method that is commonly used is the SCS procedure that is described in Technical Release No. 55 (TR-55),[7] an SCS publication available through the County Conservation District. Volume II, Chapter V, discusses the computation of peak stormwater runoff rates.

Performance Standards for Stormwater Management

Peak Stormwater Runoff Rates from Development Sites

In order to achieve the basic stormwater management standard established by Act 167 (i.e., that the maximum rate of runoff is no greater after development than prior to development activities or that reasonable measures are taken to protect downstream areas), stormwater management systems

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6 Kerr, R.L., Rachford, T.M., Reich, B.M., Lee, B.H., and Plummer, K.H., "Time-Distribution of Storm Rainfall in Pennsylvania," Institute for Research on Land and Water Resources, The Pennsylvania State University, University Park, Pennsylvania, June, 1974.

7 Soil Conservation Service, "Urban Hydrology for Small Watersheds," Technical Release No. 55, U.S. Department of Agriculture, Washington, D.C., June, 1986.

designed for new development sites shall control, at a minimum, the peak stormwater discharge rate for the 2-, 10-, and 25-year rainfall events. This shall be done in a manner required to attain one of the criteria presented below, selected at the discretion of the developer's design engineer, depending upon the location of the development site in the Delaware County portion of the Ridley Creek watershed. Provisions shall also be made for safely passing the post-development 100-year runoff flows without damaging (i.e., impairing the continued function of) those systems.

The discharge of concentrated, collected stormwater runoff from control facilities such as detention basins or storm sewers onto adjacent properties where there is no existing natural watercourse or drainageway to receive the discharge shall be avoided unless deemed absolutely necessary. Where such a discharge is absolutely necessary, easements and/or other provisions shall be proposed, approved, and implemented to prevent damage to the adjacent properties to the satisfaction of the municipal engineer. Where discharges are proposed to natural watercourses and drainageways, such discharges shall be made in a manner so as not to result in property damage or deterioration of channel stability.

Release Rate Percentage

The release rate percentage is the primary performance standard for this plan. All subareas have been given a release rate percentage which defines the percentage of the pre-development peak stormwater runoff rate that shall be considered as the base runoff rate for a particular site. That is, in order to comply with this watershed-level plan, the peak stormwater runoff rate discharging from the outfalls of a development site cannot exceed this base rate. The specific release rate percentage for each subarea (see Plate 1 for subarea identification) can be found in Table I-2 which is located on Plate 1.

The release rate percentage applies uniformly to all land developments or alterations within a subarea which result in an increase in the post-development rate of runoff from the site. Thus, the percentage represents an average value for the subarea. An individual developer can select and design drainage control measures that are most appropriate for a particular site and type of development, provided that the applicable release rate percentage for the subarea is met.

A detailed description of the specific technical steps to be followed when using the release rate percentage information (and the actual percentage values that are shown on Plate 1) is presented in Chapter V of Volume II. Basically, however, the steps that a land developer must follow to utilize the release rate percentage for a particular site are:

1) Identify, from Plate 1, the specific subarea in which the land development site is to be located.

2) Compute the pre- and post-development peak runoff rates for each stormwater outfall from the site, for the 2-, 10-, and 25-year storms, applying no stormwater management techniques. If the post-development peak runoff rate is greater than the pre-development value, proceed to Step 3.

3) Apply on-site stormwater management techniques to increase infiltration and/or reduce impervious surfaces. Recompute the post-development runoff rate for the 2-, 10-, and 25-year storms. If the runoff rate is still greater than the pre-development rates, stormwater detention will be required.

4) Using the subarea release rate percentage and the pre-development rate of runoff, multiply to find the maximum release rate from the detention facility for each design storm event. The allowable peak release rate from a storm runoff detention facility, in cubic feet per second (cfs), is equal to: the pre-development peak rate (cfs) x the release rate percentage for the subarea in which the land development site is located).

Direct Discharge

In those subareas which are immediately adjacent to Ridley Creek, development sites may happen to be located such that the total stormwater runoff flows from the site will be discharged (through outfalls) directly into Ridley Creek. Given the flow "timing" characteristics of the watershed, the post-development peak stormwater runoff rate from these sites will typically be only a minor percentage of the peak flow rate that will eventually pass the site in the main branch of Ridley Creek. In the Delaware County portion of the watershed, the peak runoff rate from these sites will also occur in advance of the Ridley Creek peak flow during the design rainfall events. Therefore, as an alternative to applying the release rate percentage on such a site, if any stormwater outfall from a site(s) which is located immediately adjacent to Ridley Creek is constructed so as to prevent erosion and scour of the Ridley Creek channel, no alteration to the post-development peak runoff rate is required.

Downstream Impact Evaluation

Any party interested in developing an area in the Delaware County portion of the Ridley Creek watershed may also be relieved from implementing the release rate percentage stormwater runoff control criterion by having an engineer experienced in hydrology and hydraulics perform one of the evaluations listed below. This aspect of the plan provides desired flexibility and acknowledges the capability and ingenuity of the site design and municipal engineers in Delaware County. Calculations performed as part of these evaluations are to be coordinated with and reviewed by the municipal engineer.

1) In those areas of the watershed where man-made stormwater conveyance channels (i.e., closed storm sewers, concrete-lined channels, rip-rap protected channels, etc.) discharging directly into Ridley Creek exist or will be constructed, the total stormwater runoff flow during the design rainfall events may be directed through these channels with a post-development peak discharge which is greater than the prescribed release rate, provided that the conveyance channel has sufficient capacity to handle the flow. This criterion can allow for a condition where the post-development peak runoff rate from a site does, in fact, exceed the pre-development value -- when calculations show that reasonable steps will be taken to protect downstream areas from storm runoff impacts.

2) In any area of the watershed, a post-development discharge rate which is greater than that which is calculated using the release rate percentage may be allowed if it can be shown (through the use of acceptable engineering analysis and design) that reasonable steps are being taken to protect downstream areas from the impacts of the greater discharge rate. An evaluation (i.e., the downstream impact evaluation) must be performed which demonstrates that at any point in time, the flow rates on the existing conditions runoff hydrograph at the outlet of the subarea(s) in which the development site is located are not increased by more than five percent for storm discharges resulting from future conditions runoff (with stormwater management provisions) from the 2-, 10-, and 25-year rainfall events for the particular site. A detailed description of the specific steps to be taken to perform a downstream impact evaluation are presented in Chapter V of Volume II. Existing conditions runoff hydrographs for all identified subareas (see Plate 1) computed as part of the watershed modeling done in the development of this plan are available from the Delaware County Planning Department. The site design engineer may exercise considerable flexibility and ingenuity in providing stormwater management facilities by employing this option.

Shared Storage

Shared-storage facilities, which provide detention of runoff for more than one development site, may be considered within a single subarea. Such facilities shall meet one of the above design criteria. Runoff from the development sites involved shall be conveyed to the facility from its source in a manner so as to avoid adverse impacts, such as flooding or erosion and scour of natural channels, to downstream channels and property.

Maintenance of Stormwater Management Facilities

Maintenance Responsibilities

All facilities for the control of stormwater runoff require periodic maintenance. The following parties shall be responsible for ownership and maintenance of stormwater runoff control facilities constructed on development sites:

1) If a site is developed for commercial, industrial, or multi-residential uses under the ownership of a single person, corporation, or other management entity, the responsibility for maintenance of stormwater control facilities lies with that owner.

2) If a residential development consists of privately owned, multi- or single-family units wherein the streets, sewers, and other public improvements are to be dedicated to the municipality, stormwater control facilities shall likewise be dedicated to and maintained by the municipality. Excluded from this requirement are those facilities designed to be situated on and serve individual lots.

3) If a residential development consists of privately owned, multi- or single-family units wherein the streets, sewers, and other public improvements become the property of a community or homeowners' association, stormwater control facilities shall likewise be owned and maintained by the association.

4) If a site is developed for public or quasi-public use, such as schools, hospitals, churches, and similar institutional uses, the ownership and maintenance responsibilities shall be those of the respective organization.

5) If a site is developed for state, county, or municipal facilities such as parks, the ownership and maintenance responsibilities shall be those of the respective political entity.

In all cases, the municipality shall have the authority to require that necessary maintenance be performed by the responsible party to ensure continued safe operation and protection of downstream property.

Maintenance Plans and Schedules

It shall be the responsibility of the person(s) developing a site to provide as-built plans and a schedule for required maintenance of stormwater management control facilities to the municipality upon completion of the development. All stormwater management facilities shall have been constructed by the time of completion of the overall development site and be free of sediment or debris. Such facilities shall be subject to inspection by the municipality.

IMPLEMENTING THE WATERSHED PLAN

The Stormwater Management Act emphasizes locally administered stormwater programs with the watershed municipalities taking the lead role. Section 11(b) of the Act states:

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

Putting the watershed plan's standards and criteria into effect will require the municipalities and Delaware County to take several actions. Most of the standards and criteria will need to be applied through the municipal land use and development ordinances. However, because stormwater can be managed successfully only on a watershed basis, the Ridley Creek communities will need to cooperate on various activities. Therefore, the implementation plan includes guidelines for the required local ordinances along with recommendations for watershed coordination in performing certain regulatory and management functions. In addition, the implementation plan encourages the use of some alternative management techniques which could help the municipalities to better achieve the goals of the plan.

Recommended Ordinances

The regulatory approach for implementing this watershed stormwater management plan utilizes the powers granted by Act 247, the Municipalities Planning Code (MPC). The MPC enables counties and municipalities to adopt zoning, subdivision and land development (S/LD), and planned residential development (PRD) ordinances and to address storm drainage concerns in these ordinances. In addition, the municipal (borough, township, etc.) codes enable the adoption of building codes. Most of the land alteration activities to which stormwater controls should be applied will fall within the scope of one of these ordinances. Used in combination, they provide a comprehensive stormwater ordinance package which covers all types of land alteration activities, whether they be new development, expansion of existing uses, or redevelopment/reuse of existing lots and structures.

In addition to having the correct provisions in the proper ordinances, the municipal stormwater articles should be clear (understandable), consistent in approach and application throughout the watershed, and flexible. Flexibility in the regulatory approach is particularly important. It is not possible to write an ordinance that fits every site and condition, and land developers should be encouraged to use creative design and engineering to meet stormwater management criteria.

Flexibility can best be obtained by using a performance standard approach in the ordinances. A performance standard states an end result or outcome that is to be achieved but does not specify the means for achieving it. In comparison, a specification standard sets the exact characteristics to be used in all situations. The release rate percentage, for example, is a performance standard, while the design storms for detention basin design are specification standards. To be most effective, the stormwater provisions will combine both types of standards.

It is important to note that when there is an approved watershed plan, the stormwater provisions in the local ordinances will override other development standards. For example, the maximum density standard for a site will only apply if the stormwater standards can be met at those densities. Similarly, if certain provisions of the ordinances make it impossible to provide adequate storm drainage in accordance with the watershed plan, then these requirements should be modified.

The following sections highlight the key additions and changes to the municipal S/LD, zoning, and building ordinances needed to implement the Ridley Creek watershed stormwater management plan. The comments also cover the County's S/LD regulations. Volume II, Chapter VII, of the watershed plan provides a more in-depth explanation of the recommended additions and changes plus guidelines for incorporating them into the existing municipal ordinances.

These changes will apply to all of the Ridley Creek municipalities except Thornbury Township, which has only a very small area in the watershed (about 25 acres). The Township, however, should add language requiring developers to check the Ridley Creek watershed plan and to utilize those standards and criteria if different than the provisions in the Township's erosion and sedimentation (E/S), grading, and S/LD ordinances.

Since most of the Ridley Creek municipalities have territory in more than one watershed, the ordinances should clearly identify the provisions that apply only to the Ridley Creek portions of the municipality. For the time being, the municipalities should continue enforcing the stormwater standards contained in their existing ordinances in other sections of the municipality.

Subdivision and Land Development Ordinance

This is the ordinance that will contain most of the community's stormwater management controls, which is consistent with the enabling authorities in the MPC. The majority of the stormwater provisions should be included in one article of the S/LD ordinance to promote ease of use. For easy reference, the S/LD ordinance should also include the municipality's E/S and grading (cut/fill) provisions as another separate article. Since stormwater runoff carries and deposits sediment, control of erosion and sedimentation and stormwater management are interrelated, and it is important that the two sets of provisions be consistent (see Volume II, Chapter II). There are several good model E/S standards available from DER.

o Key Provisions of the Proposed Article for a S/LD Ordinance

1) General stormwater performance standard which incorporates the language of Section 13 of the Stormwater Management Act. This would provide an overall standard (i.e., test) for specific stormwater control measures.

2) Stormwater Plan Requirements and Review Procedures

   o No land disturbance or earthmoving activity can take place without an approved stormwater management plan for the development site.

   o Developments resulting in the creation of less then 7,500 square feet of impervious surface are exempt from full stormwater plan procedures; however, stormwater control measures must be approved by the municipal engineer.

   o A stormwater plan for the development site must be prepared and certified by a registered professional engineer with expertise in stormwater management.

   o A stormwater plan must be submitted with the preliminary S/LD plan to be forwarded to DCPD and the Conservation District for review and comment.

- A final stormwater plan shall be approved by the municipal engineer and shall be consistent with the watershed plan. Final plan approval shall be contingent upon obtaining all necessary DER permits (obstructions, E/S, etc.).

3) Stormwater Standards and Criteria - Ridley Creek. As developed for the watershed plan and described in the previous section on the plan's standards and criteria, these are:

   - The release rate percentages, direct discharge option, and downstream impact evaluation.
   - The specified method for calculating pre- and post-development runoff.
   - The specified design storms for controlling post-development peak runoff rates.

4) Design Standards for Stormwater Management Techniques and Facilities

   - All proposed techniques and facilities must be approved by the municipal engineer.
   - Control measures, such as detention facilities, can be provided off-site (see Volume II, Chapter V, for a more detailed discussion of off-site, or distributed storage facilities), provided there are easements, covenants, etc. to guarantee perpetual use and access.
   - On-site stormwater management techniques, such as detention basins and seepage pits, should be selected and designed according to the performance guidelines in the watershed plan.
   - Storage facilities must adhere to the 2- through 25-year design storm discharge requirement and the 100-year storm safety provision.
   - Storm sewers should comply with existing local regulations, and the municipal engineer should verify that the capacity of existing storm sewer systems and/or the natural channel that receives the discharge from the sewers is adequate to handle the anticipated flow.

- Developers must consider impacts of stormwater management measures on geological and soils conditions; in-depth studies may be required.

- During construction, stormwater management facilities may also be used for soil erosion and sedimentation control. Drainage channels and outfalls should be carefully designed to ensure stability against erosion.

5) Maintenance Provisions for Permanent Facilities

   - Provisions for ownership and continuous maintenance as described in the plan's standards and criteria.

   - The maintenance plan for a private facility should identify ownership, a maintenance schedule, a service provider, and funding sources.

   - As-built plans must be submitted for all stormwater control facilities except those located on an individual lot/structure, and all facilities must be cleaned and inspected before acceptance and/or dedication.

6) Other Provisions (may appear in other articles of the S/LD ordinance)

   - Regular inspections during construction to assure proper installation of the approved stormwater management controls.

   - A fee schedule to cover plan review and inspection costs.

   - Stormwater management facilities covered by required performance and maintenance bonds.

   - Penalties for violation of the approved stormwater plan for the development site.

Zoning Ordinance

Not all land alteration activities will fall under the definition of "subdivision" or "land development." Therefore, it is important to link the municipal zoning ordinance into the stormwater ordinance package. Through its zoning ordinances, the municipality can assure the application of the watershed plan's standards to single lot (or single structure) developments, expansions or reuses of existing uses and structures, and special land use activities, (e.g., farming).

Incorporating adequate stormwater management provisions does not require substantial changes to the existing municipal zoning ordinances and maps. However, all municipalities are encouraged to examine their zoning district designations in light of the watershed plan and to allow for cluster development, PRDs, or similar zoning techniques. For many sites, these techniques will allow the necessary flexibility to meet the stormwater management standards while still providing good site design and preserving natural features and amenities.

- Key Additions/Changes Being Proposed for Local Zoning Ordinances

  1) The release rate percentage map should be adopted as an overlay to the zoning map. If possible, designated 100-year floodplains should be shown on the overlay.

  2) A provision should be added to the general provisions or supplementary regulations section of the ordinance requiring:

     - All uses covered by the ordinance to comply with the requirements of the applicable watershed stormwater management plan and applicable provisions of the S/LD ordinance and building code (reference to ordinance sections).

     - New agricultural activities (if permitted by the ordinance) must have a conservation plan incorporating stormwater management provisions in accordance with the standards and criteria of this plan prepared (or reviewed) by SCS. Appropriate administrative procedures of the County Conservation District must be followed.

  3) Any specific stormwater management requirements or plans in other sections of the ordinance, such as the individual district provisions, should be removed to avoid possible regulatory conflicts.

  4) The zoning officer and/or building inspector should not issue any building permits until all other state and local permits have been obtained, including floodplain, obstructions, and E/S.

Building Code

The inclusion of stormwater provisions in the building code (or appropriate referencing to sections of the S/LD and zoning ordinances) provides an additional guarantee that stormwater controls will be applied to all building construction in the municipality. By stipulating that a building permit cannot be obtained unless the application is consistent with the site's stormwater management plan, it covers the situation where the builder and the developer who prepared the approved stormwater plan are not the same entity.

In addition, building code provisions generally cover such stormwater management techniques as rooftop storage, porous pavement, parking lot storage, and connection of building storm drains to storm sewer systems. Many of the watershed municipalities presently use the BOCA Basic Building Code (various editions). As part of the publication "Stormwater Management Guidelines and Model Ordinances," DER provides a useful guide to appropriate amendments to the BOCA Code.

Delaware County Subdivision and Land Development Ordinance

At present, the County's S/LD ordinance includes standards for E/S control and storm drainage systems (primarily storm sewers). The County's ordinance only applies to Brookhaven, Eddystone, and Parkside Boroughs; the remaining Ridley Creek municipalities enforce their own ordinances. The MPC requires municipalities to submit all S/LD plans to the county planning commission for review, although the comments are not binding on the municipality.

Most of the stormwater management provisions in the County's S/LD ordinance are written as fairly broad performance standards, which minimizes potential conflict with more specific municipal standards. However, in light of the findings of this plan, the County may want to consider certain modifications to some of the sections. A general provision added to the County's ordinance could avoid any conflict between the County's stormwater standards and local provisions adopted pursuant to a watershed plan. The provision should state that stormwater management must be provided for a site in accordance with the approved watershed plan. In areas that do not have approved watershed plans, the existing provisions in the County's ordinance would apply.

Watershed-Level Coordination

There are numerous opportunities for the Ridley Creek municipalities to cooperate on implementing the watershed stormwater management plan. Although individual municipalities traditionally have been the focus for stormwater management activities, the watershed plan clearly demonstrates that planning and implementing an effective stormwater management system requires a watershed-wide perspective. Further, watershed coordination is consistent with Act 167, which requires municipalities to prevent stormwater damage and problems throughout the watershed.

Carrying out an effective stormwater management program will require skilled personnel and financial commitments, and the watershed municipalities may find it economical to provide these jointly, rather than individually. There are several options for organizing watershed coordination; only a few alternatives are discussed here. The final decision, of course, will be up to the County and the municipalities. However, the bottom line remains: safe stormwater management requires watershed cooperation.

Preparation of the Stormwater Ordinances

One of the first areas where watershed coordination will be necessary is in the drafting of the stormwater management provisions in the municipal ordinances. The watershed plan provides a basic guide as to form and content, but additional work will be required to tailor these specifically to each municipality's existing ordinance system. It will be particularly important to ensure that any adaptations do not result in changing the effect or consistency of the existing provisions.

This ordinance coordination can be accomplished by having DCPD review all of the stormwater management ordinances relating to zoning and S/LD before they are adopted by the municipalities. Since the MPC already requires municipalities to submit amendments to their zoning ordinance to the county planning agency for review, this County overview of the stormwater management provisions is not a new activity. In addition to reviewing the ordinances, the County's planners could also provide technical assistance during their preparation.

Ordinance Administration and Enforcement

This is the area where the municipalities will incur the most costs for stormwater management and where there are definite opportunities to reduce them through cooperation. Administration and enforcement includes site plan reviews, construction inspection, monitoring, and enforcement.

Since the watershed plan establishes a uniform set of stormwater standards and criteria, the watershed municipalities can readily cooperate on ordinance administration. Municipalities could share the costs for trained and experienced staff required to perform the plan reviews and on-site inspections. Whether handled by consultants or paid staff, the fees/salary could be shared proportionally by the watershed municipalities on some formula basis (size, development activity, etc.).

Another option would be for the County and the municipalities to agree that all technical stormwater reviews would be performed by either DCPD or the Conservation District. Since the Planning Commission already reviews local S/LD plans, this alternative may be the most efficient in the long run. In addition, it would help to assure that the potential impacts of a proposed development on downstream locations are considered during the plan review. On the other hand, the technical expertise to perform these reviews might best be found through the Conservation District at SCS. SCS has expressed a willingness to perform this task. If one of these options is pursued, then the review agency should be supplied a copy of the as-built plans.

A County technical review would probably require additional staff, and the County and municipalities would have to agree on an equitable cost sharing arrangement. However, developer's fees should cover most of the plan review and inspection costs, whether performed by municipal or County staff.

Maintenance of Stormwater Management Facilities

Proper maintenance of stormwater management facilities has been identified as a critical element of an effective watershed plan. Under this stormwater management plan, municipalities will be assuming greater responsibility for continuing maintenance of their stormwater detention facilities. Again, this is an area where cooperative action could result in cost savings. Actual maintenance requirements will depend on the number and type of facilities constructed and, therefore, are difficult to project at this point.

It may be that existing municipal crews can reasonably handle the cleaning, mowing, etc., of the facilities. However, one approach worth considering is that of municipalities contracting jointly with one or more private firms to provide periodic maintenance to all publicly owned detention facilities in the watershed. This approach would permit some economies of scale and would allow the firm(s) to schedule maintenance activities in an efficient way. Another option would be for one or two of the larger municipalities to agree to provide maintenance on a contractual basis to the other municipalities. Such maintenance agreements could be extended to major stormwater structures, such as culverts and bridges, the operation of which is critical to the watershed.

Beyond this direct responsibility for the maintenance of their own facilities, the municipalities should oversee and enforce the maintenance of all facilities within their boundaries, be they private or public. To accomplish this, it will be necessary to monitor the maintenance of all stormwater control facilities. This monitoring could be reasonably handled on a uniform basis by the County Conservation District. District personnel have the necessary experience to accomplish this important function and could inspect facilities (e.g., detention ponds) annually and provide a report to the owner and municipality. If adequate maintenance is not being provided (according to the approved maintenance plan), then the municipality can follow up with appropriate enforcement actions. Costs for the district's inspections could be paid annually by the facility owners or could be included in a single fee paid at the time of site plan approval.

Alternative Management Techniques

An additional benefit of a watershed-level stormwater runoff study is the opportunity to develop and analyze alternative stormwater management techniques. Several of these techniques were evaluated for their potential for implementation in the Delaware County portion of the Ridley Creek watershed. The ultimate goals of these techniques are to streamline the institutional stormwater management process, provide for a beneficial use of stormwater runoff, and assure that funds utilized for stormwater management are used effectively.

These methods are referred to as either technical stormwater management practices or institutional stormwater management systems. A technical practice involves detailed technical analyses necessary to define the appropriate criteria for location and design of a stormwater management device. Volume II, Chapter V, provides a detailed description of stormwater management techniques for the Delaware County portion of the Ridley Creek watershed. An institutional system defines procedures by which regulatory agencies implement the standards and criteria for stormwater management.

As a result of the watershed-level investigation of stormwater related problems and practices in the Delaware County portion of the Ridley Creek watershed, implementation of the following techniques is strongly recommended.

Technical Stormwater Management Practices

Withdrawal of stream flow for water supply by the Media Water Authority is an established use of the Ridley Creek water resource. An evaluation of the expected loss in annual infiltration of rainfall that is projected to result from development in the Delaware County portion of the watershed above the Media Water Authority intake is included in Chapter V of Volume II. The result of that evaluation and the increasing demand for water supply in the Media Water Authority's service area establish the need to develop measures to replace the lost infiltration, or even to provide for a net gain, thereby augmenting the available water resource in Ridley Creek. Two technical practices have been identified in this watershed plan which would allow for a maximum benefit to be realized at a minimal cost with respect to augmenting the baseflow needs of the Media Water Authority. Chapter V of Volume II describes these practices in great detail. Brief descriptions, however, are presented below.

On-Site Infiltration

In all subareas that contribute to the flow in Ridley Creek above the Media Borough intake, measures should be employed on all development sites to induce infiltration of stormwater runoff. A realistic amount of infiltration that could provide a significant water resource benefit at a minimal cost is equal to a percentage of the difference between pre- and post-development infiltration conditions and is termed "initial abstraction" in the detailed discussion that is presented in Volume II. Initial abstraction shall be calculated as defined in SCS's TR-55. Specifically, initial abstraction is the depth of rainfall, in any precipitation event, that is captured on vegetation, buildings, and small depressions of a site and saturates the soil (in predevelopment conditions) before infiltration and runoff begin. Initial abstraction is independent of rainfall frequency and represents the minimum increase in runoff that occurs as a site is transformed from natural conditions to a developed condition. A detailed example of the computation of initial abstraction is provided in Volume II.

Regional Baseflow Augmentation System

The feasibility of a regional system for recharge of shallow groundwater and, therefore, for baseflow augmentation using off-stream stormwater impoundments for peak runoff rate reduction was evaluated for this stormwater management plan. Peak flows in Ridley Creek and selected tributaries could be "skimmed off" into off-stream impoundments and stored. Between rainfall events, the stored water could be pumped to a system of hillside infiltration trenches, allowed to percolate into the shallow groundwater system, and move by gravity to augment the baseflow of Ridley Creek and its tributaries. A conceptual layout for a potential pilot system is presented in Volume II.

Institutional Stormwater Management System

As a part of the plan preparation effort, various institutional stormwater management alternatives were examined which might be capable of performing the continuing planning, maintenance, financing, and regulatory activities identified by the plan. Obviously, there are numerous acceptable approaches, and the institutional system will have to be tailored to the specific conditions and needs of the watershed. It will be the task of the municipalities within the watershed to select the most feasible system consistent with the watershed stormwater plan and their own needs and objectives. In any case, stormwater management will require intermunicipal coordination and cooperation within the watershed. The following institutional system is recommended to assist in the implementation of the watershed plan.

A Standard Process for Designing a Stormwater Management System on a Developing Site

Adoption of and adherence to a consistent and coordinated stormwater management design procedure is an essential component of the total site development process which involves alteration of land and results in an increase in the percentage of impervious area. Similarly, a stormwater management plan is an integral part of the total site improvement plan, which includes provisions for grading, landscaping, erosion control, streets, sanitary wastewater facilities, water facilities, and other utilities. The site development design and review process is implemented by efforts of the developer, technical consultants, municipal engineers, and local officials. Other agencies, including DER, the county or local planning commissions, and a sanitary wastewater authority, also have significant impact on the stormwater management plan for a new land development project.

A flow diagram of the proposed stormwater management design and review process that should be used by all parties involved in land development in the Delaware County portion of the Ridley Creek watershed is presented in Appendix E of Volume II. The use of a standard stormwater management plan development and review process is required to ensure the compatibility of new stormwater systems in the watershed with the comprehensive watershed stormwater management plan.

FINANCING STORMWATER MANAGEMENT

In implementing a feasible stormwater management program, financing is bound to be one of the major concerns, particularly in light of current fiscal constraints. At first, it may be tempting to adopt the approach that "the one who creates the cost pays the cost," thus placing most of the financial responsibility on the local municipality and private developer. However, this approach may not be realistic - or totally fair. Many of today's stormwater concerns are the result of years of insufficient planning and lack of attention to stormwater drainage by all levels of government as well as the private sector. Therefore, everyone should share in the cost of the solutions, whether those solutions involve activities to prevent new problems or to correct existing ones.

The following paragraphs briefly describe some of the financing alternatives available for stormwater management. Most of these are applicable to both the municipalities and the County. They can be pursued under existing legal authorities, although a few may require new or changed legislation to make them useful in stormwater management. The financing alternatives include techniques to finance capital improvement projects, operation and maintenance activities, and local ordinance administration.

Chapter 111 Funding

Chapter 111 (issued under Section 17 of the Stormwater Management Act) provides authorization for planning grants and the reimbursement of up to 75 percent of the costs associated with the preparation or revision of watershed stormwater management plans and the preparation, administration, enforcement, implementation, and revision of stormwater regulations in municipalities for which there is an adopted watershed plan. Some of the following activities are considered allowable costs under Chapter 111:

- the preparation and enactment of stormwater regulations (including technical and legal services)

- administrative, enforcement, and implementation activities (including the review of the stormwater management component of development plans, fees for special consultations, and monitoring and inspection activities)

Tax Revenues and Annual Budgeting

General and special purpose tax revenues are probably the most frequently used means of financing stormwater related projects for local municipalities, particularly operation and maintenance costs. Real estate taxes are the main source of local tax revenues, along with wage taxes and other special taxes or assessments. Funds received by municipalities from federal revenue sharing go into the general fund and can be used for stormwater projects. State liquid fuel monies can be used for stormwater and drainage structures related to street construction and repair.

It is often difficult for smaller or less developed communities to obtain financing or to accumulate funds for larger stormwater or flood control projects. One solution to this problem is for a municipality to establish a capital improvement reserve fund. Each year the local government can set aside an amount for the reserve fund, and funds can be allowed to accumulate for larger projects. The principal advantage of the reserve fund is that it allows municipalities to put projects on a "pay-as-you-go" basis, thus saving the interest costs for borrowing. A capital improvement reserve fund also enables a municipality to set up an ongoing program for improving and maintaining facilities.

There are various ways of generating revenues for the reserve fund. One way is to maintain the property tax levies allocated to debt retirement at a constant level. Usually existing debt drops as a percentage of property tax revenues as annual payments for debt service decline and assessed valuation of property increases. By maintaining the tax at its current rate (if taxes are not too high), a community can earmark those "extra" funds to the capital improvement reserve fund.

Another approach might be to allocate a portion of the funds from such sources as parking meters, amusement taxes, service charges, and licensing or permitting fees. For example, a community could include a special set-aside for the "stormwater capital improvement reserve fund" from its building permit fees. Also, any operating surplus for a fiscal year (or some portion thereof) could be transferred to the reserve fund.

Special Assessments

Special assessments may be levied on affected properties to finance specific projects, most often capital improvements. The assessment rate is set on a formula basis which relates the amount of the assessment to the value of the services or benefits provided. Special assessments are applicable to a project with one or more of these characteristics:

1) It provides special benefits to the property which are direct and measurable, such as storm sewers, catch basins, curbs, and gutters.

2) It provides general benefits to a localized area where the whole area benefits, although not uniformly (e.g., flood control facilities).

3) It provides public appurtenances to private property (e.g., sewers, streets, and detention ponds).

4) It abates a public nuisance (e.g., detention pond).

The special assessment has not been used widely in Pennsylvania for storm drainage facilities. The major drawback has been an equitable formula for allocating the assessment to affected properties, both upstream and downstream of the facility.

However, this mechanism merits further consideration. It may be particularly applicable in areas where storm sewer systems are recommended (or require improvement) or where a detention facility is proposed to serve one or more developments in the watershed. The watershed plan provides a basis (using PSRM) to assess how properties will be affected (benefitted) by proposed stormwater facilities. Therefore, it can aid in establishing an equitable, legally defensible assessment formula.

User Charges

User or service charges may become more popular in the future in financing stormwater management activities. To utilize this approach, though, it is necessary to have a stormwater plan to develop sound cost estimates for implementing the stormwater management system. User charges have been utilized in other states where communities have established a separate stormwater utility. In this arrangement, the utility owns and operates all aspects of stormwater management and flood control and charges a fee for property owners based on lot area and estimated runoff rates. A stormwater utility appears to be possible in Pennsylvania, but it would have to be licensed and regulated under the Public Utility Commission, similar to some privately owned and operated package sewage treatment plants.

It is not clear whether municipalities could institute user charges for a public storm drainage system under existing legislation, especially without local voter approval. However, user charges should be feasible where it is possible to define the service area of a facility, such as a detention pond serving one or more subdivisions. Such fees could be determined by considering various physical factors affecting runoff rate (e.g., amount of impervious surface, soil and slope conditions, etc.) which can be documented in the stormwater plan as well as on actual operation and maintenance costs for the facility.

Municipal Bonds

Most long-term borrowing by municipalities and authorities is done by issuing bonds. Pennsylvania's local governments and authorities are governed in this area by the Local Government Unit Debt Act (Act 185 - 1972). This Act regulates the type of bonds that agencies may issue and establishes debt limitations for municipalities.

Two types of bonds may have some applicability for stormwater management. Electoral debt bonds may be issued by a municipality following election approval. If the electorate approves bonds for a specified project, such as the construction of a storm sewer system, then the electoral bonds are not subject to any debt limitation. Non-electoral general obligation bonds pledge the general taxing powers of a municipality for repayment of the bonds and, as a result, do not have any coverage factors on their repayment.

Other Grant Funds

In the past, communities depended heavily on federal and state grants for major capital improvement and flood control projects. However, given the present state of flux in federal and state funding programs, it is unclear how secure a source of financing these will be in the future. For this reason, this study does not present any extensive catalogue of grant programs. If a community has a specific project, it should contact the appropriate state or federal agency to determine if any funding assistance is currently available.

On the federal level, the U.S. Army Corps of Engineers can provide technical assistance (for planning, design, and construction) of specific stormwater projects and will assist in smaller improvement projects if necessary to protect a public facility. There are also funds and technical assistance available from SCS. The updating of local ordinances is an eligible activity under the Community Development Block Grant Program (CDBG).

The Pennsylvania Department of Community Affairs (DCA) and DER provide technical assistance, information and education programs, and some funding for capital improvements. DCA administers the floodplain management program and assists communities with the preparation and adoption of their floodplain ordinances and other floodplain management activities. Also, under Act 167, DCA is assigned responsibility for conducting education and informational programs. DER provides technical assistance (including public education) on stormwater and E/S problems, partial funding to the County Conservation District, and financial assistance for stream improvements (e.g., bank erosion) where the problems affect a public facility.

Private Financing

A substantial portion of the costs of future stormwater management activities will be provided by private land developers. In most communities, developers will be responsible for the initial construction of any facilities required to serve their site and, in some cases, for off-site improvements necessitated by the development, such as increasing the size of a downstream culvert. A developer's application/permit fees provide the major source of funds for local ordinance administration, including plan reviews, inspection, and enforcement. Some municipalities use a fixed fee system, while other communities use the developer's fee approach, which is a fee based on an estimate of actual costs to the municipality for professional reviews, hearings, and inspections. In general, for larger developments the developer's fee is the preferable, and sometimes more equitable, approach. In either event, a major development should pay most of the administrative costs that it generates.

PRIORITIES FOR IMPLEMENTATION

This watershed stormwater management plan for Delaware County addresses the plan requirements (Section 5(b), Act 167) that are identified in the Stormwater Management Guidelines (DER, Bureau of Dams and Waterway Management, May, 1985). One of the key requirements concerns the identification of the implementation priority to be given to the various elements of the watershed plan. This section identifies and summarizes these elements and presents a discussion of the general emphasis, or priority, that should be given to them.

Standards and criteria which set performance standards for the individual stormwater management plans that will need to be prepared for future developing sites have been developed and presented. Three stormwater discharge options are provided to allow for maximum flexibility for land developers and municipalities in the design of stormwater management plans. Design storms have been specified, and criteria have been established for the design of on-site facilities to control storm runoff in a manner that is consistent with the performance standards of the watershed plan. The responsibility for maintenance of stormwater management facilities has also been identified, along with recommended arrangements for organizing and implementing maintenance activities.

The additions and changes to the various municipal ordinances which are needed to help ensure that effective, coordinated management of storm runoff is achieved in the Delaware County portion of the Ridley Creek watershed have also been discussed. Those changes and/or additions to municipal ordinances will be necessary to ensure that stormwater management practices on developing sites are consistent with the standards and criteria of this plan.

Recommendations have also been made for cooperative efforts and other alternative management techniques which would help in the implementation of the watershed plan. Specifically, two concepts are presented which make use of stormwater runoff to enhance the overall water resource system of the Ridley Creek watershed through the recharge of the shallow groundwater system. An institutional approach which lays out an effective process for the design, review, and approval of stormwater management plans for individual developing sites in accordance with the overall watershed plan is also recommended to help in the long-term implementation of the plan. Possible sources for financing the implementation of the provisions of the watershed plan are also presented.

The key priority for the effective implementation of this watershed plan is its adoption by Delaware County Council. This is a necessary step in order for the standards and criteria for stormwater management in the Ridley Creek watershed to be used to help achieve the long-term stormwater management goals that have been identified as part of this watershed plan. This step needs the full support and involvement of the municipalities in the watershed. Following an official adoption of the plan by the County, the municipalities in the watershed will need to incorporate the required ordinance changes and additions that are presented in this plan into their own ordinances in order to be consistent with the standards and criteria of the watershed plan.

The other recommendations that have been made are items of lesser priority than that discussed above. The stormwater management recommendations involve a fair amount of watershed-level coordination, but they can result in the greatest degree of long-term runoff control in the most cost-effective manner. The standards and criteria are, however, necessary provisions to ensure that stormwater management in the Delaware County portion of the watershed yields sound, identifiable benefits and is also consistent with the requirements of Act 167.

WATERSHED PLAN UPDATES

DCPD will assume responsibility for future updates of the watershed plan. The first update was completed as part of the Department's 1987 revision. The next update will be completed within five years, providing matching funds are available, but the department will establish a monitoring system to determine if an update is needed sooner. In addition, the department will continue to preserve the data base generated during the initial planning study and which now reflects the first update in order to facilitate future plan updates.

At this time, there are several check points that DCPD can use to assess the need for updating the watershed plan. These include:

- Applications for S/LD plan reviews
- Zoning revisions or curative amendments resulting in significant land use changes (from land use projects used for the watershed plan)
- Complaints from developers and/or municipalities concerning the impact or requirements of the watershed plan
- Changes in stream conditions that indicate that the plan's stormwater management standards and criteria are ineffective
- Updates of the flood insurance studies and maps
- Construction or modification of major stream obstructions, thus altering stormwater runoff flows and rates

By evaluating S/LD applications and zoning changes as they come into the department, it will be possible to identify major land use changes that could affect the overall reliability of the watershed stormwater management standards. The development of any major stormwater generators, such as a regional shopping mall, an industrial park, or a highway, should trigger a review of the watershed plan. Also, if projected development densities vary substantially, upward or downward, then a plan review would be in order.

The funding for plan updates may come from a variety of sources, but the principal sources probably will be state Chapter 111 grants as well as County funds. Also, the

County and municipalities could establish a stormwater reserve fund to which they would make an annual set-aside of tax (or general fund) revenues. This fund could be allowed to accumulate and be used for plan updates and perhaps major capital projects to improve or correct stormwater problems in the watershed.

ACT 167 PILOT

STORMWATER MANAGEMENT PLAN

FOR THE

RIDLEY CREEK WATERSHED (SWM 23:1)

VOLUME II

RIDLEY CREEK STORMWATER MANAGEMENT STUDY

DRAFT

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Office of Coastal Zone Management

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CHAPTER I

INTRODUCTION AND SUMMARY OF STUDY APPROACH

Basics of Hydrology

Water is located in all regions of the earth. However, its distribution, quality, quantity, and mode of occurrence are highly variable from one location to another. Hydrology is the science of dealing with the properties, distribution, and circulation of water on the surface of the land, in the soil, through fractures in underlying rocks, and in the atmosphere.

The hydrologic cycle, illustrated on Figure I-1, describes the endless movement of water between the earth and atmosphere through the physical processes of evaporation, transpiration, and precipitation. Water evaporates from oceans, inland lakes, man-made impoundments, flowing streams, and the soil. Transpiration is the process by which vegetation returns water to the atmosphere. Water is transported horizontally through the atmosphere in clouds in the form of vapor, liquid, and ice crystals. Water falls back to earth as precipitation directly into surface waters or onto the land where approximately thirty percent runs off into surface waters. The remaining precipitation that does not evaporate infiltrates into the earth and replenishes groundwater supplies. A portion of the groundwater percolates slowly down through the ground to reappear as baseflow in streams or as seepage into lakes.

Stormwater

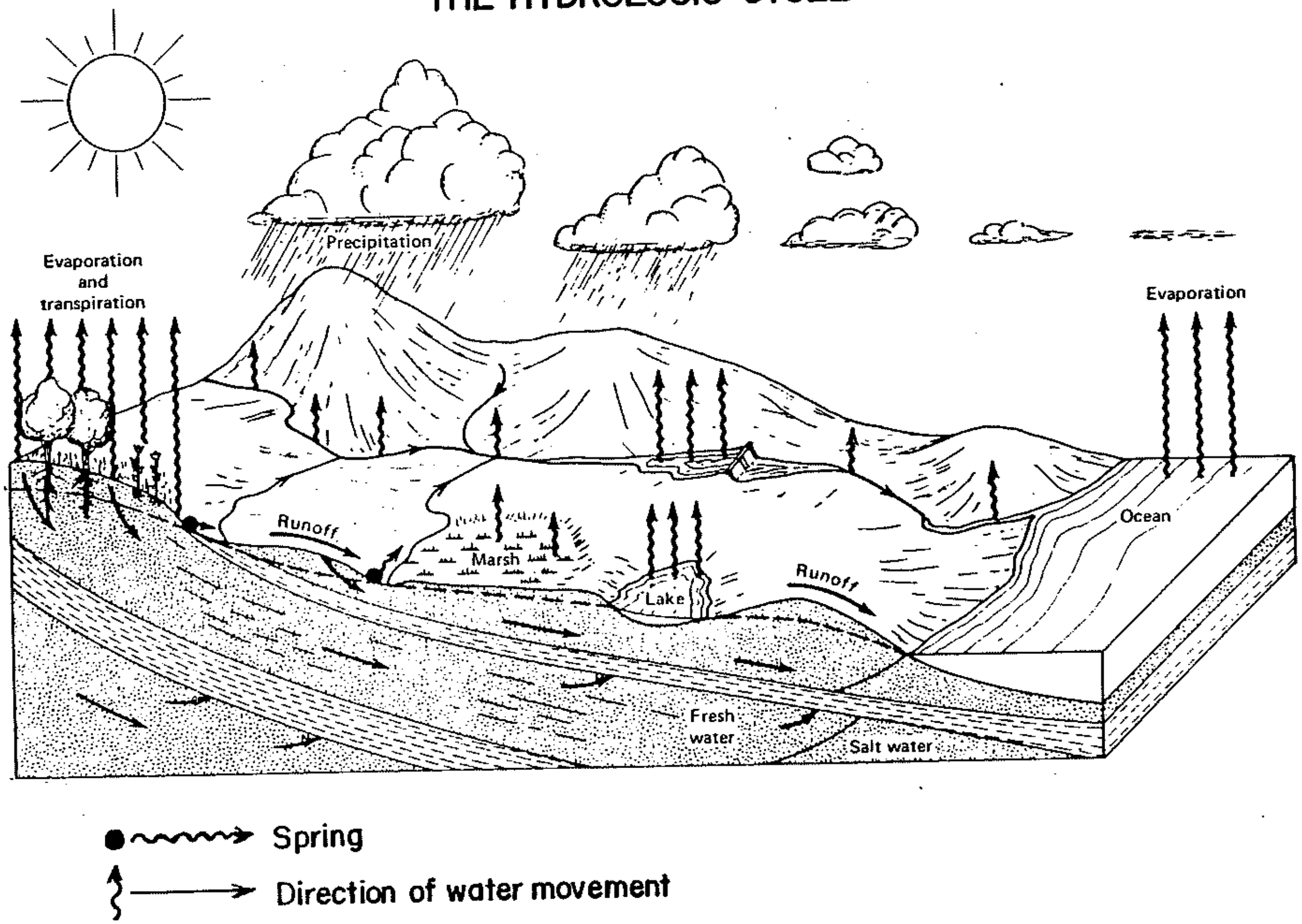
The water that runs off the land into surface waters during and immediately following a rainfall event is referred to as stormwater. In a watershed undergoing urban expansion, the volume of stormwater resulting from a particular rainfall event increases because of the reduction in pervious land area (land not covered by pavement, concrete, or buildings). Although many factors interact to affect this segment of the hydrologic cycle, the most significant that influence the volume of stormwater are:

- Precipitation - The volume of water that falls on a specific land area over a given period of time.
- Surface or depression storage - The volume of precipitation that is stored in depressions, either natural or attributed to human activities, on the surface of a specific land area.
- Infiltration - The volume of precipitation that infiltrates into the ground over a specific land area.

Precipitation

Precipitation is the most variable input to the generation of stormwater runoff. The quantity of precipitation varies geographically, temporally, and seasonally. Records have shown differences of twenty

FIGURE I–I
THE HYDROLOGIC CYCLE



percent or more in the catch of rain gages less than twenty feet apart. This highly variable nature would preclude the possibility of practical hydrologic analysis if it were not for the accumulation and analysis of rainfall measurements made by the National Weather Service and other research efforts.

Time variations in rainfall accumulation are extremely important in the rainfall-stormwater runoff process, particularly in urban areas. For example, Figure I-2 displays two rainfall hyetographs which illustrate the significant time variation of rainfall occurring during two thirty-minute rainfall events of equal volume. Even though the rainfall volumes are equivalent, stormwater runoff flow rates generated for identical time intervals over a specific land area under the influence of the illustrated rainfall events can be distinctly different for each event.

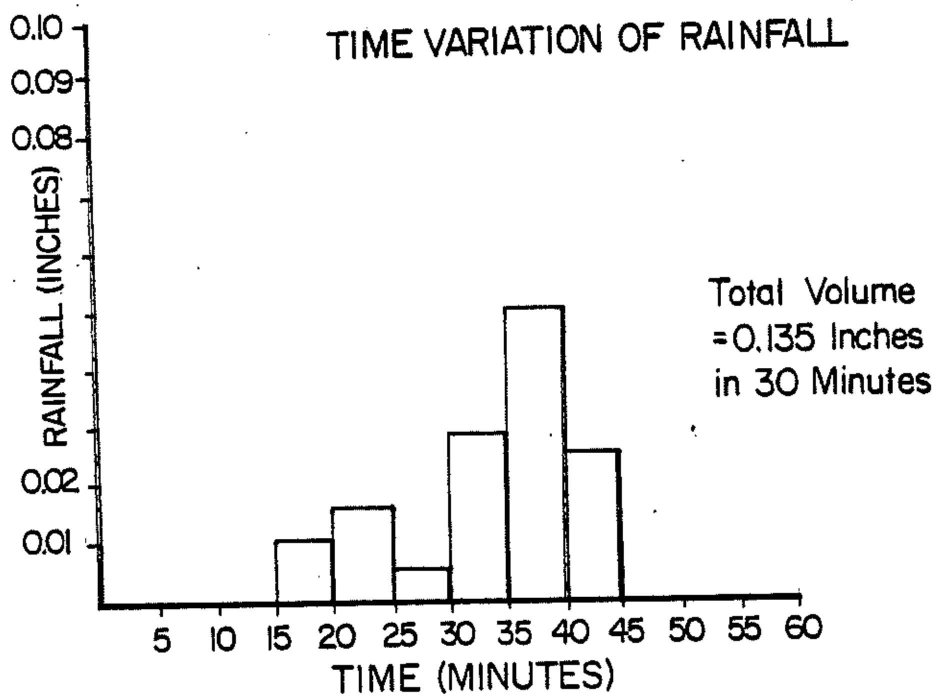
Another varying condition is the volume of precipitation falling at different locations within a watershed during a particular precipitation event. This is illustrated in Figure I-3.

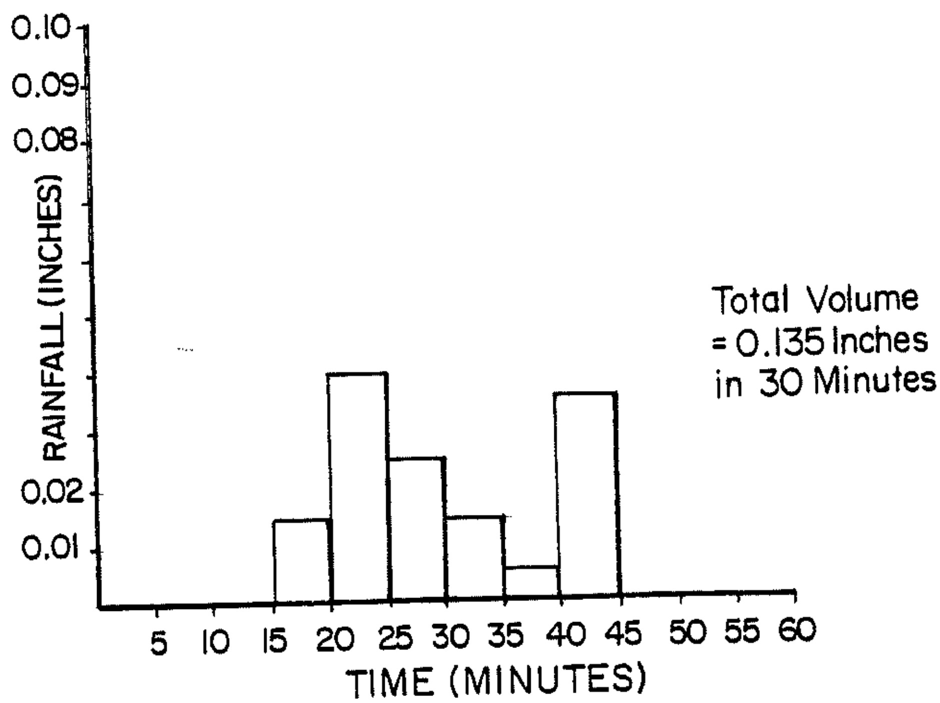
Even with these variations, the statistical analysis of precipitation data has resulted in the ability to establish the probability of storm events of specific volumes and durations. These probabilities are expressed as 1-, 2-,..., 10-,..., 25-, and 100-year storm events. That is, the probability of a 25-year storm event occurring in any year is four percent. The specific rainfall volumes for a 24-hour duration have been developed for the 2-, 10-, 25-, and 100-year storm events in Delaware County. These volumes are presented in Table I-1. Figure I-4 shows the rainfall-intensity-duration curves developed from data [illegible] Philadelphia International Airport rainfall gage. From

- The more intense the rainfall, the less likely is the event to occur.

FIGURE I-2

TIME VARIATION OF RAINFALL





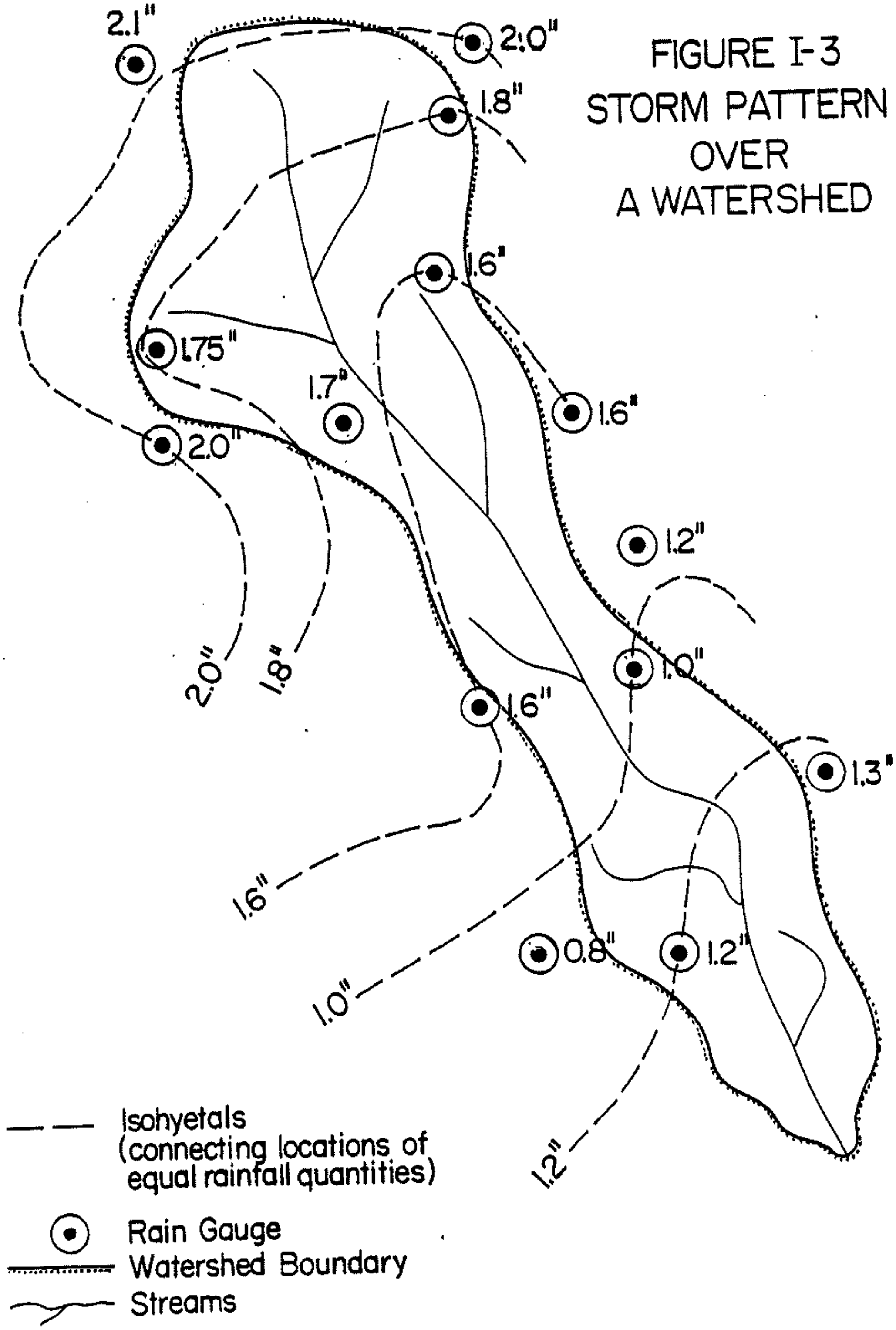
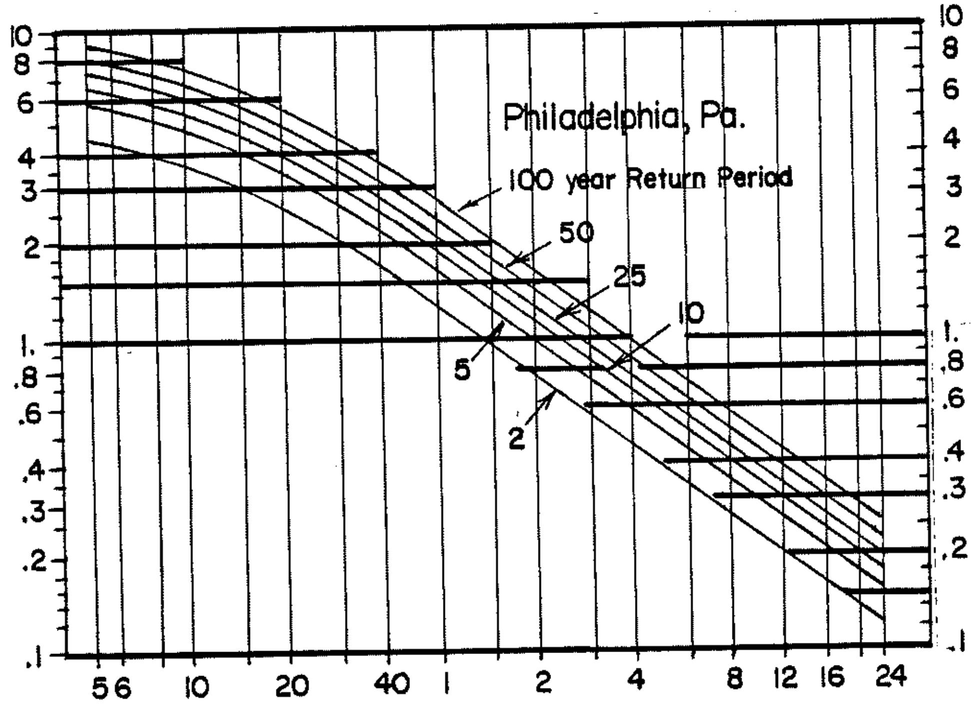


FIGURE I-3
STORM PATTERN
OVER
A WATERSHED

Figure I-4
RAINFALL INTENSITY-DURATION-FREQUENCY CURVES
FOR PHILADELPHIA, PENNSYLVANIA



Rainfall Duration

Source: Pennsylvania Department of Transportation

Surface or Depression Storage

The initial volume of rain falling to the ground during any event becomes trapped in numerous small, natural or man-made depressions. The only escape of this stored water is through evaporation or infiltration. Development activities often alter the terrain to make acreage available for building and to provide for mobility of equipment during construction activities. These practices usually reduce the amount of surface storage, thereby increasing both the volume and rate of stormwater runoff. Specially designed stormwater management facilities (e.g., detention basins, terraced slopes, and level spreaders) incorporated in site designs may artificially provide the surface storage lost during development.

Infiltration

The infiltration rate, the rate at which water enters the soil at the surface, is controlled by surface conditions. The two factors characterizing surface conditions are soil type and cover type. Urban areas are seldom completely covered by impervious surfaces. Development on soils having a high infiltration rate (sands or silts) increases the potential for high runoff volumes and peak runoff discharges. Site designers should give strong consideration to building and road layouts which minimize coverage of areas having soils with a high infiltration rate.

In addition to soil type, the surface cover condition affects runoff volumes by influencing the infiltration rate of the underlying soils. When impervious surfaces are constructed over a land area, the potential for infiltration is virtually eliminated. Forested land, with its covering of natural litter and humus, is one of the best surface covers for promoting infiltration of rainfall.

Estimating the Rate and Volume of Stormwater Runoff

At any point of interest along a waterway, the rate of stormwater runoff can be calculated by evaluating the hydrologic characteristics of the watershed (or land area) draining to that point. The hydrologic characteristics refer to precipitation, surface storage, and infiltration as described in the previous sections.

The excess precipitation remaining after surface storage is filled and the infiltration rate of the land area is exceeded becomes overland flow. Overland flow moves in a thin film on the land surface prior to collecting in a defined "channel" (e.g., paved roadside berm, grass-covered channel, storm sewer, intermittent stream, etc.). The stormwater runoff that flows from all channels which are tributary to a particular point of interest (i.e., a bridge or a chronic flooding location along a stream) can now be combined to form what is referred to as a "hydrograph" at that point.

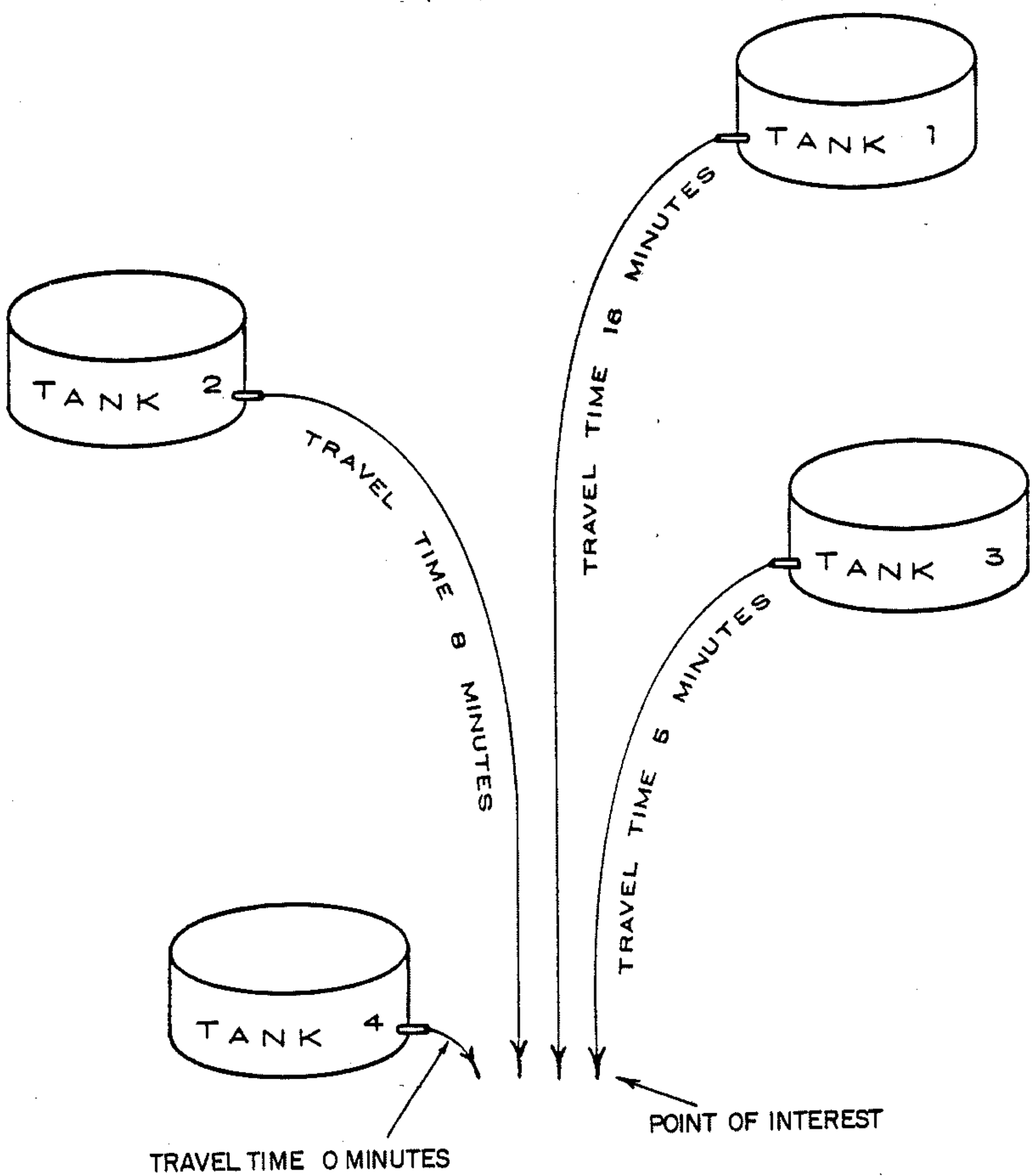
Hydrographs

A hydrograph graphically illustrates the rate of runoff in relation to time at a point of interest. This "point of interest" could be a bridge, a culvert, or a constricted channel section. There are a variety of ways to prepare a hydrograph. The most accurate is by comparing recorded rainfall to recorded stream flows at a gage. This is an ideal approach but is rarely possible due to the lack of recording stations at points of interest. Lacking this data, the common practice involves generation of information concerning the rate of runoff by estimating values for individual elements of the hydrologic cycle.

To illustrate how a hydrograph is prepared, the following example using equal sized water tanks in place of watershed subbasins will be used (Figure I-5). The example presented here simulates ideal field conditions, which differ from those encountered in a watershed as follows:

- o The total flow volume from each tank is the same. In an actual watershed, the runoff quantity and rate vary significantly due to the influences of soil infiltration, storage, and size of the basin (and subbasins).

FIGURE I-5
TANK TRAVEL TIMES



- The rate of flow from each tank is uniform. In the example, it takes five minutes to open the valves completely in each tank. At this point, the maximum flow is 4 gallons per minute (gpm). Fifteen minutes later, the tanks are drained completely, with the rate of flow dropping constantly from 4 gpm to 0 over this fifteen-minute period. In nature, this is replaced by rainfall intensity values which vary over time in a nonlinear fashion.

- The travel time for the water from each tank to pass the point of interest has been assumed, making the cumulative runoff rate at that point readily determinable. In an actual watershed, these travel time values are determined from flow velocities that are based on the variations in the physical characteristics of the flow channels.

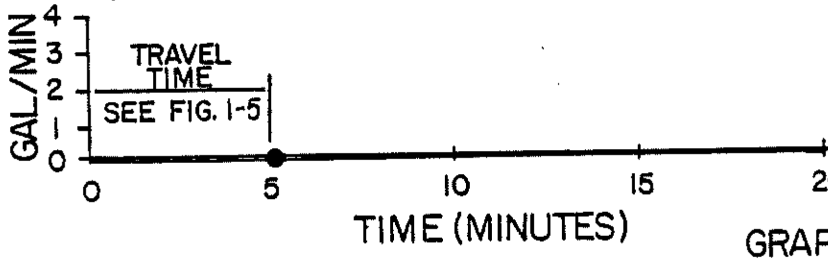
The key to understanding the formation of a watershed hydrograph is to realize that it is generated by runoff contributions from subbasins within the watershed. In the case of the water tank example (Figure I-5), the total rate of flow passing the point of interest is a result of the contributions from the individual tanks. Figure I-6 is the hydrograph associated with Tank 3. In Figure I-6, it has been assumed that it takes five minutes (travel time) for the first drop of water released from the tank to reach the point of interest (Graph A). Figure I-6 also shows the increase (Graph B) and decrease (Graph C) in flow rate at the point of interest resulting from the opening of the valve (five minutes) and the draining of the tank (fifteen minutes). Thus, the maximum flow rate from Tank 3 occurs at the point of interest ten minutes after the valve for Tank 3 is opened. This time represents the combined time of travel (five minutes) and valve opening (five minutes).

When all of the tank valves are opened simultaneously, similar graphs are created for other tanks (see Figure I-7). For this example, because all flow rates and volumes are the same, the only variation among the hydrographs is the travel time for the first drops from the various tanks to reach the point of interest. It should be noted that the beginning point for each hydrograph in Figure I-7 represents that point in time when the flow from a tank begins to pass the point of interest.

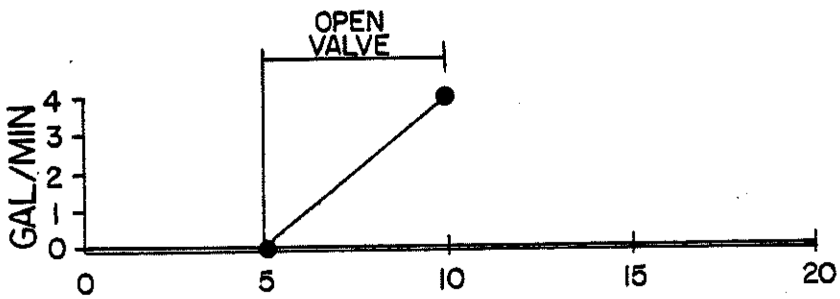
As each tank drains, the volume of water in the tank reduces the gallons per minute discharging from the tank to zero. As shown in the hydrograph in Figure I-7, the last drop leaving Tank 3 passes the point of interest twenty-five minutes after the first drop leaves the tank. The figure also shows that the flow at the point of interest from Tank 3 reaches its maximum rate ten minutes into the overall storm runoff event.

Figure I-7 also shows the rates of flow for the other tanks, which were developed in a similar fashion. All of these hydrographs are then

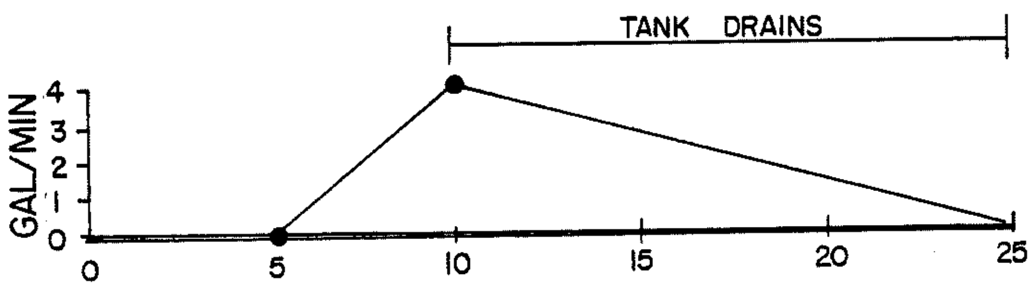
FIGURE I-6



GRAPH A



GRAPH B

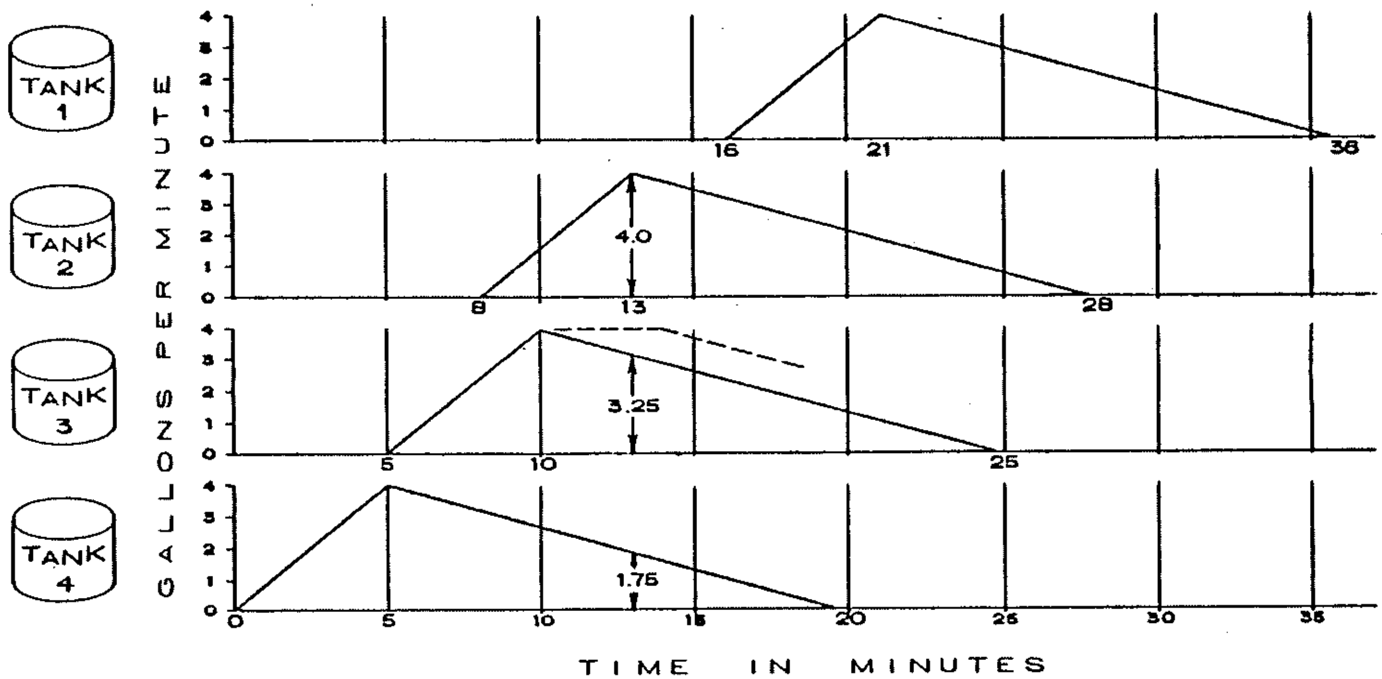


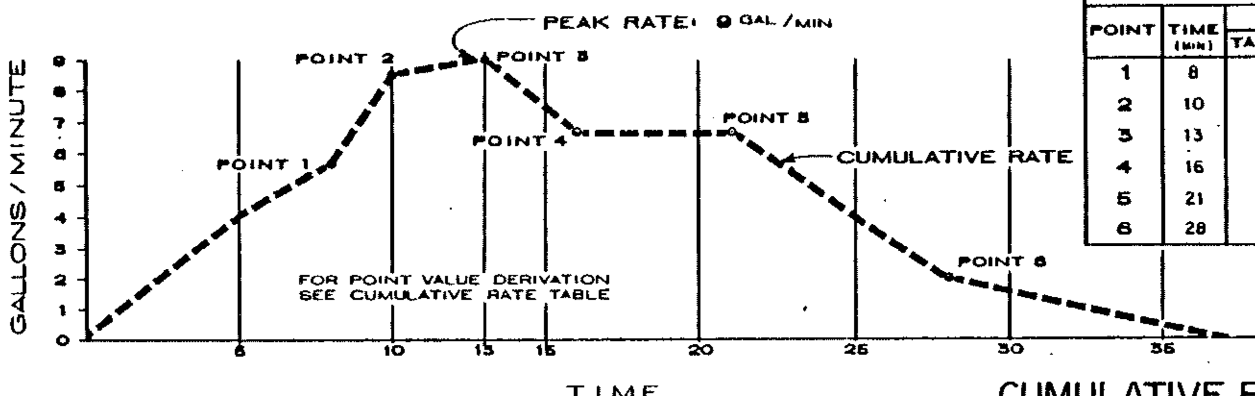
GRAPH C

TIME (MINUTES)	0	5	6	7	8	9	10	15	20	25	30	35
FLOW RATE GAL/MIN	0	0	.8	1.6	2.4	3.2	4	2.7	1.3	0	0	0

TANK 3 FLOW RATE GRAPH

FIGURE I-7





CUMULATIVE RATE TABLE						
		CONTRIBUTING GAL./MIN				
POINT	TIME (MIN)	TANK 1	TANK 2	TANK 3	TANK 4	TOTAL
1	8	0	0	2.4	3.25	5.65
2	10	0	1.6	4	2.75	8.35
3	13	0	4.0	3.25	1.75	9
4	16	0	3.25	2.5	1	6.75
5	21	4	1.75	1	0	6.75
6	28	2	0	0	0	2

CUMULATIVE FLOW RATE

plotted over a common time span. To determine the cumulative rate of flow from each tank at the point of interest and for a selected point in time, the flow rates associated with each tank at the particular time of interest are totaled. Figure I-7 has a cumulative flow rate table, which illustrates the contributing rate for various points along the hydrographs. The points are plotted, which furnishes a graphical description of the cumulative flow rate at the point of interest. The "peak rate" is the highest value (point 3) which, for this example, is 9 gpm and occurs thirteen minutes after all the valves were opened. It should be noted that the travel time for Tank 1 is sixteen minutes, which means that flow from Tank 1 has not even arrived at the point of interest when the overall peak rate at that point occurs.

This example uses ideal conditions with uniform values. If the sizes of the tanks vary, if the time required to open the valves varies, if the time of draining the tanks varies, or if the maximum rate from each tank varies, the overall system of flow rates would be very complex. This complexity, however, is what actually occurs in a watershed. The concept used to develop the cumulative flow rate explained above, however, would be the same.

Applying the Example to Watershed Conditions

By altering some of the values used in the example, it is possible to see the application of this concept to an actual watershed condition. In a watershed, flow rates from each subbasin will vary to reflect size and infiltration characteristics, travel times will vary to reflect channel slope and configuration, and maximum flow rates may change as infiltration characteristics are reduced due to land use changes. The following variations of the conditions used for the previous example are presented to illustrate this point:

1. The flow rate from Tank 2 that is contributing to the peak rate at the point of interest is equal to 4 gpm (i.e., the maximum flow rate from the tank). If a change in conditions occurred whereby the maximum flow rate from Tank 2 increased to 5 gpm, the peak rate at the point of interest would increase from 9 to 10 gpm. In a watershed, this is what occurs when development increases the rate of runoff from a site.

2. The travel time for Tank 1 is greater than the time at which the cumulative peak rate occurs (thirteen minutes). If the travel time is reduced to less than thirteen minutes, then Tank 1 also will begin to contribute to the peak rate at the point of interest, again resulting in an increase in the peak at the downstream point. In a watershed this could occur when flow velocity increases and the travel time is reduced. For example, changing a natural channel to a concrete-lined ditch or to a storm sewer system increases velocity and reduces travel time to the point of interest.

3. The maximum flow rate of 4 gpm from Tank 3 occurs before the peak rate. If the maximum flow rate of 4 gpm were to be main-

tained for a longer time (see dashed line in Figure I-7, Tank 3), the contributing rate from Tank 3 would increase from 3.25 to 4.0 gpm, and the peak rate at the downstream point of interest would increase from 9.0 to 9.75. In a watershed, this could occur if new development increased the volume of runoff and the developer constructed a detention facility and released the maximum rate over a longer period of time.

A comprehensive strategy of stormwater management requires an understanding of the hydrologic cycle as well as the techniques that can be used to estimate the rate of runoff. This chapter used a simple example to illustrate these basic principles. Chapter IV of this report describes the technical details of the simulation modeling approach that was used for this "pilot" study to furnish the necessary storm runoff information for the Ridley Creek watershed.

CHAPTER II

RATIONALE AND LEGAL FRAMEWORK FOR STORMWATER MANAGEMENT

The Need for Stormwater Management

The alteration of native cover and contours to residential, commercial, industrial, and cropland uses results, in almost all cases, in decreased infiltration of rainfall. This results in an increase in both the volume and rate of stormwater runoff. As development has increased, so has the problem of dealing with the increasing quantity of stormwater runoff. Failure to properly manage increased or accelerated runoff has resulted in greater flooding, stream channel erosion and siltation, and reduced groundwater recharge. The cumulative effect of development in some areas of the State has resulted in flooding of both small and large streams, with property damages running into the millions of dollars and even causing loss of life.

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

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

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

The Need for a Comprehensive Approach

Up to now, stormwater management has been oriented primarily toward addressing the increase in peak runoff rates discharging from individual development sites to protect property immediately downstream. Minimal attention has been given to the effects on locations further downstream (frequently because they were located in another municipality) or to designing stormwater controls within the context of the entire watershed. Management of stormwater has typically been regulated on a municipal level with little or no designed consistency among adjoining municipalities in the same watershed concerning the types or degree of control to be practiced.

Act 167 changes this approach by instituting a comprehensive program of stormwater planning and management. The Act requires Pennsylvania counties to prepare and adopt watershed stormwater management plans for each watershed located in the county, as designated by the Pennsylvania Department of Environmental Resources (PA DER). These plans are to be prepared in consultation with the municipalities located in the watershed, working through a watershed advisory committee. The plans are to provide for uniform standards and criteria throughout a watershed for the management of stormwater runoff from developing sites. The types and degree of controls that are prescribed need to be based on the expected development patterns and hydrologic characteristics of each individual watershed.

The rate of runoff that occurs at any point within a watershed is made up of the flow contributions from the various subbasins within the watershed. A comprehensive watershed planning approach requires the analysis of runoff rates for the individual subbasins as well as an evaluation of the collective effects on the watershed. This is because the peak (maximum) rate of runoff at any point in a watershed results from an accumulation of the rates of runoff contributing to that point from the individual subbasins of that watershed.

A critical element for the determination of the peak flow at a point of interest is the <u>timing</u> of the arrival of flow from the contributing subbasins, or subareas, as expressed by the combination of their runoff hydrographs. The combination of shape, size, topography, and land use patterns is unique for each watershed in the Commonwealth as well as for each subarea of which it is comprised. The expected future land use patterns of any watershed, likewise, will vary. It is imperative then that standards and criteria for stormwater management reflect the individual character of the watershed in which they are to be practiced.

The standards and criteria for stormwater management practices presented in this plan have been developed solely for the Delaware County portion of the Ridley Creek watershed. These standards and criteria are based on the specific configuration and existing conditions of the watershed and the potential impacts of expected future development. While many of the types and concepts of control that are recommended may be appropriate in other watersheds as well, they cannot be considered to be broadly applicable until a similar watershed planning study is completed.

<u>Stormwater Management vs. Flood Control Management</u>

On October 4, 1978, with the passage of the Stormwater Management Act (Act 167) and its companion bill, the Floodplain Management

Act (Act 166), the Commonwealth of Pennsylvania embarked on a significant new course to reduce flooding and the problems caused by inadequately controlled stormwater runoff. Recognizing the repeated threats to public health and safety, the Legislature mandated a comprehensive approach to planning and managing excess stormwater runoff. The Stormwater Management Act sets up a program for managing accelerated runoff so that it does not lead to flooding, while the Floodplain Management Act provides for the preservation and restoration of floodplains which are natural stormwater storage areas. These intimately related, yet distinctly separate, programs are now being implemented.

The Floodplain Management Program in Pennsylvania works to prevent damages due to flooding through what may be considered to be primarily non-structural means. The Floodplain Management Act requires that municipalities participate in the National Flood Insurance Program, allowing owners of existing properties in the designated floodplains to purchase flood insurance at reduced rates. Municipalities must also adopt ordinances prohibiting new construction that could be inundated by flood waters.

The base flood selected for this program is the 100-year flood, an extreme hydrological event. The limits of the 100-year floodplain have been delineated on major and minor streams for all flood-prone municipalities in Pennsylvania. Those limits were drawn based on either detailed computer backwater analyses or on more approximate methods, depending on the size of the stream being studied. When detailed methods were used, floodplain elevations were determined based on statistically derived flow rates for the 100-year flood. In the Ridley Creek watershed, only portions of Ridley Creek and Stackhouse Mill Run were dealt with in such detail.

The Floodplain Management Program is not intended to deal with structural means of flood control such as dams, levees, or the like. There is no intent or effort to control the flood flow rates on which the floodplain boundaries are based. Significant increases in flood flow rates due to land development can result in higher flood elevations and broader floodplains, undermining the entire program. However, within the accuracy of even the detailed methods, increases in peak flow rates of more than just a few percent are required in most cases to cause a noticeable increase in calculated flood elevations. The very magnitude of the base flood event selected for regulation purposes in the Floodplain Management Program, i.e., the 100-year event, requires extrapolation of data and some subjective decision making in the determination of its peak flow rate.

The design of storm drainage, on the other hand, has traditionally been based on storms of more frequent occurrence, in the range of 5-, 10-, or 25-year events. Design of storm sewer conveyance systems on the basis of larger events, like the 100-year storm, has not been considered to be cost-effective. The largest and most frequently used design storm for drainage systems in the Delaware County portion of the Ridley Creek watershed is the 10-year event. The Pennsylvania

Department of Transportation uses 25- and 10-year design storms for primary and secondary highways, respectively, and the 50-year storm for interstate highway drainage.

What design storm frequency is appropriate for the management of stormwater runoff? The answer will depend largely on how stormwater management is defined. Act 167 does not specifically define what "stormwater management" is but requires that measures be taken so that post-development runoff rates do not exceed pre-development rates. The Pennsylvania Stormwater Management Guidelines make no specific recommendation as to the appropriate return period(s) to be used for stormwater management, but instead, suggest that sound design frequency criteria be developed for a complete flood frequency analysis of both pre- and post-development conditions for 2- to 10-year floods. Since no state-level criteria have been adopted for stormwater detention or other stormwater management measures, criteria must be adopted by each municipality. A primary purpose of this comprehensive watershed planning effort is to establish design frequency criteria which reflect the specific needs and characteristics of each watershed. The criteria adopted by local municipalities should, therefore, be in accordance with the requirements of the pertinent approved watershed stormwater management plan.

The Pennsylvania Association of Conservation District Directors recommends that 2-, 10-, 25-, 50-, and 100-year discharges from "major" drainage systems not exceed existing conditions. At the same time, there is some question as to the appropriateness and practicality of providing such complete control. If collection systems are designed for, at most, the 25-year event, runoff from more severe events may not reach a site's stormwater management system. Large-scale flood control projects are typically built only when the benefits, in terms of flood damages that are prevented, exceed the cost of the project itself. The construction of large flood control facilities represents a substantial cost to land developers, which are then passed on to home buyers and commercial tenants. Benefit-cost type analyses have not been done to justify current stormwater management practices in portions of the Ridley Creek watershed.

In this stormwater management study, analyses were performed using a model of existing and expected future runoff conditions to determine appropriate design frequencies for stormwater management in the Ridley Creek watershed. The primary objective was to identify the largest return period event for which control is required to prevent damage in the watershed. With that aim, it would seem appropriate to consider stormwater management as control of the accelerated runoff of more frequent, troublesome events in a more cost-effective manner. Control of larger events, including the 100-year storm, would then be considered as flood control. Controlling increased runoff from events of a greater frequency than the 100-year storm (i.e., the 10-year or 25-year design storm) is justifiable within the intent of Act 167, but only if peak flow rates and flood elevations throughout the watershed do not increase significantly for the larger events. The actual impacts of controlling only more frequent events depend heavily on the configuration and development characteristics of a particular watershed. The design storms prescribed for on-site controls in the standards and criteria for stormwater management in the Delaware County portion of the Ridley Creek watershed pertain only to that portion of the watershed and the specific needs for control of the increased runoff from future development that are anticipated.

Legal Framework

The laws governing surface drainage rights and liabilities have developed over the years as part of Pennsylvania's system of common law.[1] It is a very complex system, not widely understood by non-lawyers, and one which does not always lead to an easy determination of who has what rights and when. Some people have suggested that legal complexities relating to stormwater management may be one reason why more Pennsylvania municipalities have not already developed stormwater regulations. There simply appear to be too many gray areas for many local officials' tastes.

For this reason, and because of the extent to which the Stormwater Management Act (Act 167) redefines prior common law, this section provides a discussion of Act 167 - its provisions and potential interpretation - and the other principal state statutes which relate to stormwater management, land development regulation, and local governmental liabilities. The other four statutes of primary concern are the:

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

These laws, in conjunction with Act 167 and the municipal codes, collectively provide the legal mandates and powers to plan and implement a comprehensive stormwater management program at the local level.

Key provisions of these five laws are highlighted here as they pertain to the watershed stormwater plan and implementation program. A brief overview of the Political Subdivision Tort Claims Act, which governs municipal governmental liability, is also included, primarily to point out its potential relationship to municipal stormwater management activities. However, the comments on these laws in no way

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1 Common law is the system of laws of any state that is based on court decisions, on the doctrines implicit in those decisions, and on customs and usages rather than on statutes adopted by legislative action.

constitute official legal opinions or advice on any specific case or issue. This caveat is especially true for Act 167, since there are presently no administrative regulations or case law to interpret the Act. This section is simply intended to promote a better understanding among local officials of the legal framework for stormwater management.

Stormwater 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 so that reasonable measures are taken to protect other persons and property. A primary goal of this Act is to prevent future problems resulting from uncontrolled runoff, including flooding, erosion and sedimentation, landslides, 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

One of the Act's innovative features is the creation of a public stormwater planning, management, and control system at the watershed level. Stormwater plans are to be prepared by the counties for each watershed delineated by DER. Counties must organize a watershed advisory committee composed of representatives from the municipalities in the watershed and the conservation district to advise the county during the planning process. The plans are to be adopted by the county governing bodies 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 the State Water Plan, regional water quality plans, 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) must 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.

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 with the standards of the Stormwater Management Act. Failure to adopt and implement the necessary ordinances could result in the State's withholding funds from the General Fund for which the municipality might be eligible.

Section 13 Standard for Stormwater Management

The basic premise of the Act is that those whose activities generate additional runoff, increase its velocity, or change the direction of its flow are responsible for controlling and managing that runoff in such a way that reasonable measures are taken to protect other persons or property, both now and in the future. The Act expresses the Commonwealth's policy to no longer condone the disregard of possible adverse impacts of increased runoff from site development activities and to no longer accept actions that simply shift the burden of stormwater management to downstream property owners and/or a public body.

Section 13 of Act 167 defines the legal duties required of developers and others engaged in the alteration of land. The prevalent interpretation is that this section of the Act became effective immediately upon its signing (October 4, 1978). These new standards essentially expand and broaden or redefine prior common law drainage rules. Section 13 reads:

> 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. Thus, when public agencies build public facilities like storm sewers, roads, buildings, or utility lines, they must comply with Section 13 standards. With this coverage, Section 13 is a truly comprehensive standard for stormwater control.

Section 13's primary measure of sound stormwater management is taking reasonable steps to protect health and property from possible injury. This general duty is contained in the language which precedes Sections 13(1) and 13(2). Therefore, the "bottom line" for stormwater management is "take reasonable steps to protect downstream areas," with the section going on to prescribe two alternatives (subsections one and two) for meeting this basic objective.

When Section 13 is read in conjunction with other portions of the Act, it becomes apparent that the basic "reasonable step" standard does not stop at the perimeters of the development site or the immediately adjacent properties. Rather, the intent of the Act is to protect persons and property downstream of the site as well.

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 is intended to manage runoff at the watershed level. Section 5(c)(1) requires that the watershed plans contain provisions to manage stormwater so that an activity in one municipality does not adversely affect persons or property in another municipality in the watershed or in basins to which the watershed is tributary. Further, the language in both Sections 13(1) and 13(2) implies no spatial limitation. Section 13(1) does not contain any language indicating that no increase in the maximum rate means only at the development site's boundary, nor does Section 13(2) suggest that its reasonable step provision applies only to neighboring or nearby property.

Changes in runoff characteristics, such as volume, direction, and velocity as identified in Section 13(2), can affect a stream all the way to its mouth. These changes may result in either an increase in the peak rate, injury, or both at some downstream point. (Refer to earlier discussion on basics of hydrology.) Therefore, stormwater plans and management activities must consider the watershed impact of land alteration activities, and runoff controls must be designed to protect against reasonably foreseeable injury from the boundary of the site and downstream as far as the runoff impact can be determined.

Section 13(1) provides that the maximum (peak) rate of runoff after development, for any level storm, cannot 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 pre-development maximum rate of flow will not be exceeded. This is an important point. If the standard did not permit any increase in volume, it would limit the use of many sites unless additional runoff could be permanently stored or recharged on-site.

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 protect downstream areas 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 pre-development discharge point. This interpretation seems consistent with the purposes 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 detention system.

Section 13(2)'s purpose is to make the statutory drainage standard more flexible. Section 13(2) permits changes in runoff characteristics, including increased runoff rates, provided that reasonable measures are taken to protect downstream areas from storm runoff damage. 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, adversely affecting downstream areas.

The determination of which approach, 13(1) or 13(2), applies and under what conditions lies with the watershed management plan. As indicated above, the watershed plan can determine that increased runoff rates are appropriate where adequate storm sewer systems exist. Further, it could identify areas in the watershed where increased rates would be beneficial to drain runoff from the area as quickly as possible. The plan could also establish technical standards and procedures by which site developers can determine if increasing the rate of runoff from their sites will create adverse effects, either immediately adjacent to the site or at some downstream location. Thus, the watershed plans will result in a more defined and, therefore, a more usable Section 13(2) standard. One of the purposes of the watershed stormwater management planning process is to identify when and how the strict Section 13(1) standard can and should be modified. Once this analysis is completed, implementing ordinances can be based on the Section 13(2) standard.

Violations, Penalties, and Remedies

Section 15 of Act 167 makes any violation of the provisions 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 actual damage results. Any aggrieved person, affected municipality, or DER can institute suits to restrain or abate a violation, such as enjoining a municipality from making a negligent stormwater plan approval, or can sue for damages caused by a violation of the Act. Similarly, an aggrieved party may be able to force a municipality (or an official) to enforce the stormwater provisions of an ordinance by going to court and obtaining a writ of mandamus.

The State is not subject to the penalty provisions of the Act, and local municipalities, counties, and state agencies are protected to a large extent from private damage suits by governmental immunity statutes (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.

Floodplain Management Act (Act 166-1978)

The Floodplain Management Act is the companion law to the Stormwater Management Act. Its basic purposes are to bring about a more intelligent use of floodplain areas and to encourage comprehensive and coordinated programs of floodplain management. The Act requires municipalities with floodplain areas to participate in the National Flood Insurance Program and to enact regulations pertaining to development in floodplain areas. The regulations enacted by municipalities must control new construction and development, at least in accordance with the minimum requirements established by the Federal Emergency Management Agency (FEMA), formerly the Federal Insurance Administration (FIA). In addition, the Act requires a closer regulation of certain specific kinds of development in floodplain areas because of the special danger they may pose during times of flooding.

Under the federal flood insurance program, any proposed development must receive approval prior to construction certifying that the plan complies with the local floodplain regulations. Floodplain permits should not be granted until all other permits, such as obstruction permits, have been received. Further, they should not be granted unless the proposal is consistent with the stormwater plan for the watershed. Through this interrelated permitting process, Act 166 encompasses a comprehensive control of all activities in a floodplain. It ensures compatibility among the actions governed by the different laws.

Preserving natural floodplains is a key part of effective stormwater management. Natural flood areas should be maintained as part of the watershed's natural stormwater control system. Similarly, future stormwater management programs will help to preserve floodplain areas and ensure that properties which are not now subject to flooding do not become so in the future.

Dam Safety and Encroachments Act (Act 325-1978)

This Act replaces several older dam safety and obstruction laws. It regulates the construction, alteration, operation, maintenance, or abandonment of dams,[2] obstructions, encroachments, fill in floodplains, culverts, bridges, retaining walls, and outfalls (e.g., of storm sewers) in a stream or floodplain (100-year). Owners of both new and existing structures must obtain permits from DER, and permittees are required to inspect, maintain, and repair their obstructions annually. For example, culvert owners must inspect them annually and remove silt and debris if the carrying capacity is reduced by ten percent or more, (Regulations, Section 105.171). The Act's provisions apply to private persons (and corporations) as well as to public agencies.

When issuing permits, the regulations [Section 105.14(a)(9)] require DER to consider the project's consistency with state and local

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

floodplain and stormwater management programs. Presumably, this includes the provisions of Act 167. Also, once the watershed stormwater plan is approved, DER would review obstruction permits in light of the plan's standards and criteria. In addition, local municipalities should not issue building permits until the necessary obstruction permits are obtained.

As with the Stormwater Management Act, violations of the Dam Safety and Encroachments Act are treated as public nuisances. Therefore, municipalities can sue to enjoin or abate the nuisance or they can make necessary repairs and assess costs against the property. A private person also can sue on a private nuisance. 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, an "affected municipality" may sue in the name of the Commonwealth. An affected municipality includes one where the violation occurs or where damage or injury results. The only limitation on these suits is that the municipality must give the State Attorney General thirty days notice of the municipality's intent to act.

Clean Streams Law (Erosion and Sedimentation Regulations)

The Clean Streams Law of 1937, as amended, empowers DER to control water pollutants, and since its original enactment, the Law's scope and duties have expanded substantially. In 1972, DER determined that sediment is the single greatest pollutant, by volume, in Pennsylvania waters, and it promulgated regulations for the control of erosion and sedimentation caused by earthmoving activities. Because stormwater runoff carries and deposits sediment, control of erosion and sedimentation and stormwater management are interrelated. Also, sediment reduces the carrying capacity of watercourses and structures (e.g., culverts) and the holding capacity of natural and artificial stormwater facilities.

State regulations require all earthmoving activities to have erosion and sedimentation control plans, but only sites greater than twenty-five acres (except agriculture) must obtain permits prior to commencement. In Delaware County, the Conservation District administers the erosion and sedimentation regulations up to level V (does not include legal enforcement) for DER. Many local municipalities also have their own erosion and sedimentation ordinances which supplement the state regulations.

Erosion and sedimentation 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 Clean Streams Law and erosion and sedimentation regulations predate the Stormwater Management Act and, therefore, do not specifically mention the Act. However, it can be assumed that erosion and sedimentation controls should be consistent with the Stormwater Management Act and an approved watershed stormwater plan. Since the erosion and sedimentation controls could affect stormwater runoff management for the site, they would have to comply with Act 167 standards. Also, the Dam 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 a 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.

A municipality (or authority), when it is performing a proprietary function (e.g., constructing a road or a sewer), is also subject to the state erosion and sedimentation regulations. If the municipality fails to comply, then DER or another affected municipality may sue to abate the violation of the regulations and the Clean Streams Law.

Municipalities Planning Code (Act 247, as amended)

The relevance of the Municipalities Planning Code (MPC) to the stormwater management program is that it is the enabling legislation for municipalities to adopt and enforce zoning, planned residential development (PRD), subdivision and land development (S/LD), and official map ordinances. These ordinances will be the principal tools used by the municipalities to implement the watershed stormwater management plan. The various municipal codes (borough, township, city) authorize communities to adopt building and/or housing codes pursuant to their health, safety, and general welfare powers.

Where stormwater is being regulated for a land use or development activity that properly falls within the scope of one of the Planning Code authorities (e.g., zoning, S/LD, etc.), then the stormwater controls (regulations) should be included in the appropriate ordinance. Zoning, S/LD, PRD, and building ordinances regulate different and distinct aspects or parts of the land use and development process. Therefore, a comprehensive development regulation system requires, in most cases, the utilization of all three types of ordinances.

Municipalities with existing zoning, S/LD, or building ordinances could include stormwater provisions in one ordinance (most properly the S/LD) and then reference these stormwater management requirements in the other ordinances. This is essentially the approach presented in this plan. Cross-referencing the various ordinances is important as it makes ordinance administration less confusing for local officials, and it helps applicants to determine exactly what is required of them.

If a community utilizes a separate, single-purpose stormwater ordinance, the ordinance should be clearly referenced in the appropriate sections of the municipality's zoning, S/LD, PRD, and building ordinances. Also, the preamble of a separate stormwater ordinance should indicate that it is being adopted pursuant to the Municipalities Planning Code, Stormwater Management Act, and applicable sections of the municipal code. 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, PRD, or building applications, the stormwater reviews should adhere to the procedures required by the respective ordinances.

Governmental Tort[3] Immunity

Municipal immunity is a concern to local communities and officials who will be adopting and implementing stormwater management regulations. Also, state and municipal immunity statutes have been the subject of recent changes and litigation. This section summarizes the basic scope of the new (1979) Political Subdivision Tort Claims Act, which applies to local municipalities, and its potential relationship to municipal stormwater management issues. Municipal officials, of course, will have to be guided by the advice of their solicitors on potential liabilities as specific cases or situations arise.

The concept of governmental immunity comes from English common law which developed the doctrine that "the king could do no wrong." After the colonies won their independence, this doctrine was extended to the new "sovereigns," the federal and state governments. Since local governments were agents of the states, they also became invested with governmental immunity.

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3 A tort is a wrongful act, damage, or injury done willfully, negligently, or in circumstances involving strict liability, for which a civil lawsuit can be brought.

In 1973, after a series of decisions limiting municipal immunity, the Pennsylvania Supreme Court abolished the doctrine. This was the situation until 1978 when the Legislature passed the Political Subdivision Tort Claims Act (effective January 24, 1979). The Act reestablishes municipal immunity with certain statutory exceptions. (The provisions of this Act have been amended and recodified in 42 Pa. C.S. 8501 _et seq_.)

The Tort Claims Act applies to municipalities (including their agencies, commissions, and departments), municipal authorities (e.g., sewer and stormwater authorities), and counties. It limits the liability of political subdivisions for the torts of their agencies, appointed and elected officials, and employees. Under the Act, a municipality cannot be 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 recovered 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 officer, employee, or agent operating within the scope of his or her office or employment.
- The negligent acts or omissions by a local agency or its officer or employee fall within eight specified categories of activity. The specified categories are:

  (1) Operation of a motor vehicle

  (2) Care, custody, and control of personal property of others

  (3) Care, custody, and control of real property in the possession of the local agency

  (4) Dangerous condition of trees, traffic signs, lights, or other traffic controls under care, custody, or control of the local agency

  (5) Dangerous condition of stream, sewer, water, gas, or electric systems owned by the local agency

  (6) Dangerous condition of streets owned by the local agency

  (7) Dangerous condition of sidewalks within the right-of-way of streets owned by the local agency

  (8) 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 (4) through (7) 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 Tort 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 Tort 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 injury may have resulted, the Act appears to prevent the injured party from recovering damages from the municipality. Before the effective date of the Tort Claims Act, the case law in Pennsylvania would have imposed liability on the municipality in this situation.

Although other state acts, such as Act 167, appear to create municipal liability, the courts would read the acts in conjunction with the Tort Claims Act. Unless the court finds a clear, express Legislative intent to impose liability, the Tort Claims Act would control since it directly addresses this issue. An affected municipality (or aggrieved person), under Section 15(c) of the Stormwater Management Act, could seek 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 might be able to force the municipality (or official) to enforce the provisions of an ordinance by going to court and obtaining a writ of mandamus. Still, in either case no damages could be obtained from the municipality by an injured party.

Under the Tort Claims Act, however, there may be activities involving stormwater management where a municipality might be exposed to liability. A municipality or municipal authority might be liable for damage caused by its public storm sewer system. (Under Paragraph 8542(b)(5), a "sewer" system would probably include storm sewers and would definitely include a combined system.) This could occur where the system did not meet the standards set out in the Stormwater Management Act. Another area of liability could involve road support structures like culverts and bridges. The Tort Claims Act states that municipalities may be liable for an injury caused by a dangerous condition of its streets (category 6 above). If "streets" includes culverts and bridges supporting them, a culvert or bridge which did not meet the requirements of the Dam Safety and Encroachments Act or the obstruction permit could expose the municipality to action for damages. An example would be damages resulting from backwater flooding due to failure to clean culverts or undersized culverts under a municipal street.

The final area of tort immunity is that immunity given to public officials, employees, and agents themselves. Sections 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.

Finally, the Tort Claims Act only protects municipalities and their officials from private lawsuits. 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 Dam Safety and Encroachments Act and the Clean Streams Law provide for DER enforcement orders and criminal penalties for violation of the statutes.

CHAPTER III

EXISTING AND PROJECTED FUTURE WATERSHED CHARACTERISTICS

General Description of the Ridley Creek Watershed

The Ridley Creek watershed is located in the southeastern corner of Pennsylvania. The stream begins in the Piedmont Plateau in Chester County and discharges directly to the Delaware River in the Coastal Plain in Delaware County. The total drainage area is about 38.5 square miles, 21 of which are within Delaware County. Elevations range from nearly six hundred feet National Geodetic Vertical Datum (NGVD) at the headwaters in Chester County to zero feet NGVD at the mouth. The watershed may be characterized as long and narrow, its length being over six times its average width. The largest tributaries to Ridley Creek in Delaware County include Stackhouse Mill Run (2.35 mi^2), Dismal Run (1.58 mi^2), an unnamed tributary in Ridley Creek State Park (1.49 mi^2), Vernon Run (1.23 mi^2), Cold Spring Run (0.80 mi^2), and Broomalls Run (0.68 mi^2). The lowermost two miles of the main stem, from Irving's Mill Dam just downstream from Providence Road (Route 320) to the mouth of the creek at the City of Chester/Eddystone Borough boundary, are tidal. The Ridley Creek watershed contains portions of twelve municipalities in Delaware County. Large portions of the watershed are established as natural and recreational areas in Tyler Arboretum and Ridley Creek State Park.

Using forms prepared by the Pennsylvania Department of Environmental Resources (PA DER), Division of Stormwater Management, a survey was taken to obtain information from each municipality with regard to stormwater related problems, significant obstructions, existing and proposed flood control projects, stormwater control facilities, and stormwater collection facilities. Copies of the survey forms are provided in Appendix A. The results of the municipal survey were used to specify points of interest at which the technical analyses performed in this study were targeted to characterize, in general, current patterns and practices of handling stormwater in the watershed.

Floodplains

The 100-year floodplains of Ridley Creek and its tributaries have been delineated in the flood insurance studies prepared by the Federal Emergency Management Agency (FEMA) under the National Flood Insurance Program for the twelve municipalities in Delaware County (FEMA, 1975-1981). Detailed mapping of those floodplains is available in each municipality and at the Delaware County Planning Department (DCPD) and was not reproduced for this report. Fluvial flooding can occur along the entire length of the main stem. Tidal flooding or coincidental fluvial-tidal flooding may occur from the mouth upstream to the Route 320 bridge between the City of Chester and Nether Providence Township. A detailed study of flooding potential and damages has recently been performed by the U.S. Army Corps of Engineers (COE) (U.S. Army COE, 1982). The floodplain on the portion of the main stem within Ridley Creek State Park was not delineated in the flood insurance studies for Edgmont and Upper Providence Townships. Delineation of that floodplain was made in a COE Floodplain Information Report on Ridley Creek in Delaware County (U.S. Army COE, 1970).

The floodplains delineated in the flood insurance studies are recognized and used by the twelve municipalities to regulate land alteration activities (i.e., construction) in those areas. Adoption of the necessary ordinances was required by the Pennsylvania Floodplain Management Act (Act 166, 1978). The results of detailed hydrologic and hydraulic analyses performed to delineate those floodplains were acknowledged and used as described herein in the technical work performed for this study to ensure compatibility with the Pennsylvania Floodplain Management Program.

Water Obstructions

Water obstructions are man-made or natural encroachments on a stream which affect its free flow during times of normal and/or flood flows. Examples of water obstructions include dams, bridges, culverts, retaining walls, and storm sewer outfalls. Preparing a list of all such encroachments on Ridley Creek and its tributaries was beyond the scope and intent of the project. Table III-1 lists dams, bridges, and culverts which are major obstructions on the main stem and several tributaries of Ridley Creek. These obstructions were considered major with respect to the drainage area above them and their effect on flood elevations. Several other bridges crossing Ridley Creek were not found to significantly obstruct flood flows. Many small bridges and culverts cross the smaller tributary streams and drainageways. Those reported to be problematic in the municipal surveys are discussed later.

Information on the capacity of the major obstructions listed in Table III-1 was obtained from background documentation on PA DER water obstruction permits issued for those structures. Unfortunately, that information was not available for all of the obstructions that were identified as being significant.

Flood Control Projects

There are currently no flood control projects in the Ridley Creek watershed and no plans for such projects. In a recently completed investigation of flooding in the tidal portion of Ridley Creek, the U.S. Army COE found that the costs of potential flood control projects exceeded the anticipated benefits from reduced flood damages in the study area (U.S. Army COE, 1982). A federal flood control project, therefore, could not be justified.

High flood level tides were found to play a significant role in causing flood damages, especially during combination fluvial and tidal flooding events. Good stormwater management practices can keep fluvial flooding from worsening. The existing hazard of tidal flooding, however, will not be reduced.

TABLE III-1

MAJOR OBSTRUCTIONS IN THE RIDLEY CREEK WATERSHED

	Type/Stream	Location	Capacity (cfs)	Comments
1.	Bridge/Ridley Creek	Pennsylvania Ship (private), City of Chester, Borough of Eddystone	Unknown	Obstructs 50- and 100-year peak flows
2.	Bridge/Ridley Creek	Morton Avenue, City of Chester, Borough of Eddystone	Unknown	Catches debris
3.	Bridge/Ridley Creek	Washington Park Drive, City of Chester, Nether Providence Township	Unknown	Obstructs 50- and 100-year peak flows
4.	Bridge/Ridley Creek	East 25th Street, City of Chester, Nether Providence Township	Unknown	Obstructs 50- and 100-year peak flows, catches debris
5.	Dam/Ridley Creek	Irving's Mill Dam, City of Chester, Nether Providence Township	N/A	Masonry overflow weir
6.	Dam/Ridley Creek	Chester Park Dam, City of Chester, Nether Providence Township	N/A	Masonry overflow weir
7.	Bridge/Ridley Creek	Chester Park Drive, City of Chester, Nether Providence Township	8,779	Obstructs 50- and 100-year flood flows
8.	Bridge/Ridley Creek	Brookhaven Road, Brookhaven Borough, Nether Providence Township	8,763	Obstructs 50- and 100-year flood flows

TABLE III-1

MAJOR OBSTRUCTIONS IN THE RIDLEY CREEK WATERSHED
(CONTINUED)

	Type/Stream	Location	Capacity (cfs)	Comments
9.	Bridge/Ridley Creek	Sackville Mill Road, Brookhaven Borough, Nether Providence Township	Unknown	Obstructs 50- and 100-year flood flows
10.	Bridge/Ridley Creek	Manchester Road, Middletown Township, Upper Providence Township	10,271	Obstructs the 100-year peak flow
11.	Bridge/Ridley Creek	Private drive (400 ft. upstream from Manchester Road), Middletown and Upper Providence Townships	Unknown	Obstructs the 100-year peak flow
12.	Bridge/Ridley Creek	Knowlton Road, Middletown and Upper Providence Townships	8,450	Obstructs the 100-year peak flow
13.	Bridge/Ridley Creek	Upper Bank Road (private), Middletown and Upper Providence Townships	Unknown	Obstructs the 100-year peak flow
14.	Dam/Ridley Creek	Upper Bank Nursery Dam, Middletown and Upper Providence Townships	Unknown	Obstructs the 100-year peak flow
15.	Bridge/Ridley Creek	Media Station Road, Middletown and Upper Providence Townships	Unknown	Obstructs the 100-year peak flow
16.	Dam/Ridley Creek	Media Water Works, Middletown and Upper Providence Townships	N/A	Concrete overflow weir

TABLE III-1

MAJOR OBSTRUCTIONS IN THE RIDLEY CREEK WATERSHED (CONTINUED)

	Type/Stream	Location	Capacity (cfs)	Comments
17.	Bridge/Ridley Creek	Baltimore Pike, Middletown and Upper Providence Townships	14,860	Acts in conjunction with Media Water Works Dam
18.	Bridge/Ridley Creek	Rose Tree Road, Middletown and Upper Providence Townships	Unknown	Obstructs 10-, 50-, and 100-year peak flows
19.	Bridge/Ridley Creek	Sycamore Mills, Middletown and Upper Providence Townships	Unknown	Obstructs 100-year peak flow
20.	Dam/Ridley Creek	Sycamore Mills Dam, Edgmont and Upper Providence Townships	N/A	Masonry overflow weir
21.	Bridge/Ridley Creek	Gradyville Road, Edgmont Township (Ridley Creek State Park)	4,856	Obstructs 100-year peak flow
22.	Bridge/Ridley Creek	Delchester Road, Willistown Township (Chester County)	Unknown	Obstructs the 10-, 50-, and 100-year peak flows
23.	Dam/Broomalls Run	Broomalls Dam, Borough of Media	3,000+	Spillway to be reconstructed to pass the Probable Maximum Flood
24.	Culvert/Dismal Run	Painter Road, Middletown Twp.	Unknown	78-inch reinforced concrete pipe
25.	Culvert/Dismal Run	Barren Road, Middletown Twp.	Unknown	36-inch corrugated metal pipe
26.	Culvert/Stackhouse Mill Run	Pony Trail Drive, Edgmont Township	Unknown	Obstructs 10-, 50-, and 100-year peak flows

SOURCE: DER Waterway Obstruction Permits

Stormwater Collection Facilities

As part of the municipal survey, officials were asked to identify all stormwater collection facilities exceeding twenty-four inches in diameter. Given the relatively suburban nature of most of the watershed, extensive drainage systems of large diameter pipes were not identified. Details on the facilities within the more urban City of Chester were not obtained. Throughout most of the watershed, storm sewer systems serve relatively small areas, primarily for safety and convenience. Natural drainageways and stream channels are used to convey runoff toward the main stem of Ridley Creek. As a result, storm sewer collection facilities did not play a significant role in the selection of subarea breakpoints or travel times (see a detailed discussion of this in Chapter IV). Those breakpoints were located primarily at reported problem locations along natural drainage channels.

Stormwater Management Facilities

Some type of stormwater management has been practiced by most municipalities in the watershed since the mid-1970s. As a result, eighteen detention basins were identified in the watershed. This information was obtained through the municipal survey and with the help of personnel from the Delaware County Conservation District. The basins are listed in Table III-2, along with their location and ownership. The location of each is also shown on Plate No. 2, attached to this volume.

For the most part, the basins have been constructed in conjunction with new commercial or residential development and are dispersed throughout the watershed. The ownership and maintenance responsibilities for the basins vary. Two basins are owned by the municipalities in which they are located. One of the communities, Brookhaven Borough, indicated that at least two more municipally owned basins are proposed for future construction to help solve existing and anticipated problems. Aside from two other basins owned by a school district, the remaining facilities are privately owned. Private owners vary and include developers, development corporations, homeowners' associations, corporate property owners, and individual owners on whose property the facility is located.

The performance of a detention basin or other stormwater management facility will depend on its design, construction, and maintenance. Given the fact that the basins are located in different municipalities, the design criteria for each basin most likely varied. Construction of stormwater facilities according to design plans is not always accomplished, especially when actual on-site conditions vary from those expected. Municipal inspection of facilities during construction can help ensure that appropriate revisions to the original design are made as necessary. The performance of a properly designed and constructed stormwater management basin will then become a sole function of its maintenance. Proper maintenance, at the same time, is very much a function of its ease and cost, both of which need to be considered in the original design and subsequent redesigns of the facility.

TABLE III-2

EXISTING DETENTION BASINS IN THE RIDLEY CREEK WATERSHED

No.	Owner	Location	Subarea
DB-1	Nether Providence Township	Wiltshire Drive and Moore Road, Nether Providence Township	57
DB-2	Brookhaven Borough	Hilltop V Condominiums, Brookhaven Borough	56
DB-3	Plaza 352 Corporation	Plaza 352, Brookhaven Borough	55
DB-4	Lot Owner	Highland Avenue, Upper Providence Township	43
DB-5	Lot Owner	Sycamore Mills Road, Kelly Lane II, Upper Providence Township	38
DB-6	Unknown	Villages of Rose Tree, Rt. 252 and Rose Tree Road, Upper Providence Township	38
DB-7 DB-8	Rose Tree-Media School District	Springton Lake Junior High School, Upper Providence Township	36
DB-9 DB-10	Lima Estates	Rt. 352 across from Fair Acres, Middletown Township	31
DB-11 DB-12	Toft Woods Homeowners' Association	Bishop Hollow Road and Toft Woods Way, Upper Providence Township	27
DB-13	Cold Spring Farms Homeowners' Association	Valley Road, north of Rt. 352, Edgmont Township	6
DB-14	Okehocking Hills Homeowners' Association	Stackhouse Mill Road, east of Valley Road, Edgmont Township	9
DB-15	Unknown	Pier-Angeli Company, West Chester Pike, west of Providence Road, Edgmont Township	16
DB-16 DB-17	Henderson-Lawrence Corporation	Edgmont Racquet Club, West Chester Pike, west of Providence Road, Edgmont Township	16
DB-18	Providence Associates	Edgmont Plaza, West Chester Pike, west of Providence Road, Edgmont Township	16

As a supplement to the information obtained from the municipal survey, an inventory and evaluation of existing stormwater control facilities was performed by the Delaware County Conservation District. A copy of the District's report is included in Appendix B. In all, eighteen facilities were examined in the field in order to determine their actual construction and maintenance characteristics. The conclusions drawn in the report are that, under existing institutional arrangements, the existence and location of stormwater management facilities have not been adequately documented, the maintenance of the facilities found is limited (with a few exceptions), and no regulatory procedures are in effect to ensure that the owner can and will maintain the facility properly.

A comprehensive watershed stormwater management plan can and should address the issues of design, construction, and maintenance of stormwater management facilities. The design should have a uniform basis throughout the watershed and reflect consideration for the required maintenance. Institutional arrangements need to be included in the watershed plan to ensure that proper construction and maintenance are performed.

Stormwater Related Problems

Perhaps the most useful information obtained from the municipal survey for use in the technical analysis of the watershed was the identification of existing stormwater related problems. Save for main stem flooding at the Media Water Works and in the vicinity of some older bridges in the City of Chester, the problems reported were restricted to areas along the many small tributaries of Ridley Creek. Table III-3 lists the nature and location of problems reported. Their locations are also shown on Plate No. 2. The locations of many of these stormwater related problems were used to define subarea breakpoints, i.e., points where stormwater runoff flow values are of interest.

The nature of stormwater related problems varies. Inadequate drainage facilities are a repeated cause of property damage. This is primarily due to minor flooding and erosion resulting from the obstruction of the flow of stormwater runoff. The term "inadequate drainage" appears to be a "catch-all" term describing a lack of drainage facilities or undersized storm sewer systems. Obstructions include insufficient culverts and bridges and channels which are at least partially blocked by debris.

The municipal survey also sought information on proposed solutions to existing stormwater related problems. Although responses were provided by only a few of the municipalities, these responses helped to better define the real nature of the problems being reported. This information was used to break the watershed down into the subareas which drain to those problem locations or points of interest. The stormwater runoff flow rates which have been calculated for existing conditions at those locations could be used in the analysis of the problems and design of remedial solutions. Table III-3 lists the pertinent subarea which is associated with the particular problem area that was identified.

TABLE III-3

STORMWATER RELATED PROBLEMS IN THE RIDLEY CREEK WATERSHED

Problem No.	Location	Nature of Problem	Frequency of Occurrence	Subarea
P-1	Chester-SEPTA commuter rail line	Flooding caused by obstruction of flow	more than 1/year and lasting less than 1 day	65
P-2	Chester	Erosion caused by inadequate drainage	more than 1/year and lasting less than 1 day	65
P-3	Chester	Erosion caused by inadequate drainage	more than 1/year and lasting less than 1 day	64
P-4	Chester-21st Street	Flooding caused by inadequate storm sewer capacity	more than 1/year and lasting less than 1 day	64
P-5	Chester-MacDade Blvd.	Flooding caused by inadequate storm sewer capacity	more than 1/year and lasting less than 1 day	64
P-6	Eddystone-twin RR bridge	Flooding during heavy rains at high tide caused by improper drainage	more than 1/year and lasting up to 3 days	65
P-7	Eddystone-7th and Eddystone Avenue	Property damage to private residences caused by improper drainage	more than 1/year and lasting up to 3 days	65

TABLE III-3

STORMWATER RELATED PROBLEMS IN THE RIDLEY CREEK WATERSHED
(CONTINUED)

Problem No.	Location	Nature of Problem	Frequency of Occurrence	Subarea
P-8	Eddystone-Lexington Avenue	Property damage to private residences caused by improper drainage	more than 1/year and lasting up to 3 days	65
P-9	Ridley Township-ballfield south of MacDade Blvd.	Flooding and sedimentation caused by creek overflowing during heavy rains	occurred in 1971 and 1972, each time lasting 2 days	64
P-10	Parkside - Hinkson Run	Excessive erosion caused by stormwater runoff from paved area directly to stream	more than 1/year and lasting less than 1 day	58
P-11	Parkside-Robins Run	Erosion caused by inadequate drainage	more than 1/year and lasting up to 7 days	58
P-12	Parkside-Hunters Run	Erosion caused by inadequate drainage and broken storm-water pipeline	more than 1/year and lasting less than 1 day	58
P-13	Parkside-Chelton Road	Erosion caused by inadequate drainage	more than 1/year and lasting up to 2 days	58
P-14	Brookhaven-Meadow-brooke Lane	Erosion and property damage caused by inadequate drainage	more than 1/year and lasting up to 2 days	58

TABLE III-3

STORMWATER RELATED PROBLEMS IN THE RIDLEY CREEK WATERSHED
(CONTINUED)

Problem No.	Location	Nature of Problem	Frequency of Occurrence	Subarea
P-15	Brookhaven-Ridge Road	Property damage caused by inadequate drainage	more than 1/year and lasting up to 2 days	56
P-16	Brookhaven-Cambridge Road	Property damage caused by inadequate drainage	more than 1/year and lasting up to 2 days	55
P-17	Rose Valley-Rose Valley and Old Mill Roads	Inadequate drainage causes sedimentation and road flooding during intense rainfall	-	53
P-18 & P-19	Nether Providence - Brent Drive	Severe erosion and collapse of stream channel walls due to excessive stormwater flows	more than 1/year	63
P-20	Nether Providence - Garden City Manor Area	Flooding and erosion caused by inadequate drainage	more than 1/year and lasting less than 1 day	57
P-21	Nether Providence - Devon Lane and Waterford Road	Flooding and property damage caused by obstruction of flow	more than 1/year and lasting less than 1 day	59

TABLE III-3

STORMWATER RELATED PROBLEMS IN THE RIDLEY CREEK WATERSHED
(CONTINUED)

Problem No.	Location	Nature of Problem	Frequency of Occurrence	Subarea
P-22	Nether Providence - Bowers Lane	Flooding and property damage caused by obstruction of flow	more than 1/year and lasting less than 1 day	60
P-23	Nether Providence - East Rose Valley Road	Flooding and property damage caused by obstruction of flow	less than 1/year and lasting less than 1 day	60
P-24	Nether Providence - Palmers Lane	Flooding and property damage caused by obstruction of flow	more than 1/year and lasting less than 1 day	60
P-25	Nether Providence - West Rose Valley Road	Flooding and property damage caused by excess runoff resulting from roadway improvements	more than 1/year and lasting less than 1 day	60
P-26	Nether Providence - Brookside Road	Flooding and property damage caused by excess stormwater flows	recent occurrence, 1982, frequency unknown	53
P-27	Nether Providence - SEPTA commuter rail line	Flooding and property damage caused by obstruction of stormwater flows	recent occurrence, 1982, frequency unknown	52

TABLE III-3

STORMWATER RELATED PROBLEMS IN THE RIDLEY CREEK WATERSHED
(CONTINUED)

Problem No.	Location	Nature of Problem	Frequency of Occurrence	Subarea
P-28	Nether Providence - Wallingford Road	Flooding and property damage caused by obstruction of stormwater flow	recent occurrence, 1982, frequency unknown	52
P-29	Media-Galey Park Apts. Inc.	Flooding and property damage caused by obstruction of stormwater flow	one occurrence noted, 1972	48
P-30	Middletown Township - Glen Circle	Flooding and property damage caused by inadequate drainage	more than 1/year and lasting less than 1 day	50
P-31	Middletown Township - Elwyn Road	Flooding caused by inadequate drainage	less than 1/year and lasting less than 1 day	45
P-32	Middletown Township - Rose Tree and Painter Roads	Flooding caused by obstruction of flow	less than 1/year and lasting less than 1 day	40
P-33	Middletown Township - Painter and Carriage Roads	Flooding caused by inadequate drainage	less than 1/year and lasting less than 1 day	28

Land Development Patterns

Development patterns in the County have been strongly influenced by the radial orientation of highway and transit facilities extending out from Philadelphia. Except for intensive development around the City of Chester, population growth in the watershed first occurred along these radial paths, later filling in the areas between these pockets of development. Consequently, concentrated development initially occurred in the Chester area in the southern portion of the basin and in the Media area in the central portion of the watershed rather than moving progressively upstream from the Delaware River.

The major thrust of environmental planning in the County in the early 1970s revolved around the philosophy of regionalized sewerage systems. The County's Sewerage Facilities Plan and the Delaware County Regional Sewerage Project called for construction of a major interceptor from a new regional treatment plant in Chester all the way up Ridley Creek into Chester County. The County's land use plan acknowledged these plans but warned that they should be reevaluated since they were not based on the framework of a County land use plan and used unrealistically high population projections.

This concept of regionalized sewerage systems was reevaluated under the COWAMP/208 Plan and found to be undesirable. Construction of the upper Ridley Creek interceptor and the phase-out of the Media Borough sewage treatment plant were no longer recommended as part of the plan. Construction of the lower Ridley Creek interceptor has since been abandoned as well, due to funding cutbacks. Thus, there are currently no major sewer construction projects pending in the watershed. Since availability of public sewer systems is basic to large-scale development, the current status of these proposals does suggest that there are significant constraints on an intensive development scheme taking place in the watershed in the foreseeable future.

The existing pattern of development in the watershed indicates that the southern portion of the basin is close to a "built-out" condition. Minimal amounts of vacant land remain in this portion of the watershed. The northern part of the watershed, on the other hand, has potential as a population growth area with sizable areas of open space and vacant land available.

The County's land use plan calls for an orderly approach to development with future patterns of growth involving recentralizaton, infill, and growth contiguous to existing development. While the policies of the land use plan are meant to guide future growth, it is impossible to say with absolute certainty to what use a parcel will be put at a given time in the future. Nonetheless, to carry out the modeling analysis and meet the guidelines of Act 167, it was necessary to make assumptions as to what was likely to occur in the future on a parcel-by-parcel basis. The municipal zoning ordinances were relied on to predict these future conditions. Development at a built-out state was projected for the watershed, according to densities and uses allowed by current zoning. The only areas that were assumed not to be developable were the existing parks, floodplains, and slopes in excess of fifteen percent. Since protection of their environmentally sensitive areas has become an important concern to most municipalities, and many have taken steps in this direction through their ordinance and regulatory structure, it was felt that this was a valid approach to pursue.

Floodplain Development

DCPD performed an inventory of floodplain development within the Ridley Creek watershed. The majority of the development which currently exists within the delineated 100-year floodplain of Ridley Creek and its tributaries has occurred in the southernmost portion of the watershed in the City of Chester, Eddystone Borough, and Ridley Township. The floodplain in that portion of the watershed is, in general, broader and flatter and also subject to flooding due to both flood flows and high tides. Throughout much of the rest of the watershed the floodplain is narrow with steep valley walls which have restricted development. In those areas of the upper watershed where the floodplain is broader, the rural nature of the areas has kept development out of the floodplain. The upper stream valley generally lies either within Ridley Creek State Park and other public properties or within the boundaries of large estates. Development in the future is currently limited by municipal ordinances to areas outside the designated floodplain. The following is an inventory of existing development falling within sections of the Ridley Creek floodplain.

Edgmont Township

- Very low density development west of Pheasant Lane in the northeastern sector of the Township
- Sections of Okehocking Hills and Cold Spring Farms subdivisions

Upper Providence Township

- Sections of Foxdale Farms and Tymberwyck subdivisions

Rose Valley Borough

- No significant development aside from a few homes constructed near Rose Valley Road and the Borough Hall (Old Mill)

Nether Providence Township

- The neighborhoods of Garden City and Scot Glen are slightly developed within the floodplain of a tributary of Ridley Creek

Eddystone Borough

- Residential and industrial uses west of Eddystone Avenue bordering Ridley Creek

Chester City

- The northeastern sectors of the neighborhoods of Sun Village and Morton Avenue Village
- Primarily heavy industrial development east of the Conrail tracts is completely within the floodplain of the Delaware River

CHAPTER IV

TECHNICAL APPROACH FOR WATERSHED STORMWATER MANAGEMENT

The technical approach selected for this pilot stormwater plan was structured to respond to Act 167 and PA DER draft guidelines for stormwater management planning. As stated previously, Sections 5 and 13 of the Act establish the basic standard that the maximum rate of runoff is no greater after development than prior to development activities or that reasonable steps are taken to protect downstream areas. Specific standards and criteria for achieving this stormwater management objective in the Delaware County portion of the Ridley Creek watershed were developed in a logical manner as part of this pilot watershed planning study.

The technical program that led to the identification of the standards and criteria for the Ridley Creek watershed involved the collection of data describing existing and future land uses, soils, slopes, stream channel characteristics, floodplains, water obstructions, and stormwater or flood related problems in the Delaware County portion of the watershed. From that data base, a "model" of watershed stormwater runoff flows, reflecting these physical characteristics and conditions, was developed using the Penn State Runoff Model (PSRM).[4]

This chapter presents the details and characteristics of this "model development" process and describes the methodologies and procedures that were used to:

- o develop design storm information
- o model existing runoff conditions
- o model future runoff conditions

Overview of the Penn State Runoff Model

Watershed-level planning represents a fairly new direction for stormwater management and involves a complex process of goal setting, problem identification, and decision making. The key aspect of any planning program that leads to the decision-making step is the development of a sound data base. That is, the only way to be able to

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4 Lakatos, David F. (Walter B. Satterthwaite Associates, Inc.) and Aron, Gert (The Pennsylvania State University), "Penn State Runoff Model-User's Manual," June, 1981 Version, Institute for Research on Land and Water Resources, The Pennsylvania State University, University Park, Pennsylvania, June, 1981.

accurately plan for future control of storm runoff impacts is to develop accurate facts concerning future storm runoff characteristics.

The method that has been used to provide these facts for the development of this watershed stormwater management plan is runoff simulation modeling. Computer simulation models are very effective tools for analyzing the effects and impacts of stormwater runoff in urbanizing areas. Computer technology now provides the engineering profession with the ability to evaluate the critical elements of the rainfall-runoff process for an urbanizing area, such as the timing of runoff flows throughout the watershed and the specific characteristics of detention and/or delay of runoff in various sections of a watershed. It is only by evaluating these types of situations as part of an overall stormwater management analysis that an effective runoff control system can be developed.

The particular runoff simulation model that has been used for this watershed planning project is the PSRM. Use of the PSRM in Pennsylvania is increasing because of its ability to provide a cost-effective tool that can be used to evaluate stormwater management alternatives for any application, regardless of its size. In addition, it is a model that can be applied on a watershed basis to tie together several individual analyses into one coordinated stormwater management plan. This capability satisfies the needs of comprehensive stormwater planning, such as is being proposed in Pennsylvania's new Stormwater Management Act (Act 167).

The PSRM simulates rainfall-runoff events on the basis of the following information:

- Rainfall inputs:
  - rainfall amounts for particular design storm events
  - rainfall distribution, or pattern, during the course of a particular design storm event
- Watershed representation:
  - physical characteristics of the watershed, such as land use and slope data
  - conveyance system characteristics, such as drainage pipe and stream channel capacities
  - detention basin storage characteristics

Based on this input, the model predicts the outcome of the storm in the form of runoff hydrographs for each subarea in the watershed as well as for the cumulative sum of storm runoff as it passes through the watershed.

The most important information that is provided by the PSRM, which can be used to make sound stormwater management decisions, includes:

- The identification of the source of storm flows that combine in the downstream portion of a watershed and cause existing damages

- The identification of the change in existing storm runoff problem areas that will result from proposed future development

- The potential benefits that could be achieved through the use of various stormwater management alternatives--which ultimately leads to the identification of the "best" alternative for satisfying stormwater management goals in a watershed

Design Storms

Design rainfall events, or design storms, are defined and selected to provide a uniform basis for analysis of the flooding and runoff characteristics throughout an entire watershed. A design storm is identified by three basic properties:

- return period or frequency,

- duration, and

- rainfall distribution.

Frequency, or return period, refers to the likelihood of occurrence of the event in any year based on statistics from recorded events. A ten-year storm, for example, has a ten percent chance of occurring in any year, or may be expected once in every ten years. Duration refers to the length of time of rainfall in the event and is usually expressed in hours. It is equally important to know the pattern of rainfall distribution during the event in terms of the rainfall intensity during any time interval of the storm. Intensities are typically expressed in units of inches per hour.

Act 167 does not specify return periods to be used in the management of stormwater runoff. The stormwater management guidelines prepared by PA DER recommend that a complete flood frequency analysis ranging at least from a 2-year to a 100-year flood for both pre- and post-development conditions be performed in order to develop sound design frequency criteria for stormwater management. No state-level criteria have been adopted for stormwater management measures, so, therefore, they must be adopted by each municipality in accordance with approved watershed plans. The design storms selected for use in analysis of the Ridley Creek watershed were the 2-, 10-, 25-, and 100-year rainfall events.

A review of existing municipal ordinances in the watershed indicates that storm sewer collection systems are currently designed for up to the 10-year storm. There appears to be no guarantee, however, that individual development sites are being designed such that peak flows from more severe events (e.g., the 25- or 100-year events), which exceed the capacity of storm sewer systems, will reach a stormwater runoff control facility. If the drainage plan for a developing site is not designed to direct the runoff from larger storm events to control facilities, it is inappropriate to size control facilities for such infrequent events.

Stormwater drainage systems (e.g. storm sewers, swales, etc.) must be designed so that all of the runoff from the desired design storm event from portions of the development site to be controlled by a facility can flow into the facility for proper control. For the Ridley Creek watershed in Delaware County, the selected design storm for this plan is the 25-year recurrence interval event. Therefore, the drainage system for a development site must be able to convey the peak runoff rate for the 25-year design storm event to the appropriate control facilities.

In this stormwater management study, consideration has been given to the impacts of expected increased runoff at points of concern and interest all along the main stem of Ridley Creek and its tributaries in Delaware County. The impact of development has been examined for the 2-, 10-, 25-, and 100-year storm events. The effects of providing adequate storage and control of post-development peak discharges for the 10-, 25-, and 100-year frequency storms have also been investigated.

The Soil Conservation Service (SCS) 24-hour, Type II storm distribution was used to specify the pattern of rainfall for all design storm events as input to the watershed model. Figure IV-1, taken from SCS Technical Publication No. 149 (SCS, 1973[5]), shows the distribution of the Type II storm. The total 24-hour rainfall depths for each return period were obtained from the "Pennsylvania Rainfall Manual" (Kerr, et al., 1970[6]).

The Type II distribution is used in the hand calculation methods of SCS's Technical Release No. 55 (SCS, 1975[7]), which is widely used for determining pre- and post-development runoff and for sizing stormwater management facilities. The results of the watershed modeling performed with the PSRM for this study can thus be considered to be compatible with results that would be obtained on individual sites using TR-55 techniques. In order to ensure that peak flood flows reflect contributions from the entire watershed, it is necessary that a storm

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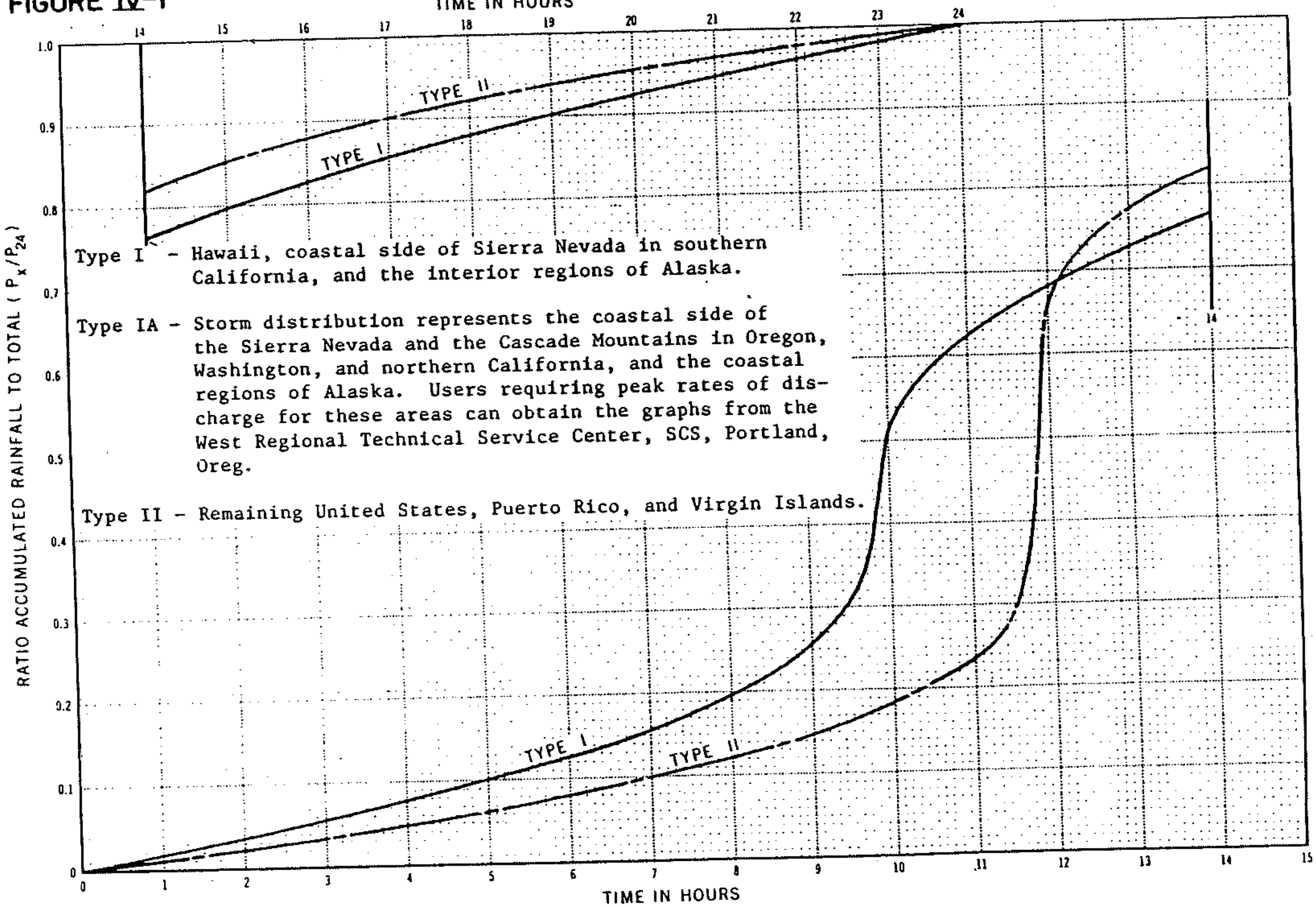
5 Soil Conservation Service, "A Method for Estimating Volume and Rate of Runoff in Small Watersheds," Technical Publication No. 149, U.S. Department of Agriculture, Washington, D.C., 1973.

6 Kerr, R.L., McGinnis, D.F., Reich, B.M., and Rachford, T.M., "Analysis of Rainfall-Duration-Frequency for Pennsylvania," Institute for Research on Land and Water Resources, The Pennsylvania State University, University Park, Pennsylvania, 1970.

7 Soil Conservation Service, "Urban Hydrology for Small Watersheds," Technical Release No. 55, U.S. Department of Agriculture, Washington, D.C., 1975.

FIGURE IV-I

SCS TYPE II -TWENTY-FOUR-HOUR RAINFALL DISTRIBUTION



duration be used which is at least as long as the total travel time to the mouth of the stream from the hydraulically most upstream point in the entire watershed. The 24-hour duration was found to be longer than the travel time required for the peak flood flow for all events to reach the mouth of Ridley Creek.

Model of Existing Conditions

Development of standards and criteria for stormwater management in the Delaware County portion of the Ridley Creek watershed was done using a computer simulation model which reflects the specific runoff characteristics of the watershed. The PSRM provided a "tool" for computing flow rates at desired points throughout the watershed under existing and future development conditions. The use of the simulation model allowed for the evaluation of runoff resulting from rainfall events of any magnitude and the evaluation of alternative concepts and systems for the control of increased runoff from those events.

Selection of Subarea Breakpoints

The initial step in the construction of the watershed model was the selection of "breakpoints." Breakpoints are locations along drainage paths, i.e., along Ridley Creek or any of its tributaries, identified and/or selected because they are considered to be of interest for a variety of reasons. In the Delaware County portion of the watershed, breakpoints were selected based on:

- o The location of existing problems, as identified by local officials in the PA DER survey,
- o Municipal, county, and state park boundaries,
- o The location of major obstructions, primarily bridges and Broomalls Lake dam,
- o Other key points of interest, especially the Media Water Filtration Plant and the USGS stream gaging station in Moylan, and
- o Confluence points of tributaries with Ridley Creek, as deemed appropriate based on engineering judgment and good modeling practice, including points downstream of large open areas where development could be anticipated to occur.

The breakpoints were used to divide the Ridley Creek watershed into sixty-five subareas or subbasins. Those subareas delineate the limits of the contributing drainage area to each of the selected points of interest. The boundaries of the subareas are shown on Plate No. 2.

Subarea Nos. 1, 2, 10, 13, and 15 lie totally in the Chester County portion of the Ridley Creek watershed. Subarea Nos. 1 through 9, along Stackhouse Mill Run near the County boundary, are generally smaller to provide greater detail for this highly developable area.

Subarea Nos. 20, 21, 22, and 26, located wholly in Ridley Creek State Park, are generally larger, since little or no change in land use is expected in the park. Developable areas draining into the park were subdivided closely so that the impacts of storm runoff due to their development could be clearly seen.

The subareas are more uniformly sized in the more developed portions of the watershed. The breakpoints in these portions of the watershed were selected to allow for the identification of peak flow rates at identified problem locations, municipal boundaries, the Media Water Filtration Plant, and the USGS gaging station at the Manchester Avenue bridge in Moylan. The subareas again become large further downstream in the watershed towards the mouth at the Delaware River. This portion of the watershed is very nearly, if not fully, developed at the present time, and the rate of runoff from those areas is not likely to change in the future. Subarea Nos. 46 and 61 are "dummy" subareas having no real land area which were necessary only for computational purposes.

Watershed Model Data Requirements

In rainfall events an entire watershed responds as the sum of the responses of its subareas. As noted earlier, PSRM[8] was used to model the response of the delineated subareas in the watershed to the design rainfall events. In the watershed model, the tedious summation of the contributions of upstream subareas is performed at each of the specified points of interest. Individual runoff hydrographs are computed for each subarea and routed downstream. The time required for the runoff to reach any downstream point reflects the travel time required between subarea outlets in the actual pipes or channels of the watershed. The flow rate at any point of interest, at any point in time, is simply the sum of flow rates from contributing subareas that have arrived at the point at that moment. The model forms a time record of the flow rates passing the point, which forms the total hydrograph for the contributing portion of the watershed. The PSRM performs this summation continuously for each design storm analysis throughout the Ridley Creek watershed, calculating runoff hydrographs from all sixty-five subareas and summing their contributions at all points of interest. At the mouth of Ridley Creek, the outlet of Subarea 65, the model is effectively summing the individual contributions of runoff from sixty-five subareas.

Subarea Runoff Characteristics

The initial step for the model to perform is the calculation of the runoff hydrographs for all subareas that result from the design storm rainfall distribution input. To calculate the runoff hydrograph for each subarea, the following hydrologic characteristics are required as input to the model:

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8 Lakatos and Aron, loc. cit.

- The total acreage
- The percentage of impervious cover, i.e., rooftops, patios, streets, parking lots, and other areas of concrete or bituminous paving
- A composite runoff curve number, as per Soil Conservation Service methods, for the areas of pervious cover, i.e., lawns, woods, meadows, pastures, and croplands
- The average land slope
- A characteristic width of overland flow

The first four items above were obtained from detailed mapping of soils, slopes, and land use supplied by the Delaware County Planning Department. To most efficiently assemble the input data for each subarea, the information on the maps was transformed into digitized data by dividing the watershed into discrete homogeneous parcels of the same soil, slope, or land use and placed on computer files. The process involved, called "digitization," is described in more detail in Appendix C. Briefly, files created for the different soils, slopes, and land uses found in the watershed are superimposed in the computer and further divided into discrete parcels having the same combination of those characteristics. The boundaries of the subareas are superimposed, and the data required for input to the model for each subarea are obtained by an aggregation procedure which determines composite subarea characteristics.

The total acreage of each subarea is determined by the computer from the digitized subarea boundaries. The aggregation procedure considers the land uses delineated in each subarea and determines the amount of impervious cover. In this study, the land uses found in the watershed were broken down into eighteen separate categories as listed in Table IV-1. The average percentage of impervious cover was determined for each land use as shown. The impervious percentage in any subarea is simply determined in the aggregation procedure by summing the total impervious cover of the various land uses found in a subarea and dividing by the total subarea acreage.

SCS runoff curve numbers are assigned to any parcel based on the soil type and type of cover found. Nearly every soil type in Pennsylvania has been assigned a hydrologic soil classification by SCS. Those that are not are assigned a classification based on judgment and the classification of surrounding soils. The runoff curve number of a parcel is determined by that classification and the type of pervious cover which occurs. A composite runoff curve number is obtained by forming a weighted average of the curve numbers of all parcels forming a subarea. Average land slopes for each subarea are found in a similar fashion as the weighted average of parcel slopes.

Runoff hydrographs for each subarea are calculated by applying the design rainfall for each design storm, as prescribed by the Type II distribution, over small time intervals. Each subarea responds by

TABLE IV-1

LAND USE CATEGORIES

Designation	Land Use - Description			Average Impervious Percentage[1]
	Residential			
A	.67 - .99	DU/acre	- (low) single family dwellings on large lots	8.7
B	1.0 - 4.9	DU/acre	- (low moderate) single family dwellings on smaller lots	17.2
C	5.0 - 8.9	DU/acre	- (moderate) single family detached and clustered townhouse dwellings	41.4
D	9.0 - 16.9	DU/acre	- (medium) semi-detached dwellings, duplexes, triplexes, quadraplexes, townhouses, and garden apartments	42.3
E	17.0 +	DU/acre	- (high) garden, mid- and high-rise apartments	60.6
	Commercial			
F	Retail		- shopping centers, malls, central business districts, strip commercial, larger neighborhood convenience centers, service stations	90.+
G	Other commercial		- offices, motels, hotels, banks	57.8
	Industrial			100
H	Heavy industrial		- manufacturing, warehouses refineries, power generating stations	
I	Light industrial		- industrial offices, light industrial parks	
J	Transportation		- railroads, trolleys, interchanges, terminals, airports	
	Public and Quasi-Public			
K	Marinas, historic sites			0.0
L	Institutional and municipal		- schools, colleges, hospitals, municipal properties, churches	90.+
	Natural Conditions			0.0
M	Cultivated		- farmlands	
N	Open space		- grassy fields, playgrounds, cemeteries	
O	Meadows		- open fields of tall grasses	
P	Light woods		- includes orchards	
Q	Heavy woods			
R	Open water			

[1] As determined by the Delaware County Planning Department

allowing an appropriate portion of the rainfall to infiltrate into pervious areas, and the rest to run off downslope toward the subarea outlet. As more and more rain falls, the runoff depth increases and moves more rapidly toward the outlet. The model records a hydrograph of the runoff arriving at the outlet throughout the period of the storm event.

Watershed Travel Times

The total flow reaching points of interest, as previously stated, is the sum of contributions arriving from upstream subareas. The PSRM simplistically looks at the watershed as a collection of individual subareas connected by drainage elements, which, in the case of the Ridley Creek watershed, are the main stem and tributaries of Ridley Creek. In order to properly translate, or route, the subarea runoff hydrographs downstream to points of interest, the times required to travel to those points must be known. The travel times in the drainage network of the watershed are found by dividing the lengths of the stream segments between subarea outlets and points of interest by the average velocities in those channels. Travel times were calculated for each drainage element that connects the subareas delineated on Plate No. 2.

Stream lengths along Ridley Creek and its tributaries were obtained by simple measurement on a map of the watershed. The average velocities were obtained by two means. Along the majority of the main stem of Ridley Creek and Stackhouse Mill Run, velocities were obtained from HEC-II water surface profile computations performed to delineate the floodplain along the creek for the National Flood Insurance Program. On portions of the main stem where backwater computations were not performed, velocities were extrapolated from stream reaches with similar flow rates, depths, and channel slopes. Typical cross-sections were obtained in the field to calculate normal depth velocities on the remaining small tributaries to Ridley Creek.

Other Input

An important attribute of PSRM is its ability to model the effects of dams or detention basins in subareas. This capability proved to be especially valuable in the analysis of alternative systems for control of the anticipated increased runoff from future development. In the simulation of existing conditions, the storage and discharge characteristics of Broomalls Dam in the Borough of Media were evaluated to reflect its effect on reducing the outflow hydrograph from Subarea 43.

Chester County Portion of the Ridley Creek Watershed

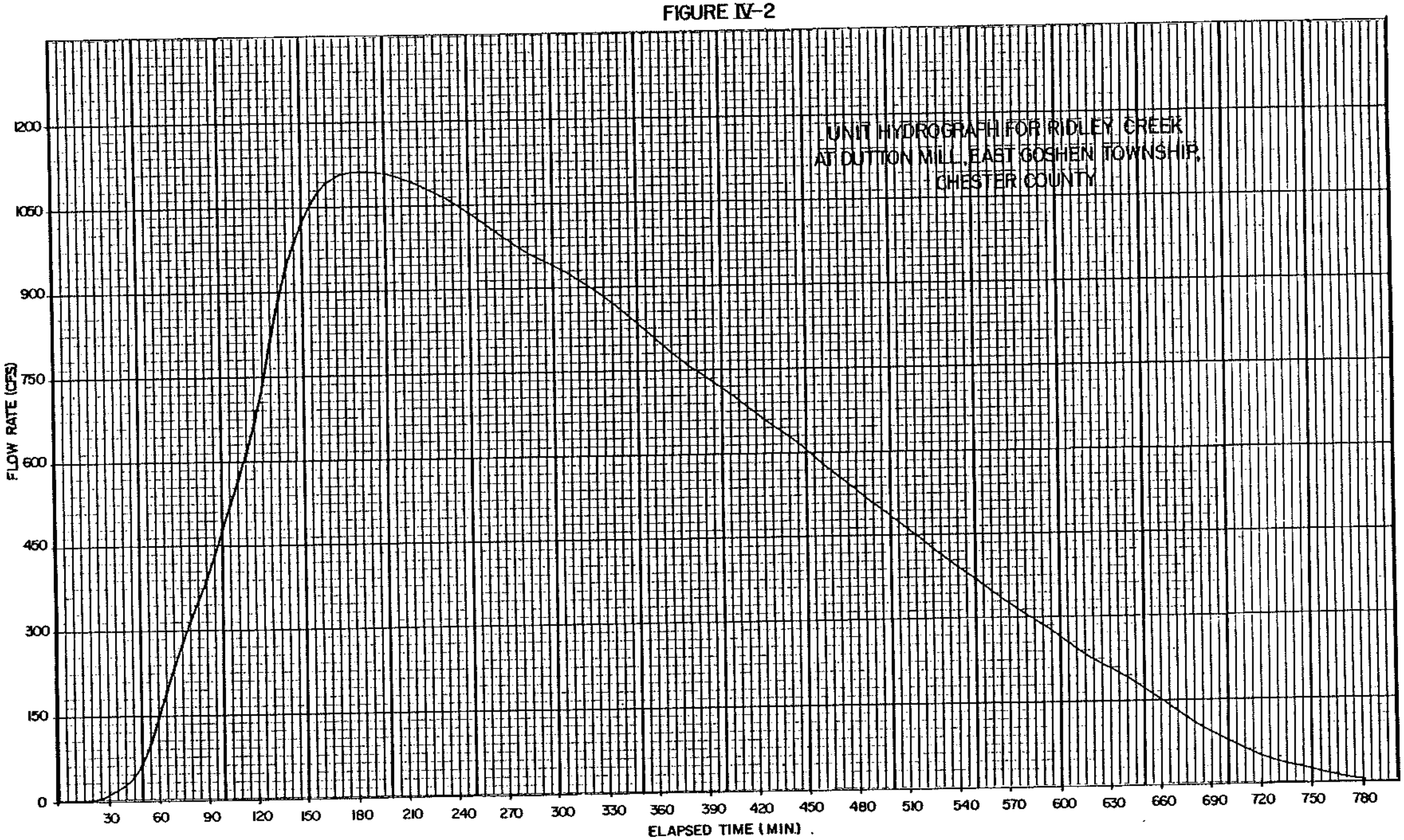
While the purpose of this study was to develop standards and criteria for stormwater management in the Delaware County portion of the Ridley Creek watershed, the effects of development on peak flow rates in that portion of the watershed could only be accurately assessed by considering the flow contributions of the entire watershed. Of the 38.5 square miles of watershed which drain to the mouth of Ridley Creek, approximately 17.5 square miles, nearly one-half of the total drainage area, are located in Chester County. For simulation purposes, breakpoints were selected on the main stem of Ridley Creek and four small tributaries at the boundary of Chester and Delaware Counties. As noted earlier, Subarea Nos. 1, 2, 10, 13, and 15 were delineated entirely in Chester County. Portions of Subarea Nos. 3, 5, 9, 12, 14, and 16 contain varying amounts of their total drainage areas in both counties.

Detailed information on soils, slopes, and land use were not obtained for the subareas or portions of subareas located in Chester County. The Chester County portions of Subarea Nos. 3, 5, 9, 12, 14, and 16 were considered similar enough to the remaining Delaware County portions of the subareas to be assigned the same composite runoff characteristics for the purpose of computing the runoff hydrographs from those subareas.

In order to provide a better and more accurate representation of the runoff characteristics of the subareas entirely within Chester County, a hydrograph was measured at the USGS stream gaging station on Ridley Creek at Dutton Mill, East Goshen Township (on the Strasburg Road Bridge), for the storm of June 29, 1982. Stream stages (depths) were measured every five to fifteen minutes during the entire storm event to obtain the shape of the hydrograph as well as the peak flow value resulting from the rainfall of 0.6 inches in 0.5 hour. The USGS rating curve for the Dutton Mill gage was used to obtain flow rates from the recorded stages or flood depths. Rainfall depths for the storm were obtained from gages at Hershey's Mill, the Media Water Filtration Plant, and Philadelphia International Airport. The hydrograph that was measured at the Dutton Mill gaging station immediately following the very heavy thunderstorm on that date displayed a simple geometry which lent itself very well to the development of a unit hydrograph for the 9.7 square miles which drain to that gage.

A unit hydrograph is a hydrograph resulting from exactly one inch of rainfall excess or runoff (rainfall in excess of that which will infiltrate) resulting from an event of specific duration spread over the contributing watershed. By simplifying complex storm distributions, like the Type II storm, into a sequence of rainfall events of the same duration as the unit hydrograph, more complicated runoff hydrographs can be created by forming a single cumulative hydrograph from the series runoff hydrographs (superposition). The depth of runoff of the June 29, 1982, storm was obtained knowing the volume of water which flowed past the gaging site during the storm, subtracting the volume of normal flow or baseflow that was included, and dividing by the 9.7 square miles of drainage area. By this procedure, it was determined that an average of 0.40 inch of rainfall excess ran off the contributing watershed during the recorded storm event. Since the recorded hydrograph was for 0.40 inch of runoff, a unit hydrograph for 1.0 inch of runoff was obtained by dividing the ordinate (flow value) at every time increment by 0.40. The resulting unit hydrograph is shown on Figure IV-2.

FIGURE IV-2


UNIT HYDROGRAPH FOR RIDLEY CREEK
AT DUTTON MILL, EAST GOSHEN TOWNSHIP,
CHESTER COUNTY
FLOW RATE (CFS)
0
150
300
450
600
750
900
1050
1200
ELAPSED TIME (MIN.)
30
60
90
120
150
180
210
240
270
300
330
360
390
420
450
480
510
540
570
600
630
660
690
720
750
780

The unit hydrograph developed for the Dutton Mill station was then non-dimensionalized to produce a generalized unit hydrograph for Chester County that could be used for subareas of any size or shape. The unit hydrograph was non-dimensionalized by dividing each recorded flow rate for the entire event by the peak flow rate that was recorded, and by dividing the times at which the flow rates were recorded (from the beginning of the storm) by the time until the peak flow occurred. In order to apply the non-dimensionalized unit hydrograph to determine runoff hydrographs for design storms in the Chester County portion of the Ridley Creek watershed, it is necessary to determine appropriate values of time to peak (T_p) and peak flow (Q_p) for the specific subareas to which the hydrograph is to be applied. Figure IV-3 shows the dimensionless unit hydrograph obtained for the Chester County portion of the watershed.

In hydrograph analysis, watershed lag is the time from the center of mass of the rainfall excess (that portion of the rainfall distribution that runs off) to the peak rate of runoff as shown on Figure IV-3. The SCS has demonstrated that the time from the beginning of the rainfall to the time at which the peak flow occurs is related to the watershed lag, L, by the relationship:

$$T_p = \frac{D}{2} + L \qquad (4.1)$$

where D is the rainfall duration of the unit hydrograph. The duration for the Chester County unit hydrograph was 0.5 hour. The watershed lag time has been shown by SCS to be related to other watershed characteristics by either of the following relationships:

$$L = 0.6 \; T_c \qquad (4.2)$$

where T_c is the time of concentration of the watershed or travel time from the watershed divide to the outlet, or

$$L = K_1 l^{0.8} \qquad (4.3)$$

where l is the hydraulic length of the watershed as measured from the outlet to the divide along the major drainage channel, and K_1 is a constant reflecting other runoff characteristics of the watershed (SCS, 1972).

Using a measured hydraulic length and the recorded lag of the June 29, 1982, storm at Dutton Mill, the constant K_1 was computed for the portion of the watershed contributing to that point and assumed applicable in Subarea Nos. 1, 2, 13, and 15. Hydraulic lengths were determined from topographic maps for each of those subareas, and Equation 4.3 was applied to obtain the respective lag times. Times to

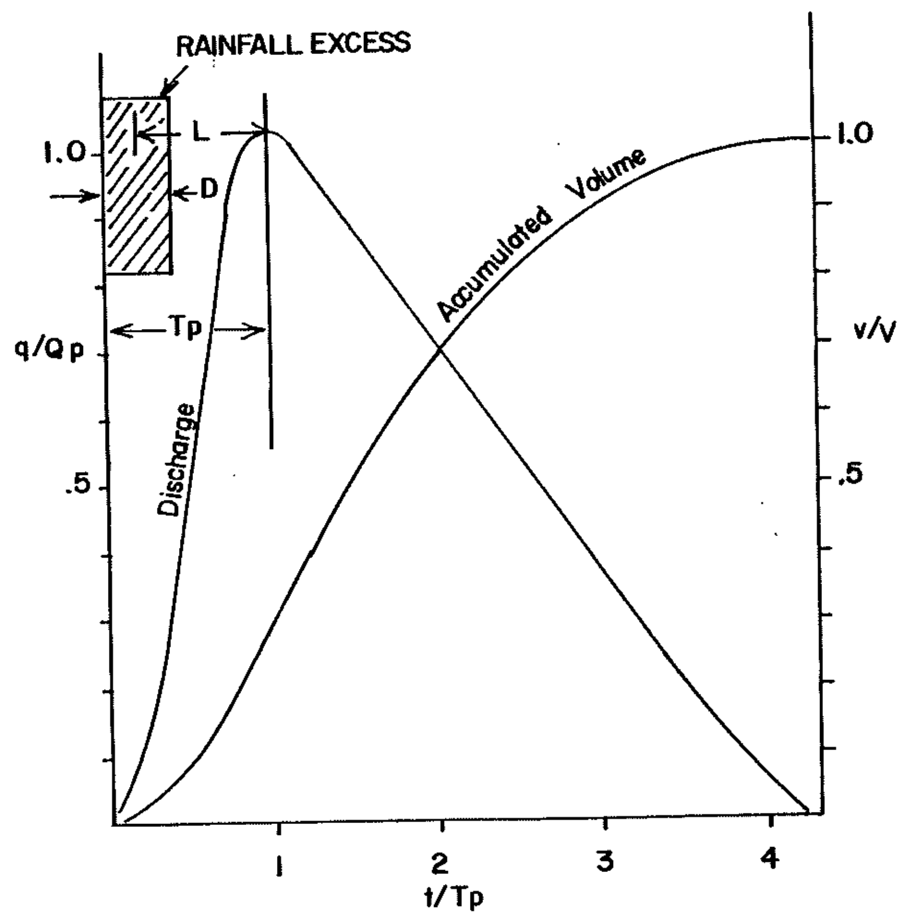


FIGURE IV-3

DIMENSIONLESS
UNIT HYDROGRAPH
FOR
CHESTER COUNTY

L – Watershed Lag

D – Duration of Rainfall Excess

t – Time

Tp – Time to Peak

q – Flow Rate at Time t

Qp – Peak Flow

v – Accumulated Volume at Time t

V – Total Accumulated Runoff Volume

peak for each of the four subareas were obtained using Equation 4.1. Equation 4.2 was used to determine the lag for Subarea 10. The time of concentration was determined from velocities in various reaches of the stream, which were obtained from the HEC-II computer output for flood insurance studies in Chester County. The time to peak for Subarea 10 was then calculated using equation 4.1.

The peak flows, Q_p, of the desired unit hydrographs were found by applying a general form of an SCS relationship:

$$Q_p = \frac{K_2 \cdot A}{Tp} \qquad (4.4)$$

where A is the drainage area of the subarea, T_p is the respective travel time, and K_2 is another constant reflecting the shape of the Dutton Mill unit hydrograph. Using Q_p and T_p of the Dutton Mill unit hydrograph and knowing the drainage area to the gaging station site (9.7 square miles), Equation 4.4 was solved for the constant K_2. That constant was assumed applicable to the Chester County subareas, allowing calculation of the peak discharge for all of their unit hydrographs.

With Q_p and T_p known for Subarea Nos. 1, 2, 10, 13, and 15, their dimensional unit hydrographs were derived from the non-dimensional unit hydrograph for the Chester County portion of the Ridley Creek watershed. Figures IV-4, IV-5, IV-6, IV-7, and IV-8 show the unit hydrographs obtained for the Chester County subareas. From these unit hydrographs, runoff hydrographs for the 2-, 10-, 25-, and 100-year storms were computed by applying the Type II rainfall distributions for those events. Rainfall excess (i.e., runoff) distributions for the design storms, needed as input to the unit hydrographs in each subbasin, were developed from supplied rainfall hyetographs by application of the SCS rainfall-runoff equation:

$$\text{direct runoff} = \frac{(P-0.2S)^2}{P + 0.8S} \qquad (4.5)$$

where P is the total precipitation in any 0.5-hour time interval of the storm (0.5 hour is the unit hydrograph duration), and the potential maximum retention (abstraction) of rainfall, S, is given by:

$$S = \frac{1000}{CN} - 10 \qquad (4.6)$$

where CN is the composite or average runoff curve number of the subarea (SCS, 1972[9]). An average curve number of 68 was assumed for the five subbasins delineated in the upper Ridley Creek watershed.

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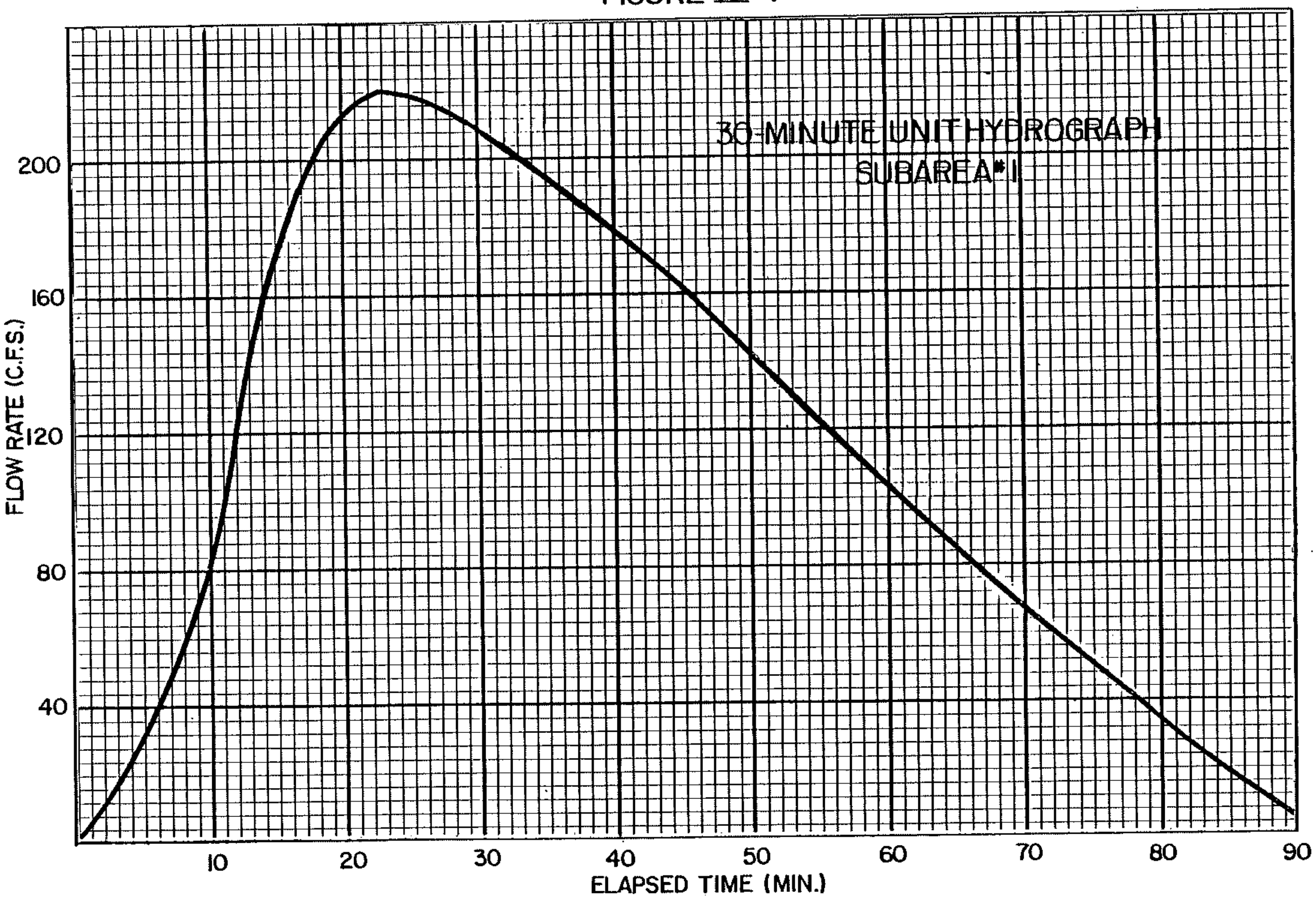
9 U.S. Department of Agriculture, Soil Conservation Service, "National Engineering Handbook-Section 4, Hydrology," U.S. Government Printing Office, Washington, D.C., August, 1972.

FIGURE IV-4



30-MINUTE UNIT HYDROGRAPH
SUBAREA #1
200
160
120
80
40
FLOW RATE (C.F.S.)
10
20
30
40
50
60
70
80
90
ELAPSED TIME (MIN.)

FIGURE IV-5

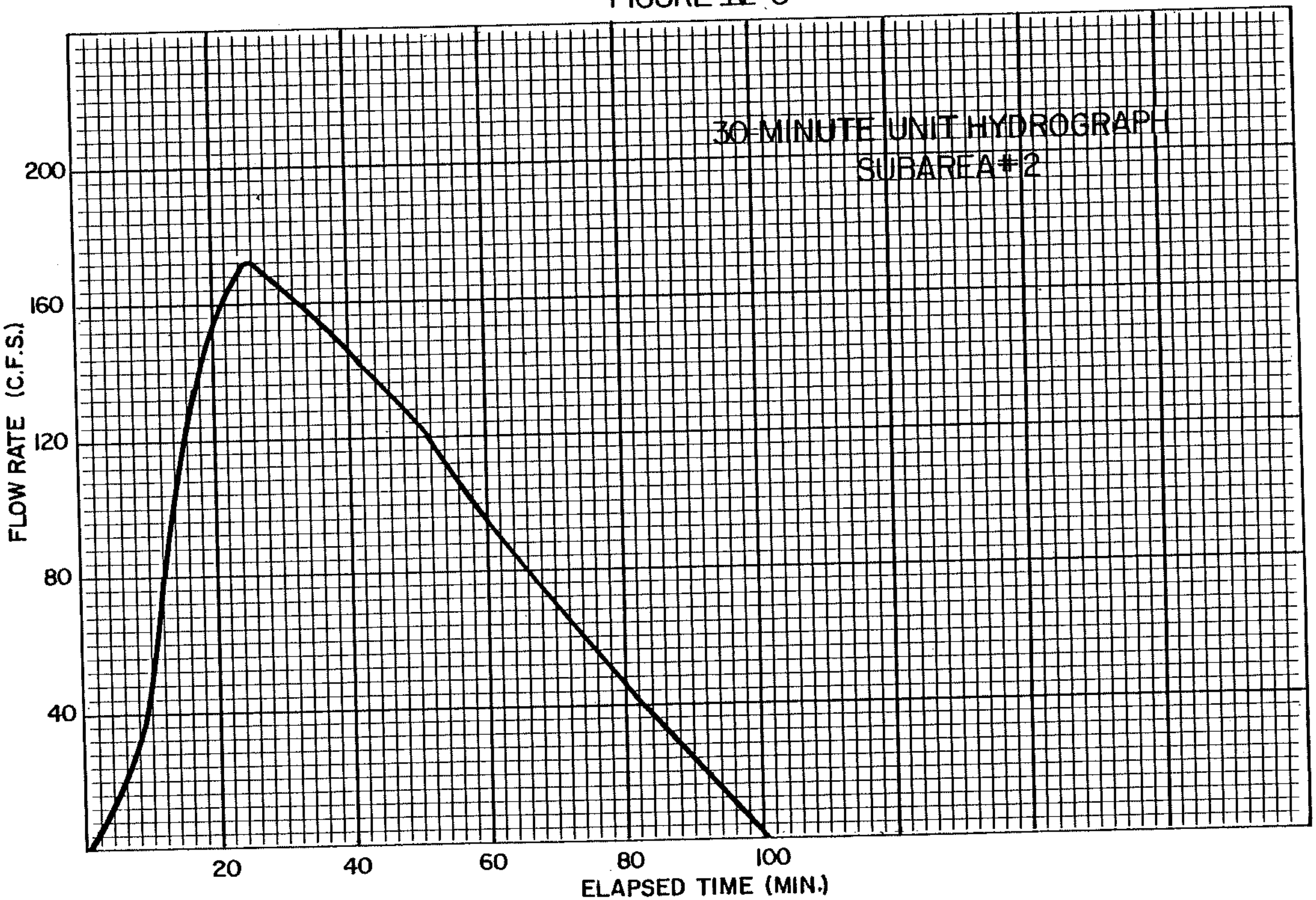

30-MINUTE UNIT HYDROGRAPH
SUBAREA #2
FLOW RATE (C.F.S.)
200
160
120
80
40
20
40
60
80
100
ELAPSED TIME (MIN.)

FIGURE IV-6

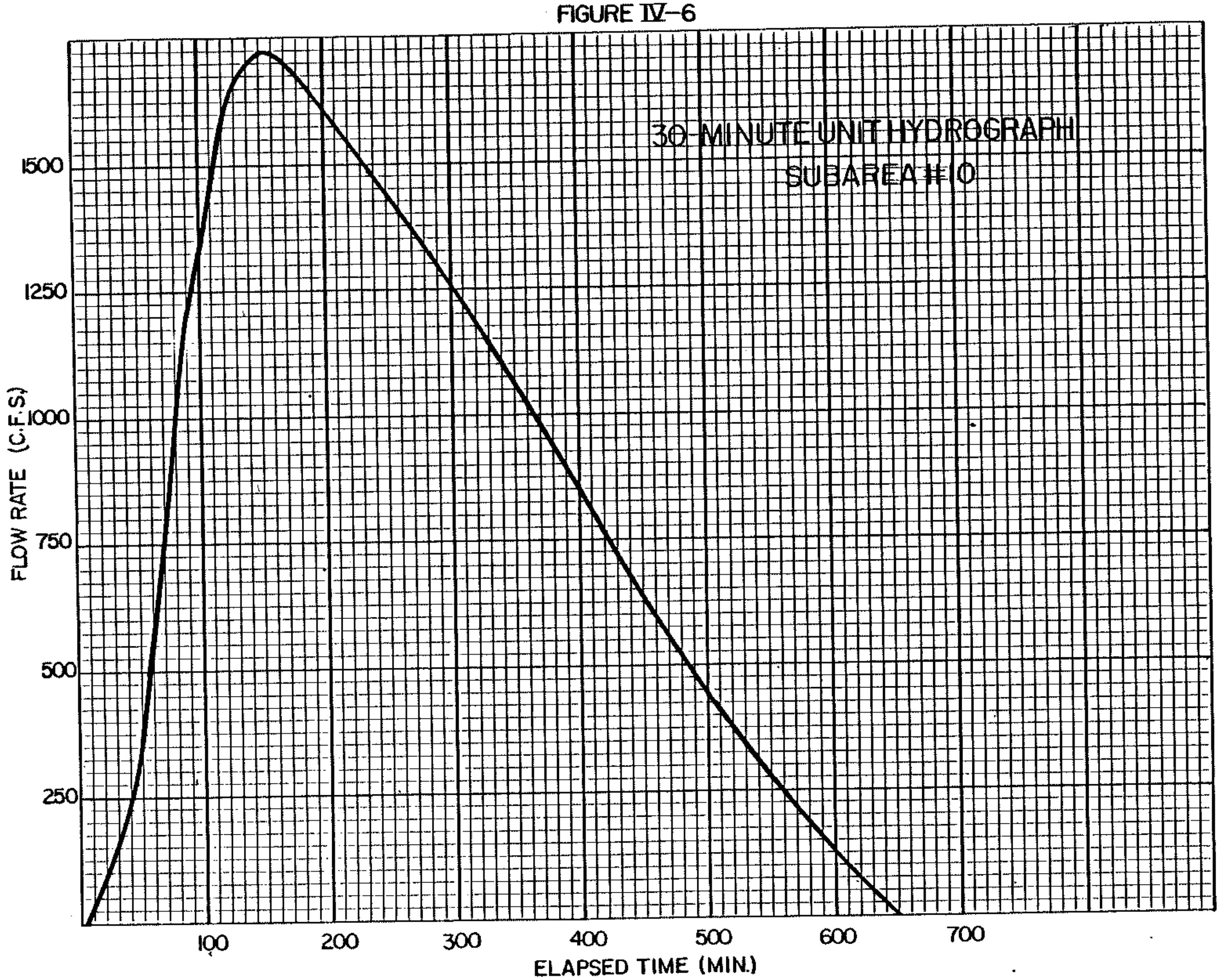

30-MINUTE UNIT HYDROGRAPH
SUBAREA #10
FLOW RATE (C.F.S.)
1500
1250
1000
750
500
250
100
200
300
400
500
600
700
ELAPSED TIME (MIN.)

FIGURE IV-7

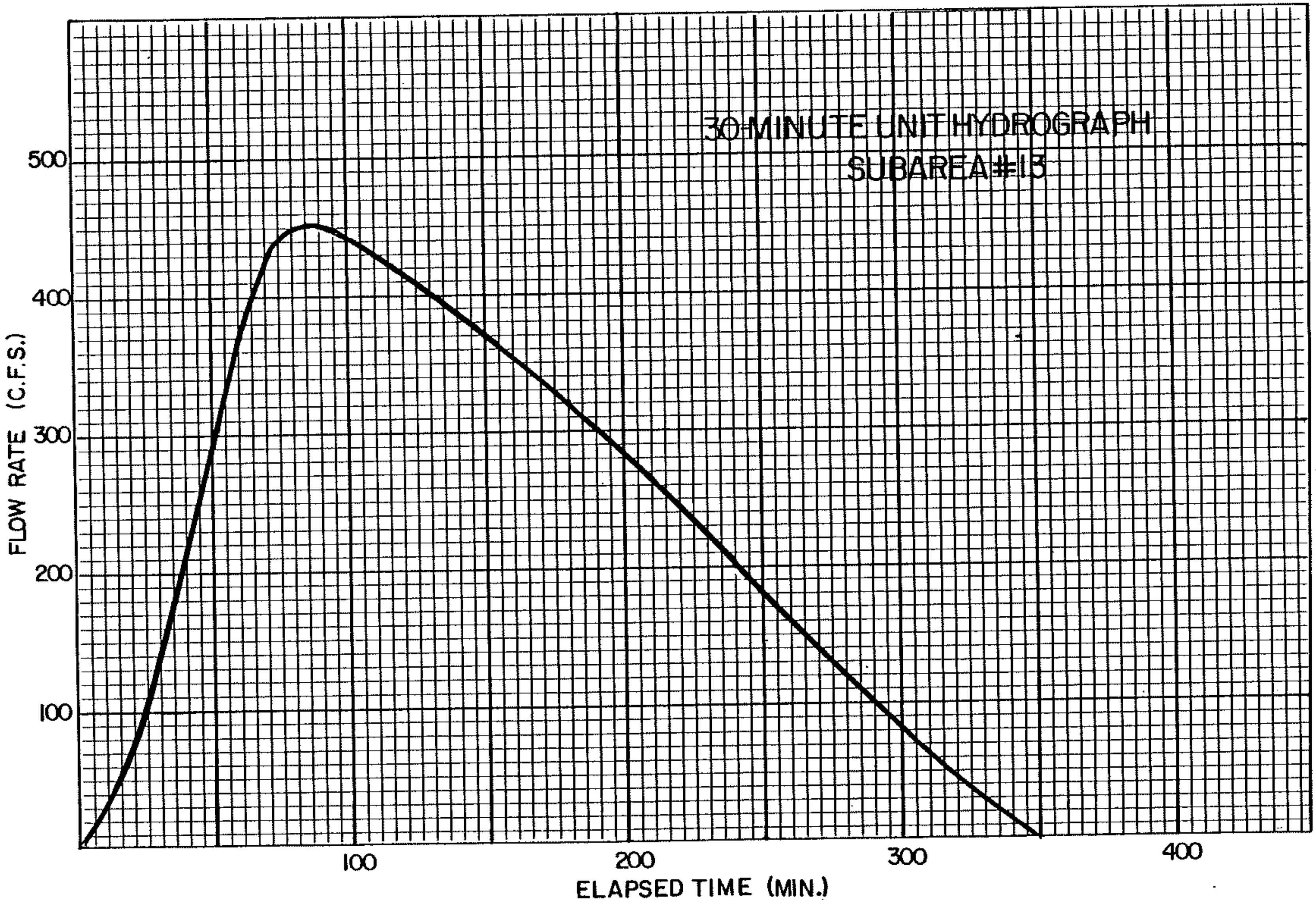
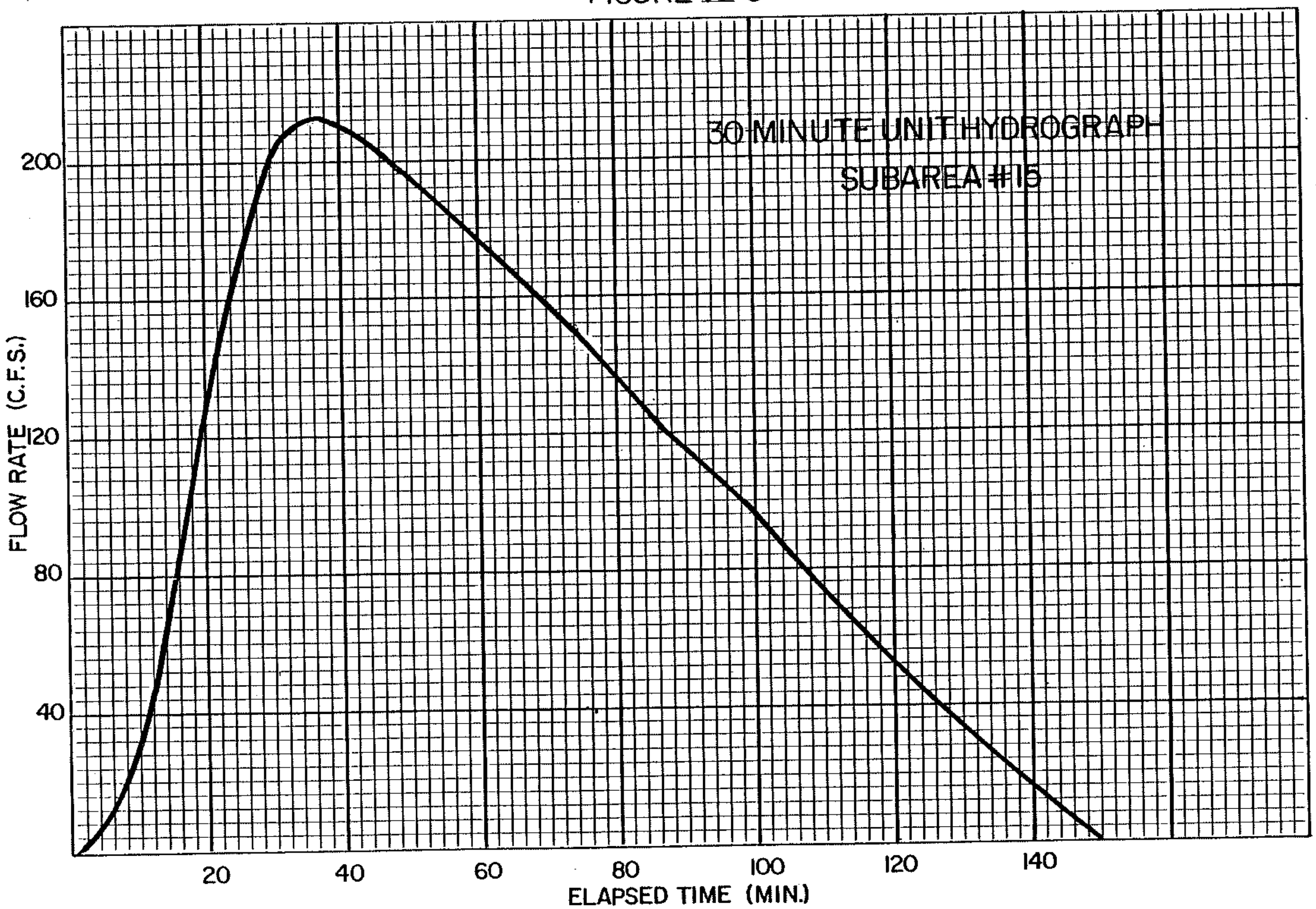

30-MINUTE UNIT HYDROGRAPH
SUBAREA #13
FLOW RATE (C.F.S.)
500
400
300
200
100
100
200
300
400
ELAPSED TIME (MIN.)

FIGURE IV-8


30 MINUTE UNIT HYDROGRAPH
SUBAREA #15
FLOW RATE (C.F.S.)
200
160
120
80
40
20
40
60
80
100
120
140
ELAPSED TIME (MIN.)

That curve number is consistent with values obtained for adjacent subareas in Delaware County using digitization of land characteristics data and is, therefore, appropriate for the land characteristics of the selected subareas in the lower end of Chester County.

The hydrographs computed for each design storm return period were used as direct input to the watershed model for both existing and future conditions. No assumptions could be made for future conditions in Chester County subareas, given the scope of this study. A critical assumption has been made that in accordance with Act 167, the peak flow rates leaving the Chester County portion of the Ridley Creek watershed will not be increased due to future development. To use the existing Chester County hydrographs in future conditions, it is also assumed that the shape of the hydrograph, especially the time to peak, does not change in the future.

In future developed conditions, the volume of runoff from Chester County subareas will certainly increase, thereby changing the hydrograph shape in some manner. A long, attenuated tail would likely have no effect on peak flows in Delaware County. What is of concern is that the time to peak not be decreased, allowing the peak flows from Chester County to catch up and combine with peak flow rates in the Delaware County portion of the watershed.

The standards and criteria developed for stormwater management alternatives in the Delaware County portion of the Ridley Creek watershed reflect the long, narrow configuration of the watershed and the timing with which the subarea contributions combine. If the peak flow rates from Chester County subareas are allowed to occur much more rapidly than at present, peak flow rates throughout the Delaware County portion of the watershed could be significantly affected.

Calibration

All simulation models involve a significant degree of subjective input in their development. Values are chosen for various hydrologic parameters describing the runoff characteristics of a watershed which represent average or expected behavior in watersheds of similar soils, slopes, etc. The specific hydrologic characteristics of an individual watershed are not necessarily reflected in such average values. Therefore, the model needs to be fine tuned, or "calibrated," to provide a more accurate representation of the real runoff and timing conditions of a watershed. Calibration of a model involves the adjustment of input parameters, within acceptable value ranges, to match the recorded response of an actual storm event. To match an event, antecedent moisture conditions and rainfall distribution must be duplicated in the model input. Adjustments to other parameters are then made to attempt to duplicate hydrograph shapes and peak flow rates at points in the watershed where recordings were made.

To calibrate the PSRM for the Ridley Creek watershed, the storm event of June 29, 1982, was used. As previously described, the resulting storm hydrograph was recorded by the project's technical consultant at the USGS stream gaging station at Dutton Mill and used to construct a dimensionless unit hydrograph for the Chester County portion of the watershed. A portion of the rising limb of the June 29, 1982, storm including the peak flow was also recorded at the USGS stream gaging station at the Manchester Road bridge on Ridley Creek in Moylan. Detailed information for rainfall depths and distribution were obtained from rain gages at Hershey's Mill Village in East Goshen Township, the Media Water Filtration Plant, and Philadelphia International Airport.

The storm of June 29, 1982, moved down the watershed, falling earlier and heavier in the upper portion of the watershed and occurring both later and in decreasing amounts in lower portions of the watershed. This pattern of rainfall was placed in the model and a run was made. The resulting peak flow at Moylan (694 cfs) was found to be very close to the recorded value (709 cfs), but it occurred at a far shorter time to peak (6.5 hours) than in the actual recorded event (9.5 hours). The time to peak appeared to be very dependent on the total of travel times along reaches of the main stem.

In the HEC-II output of the flood insurance studies for municipalities in Delaware County, travel times were noted to vary with flood events of differing return periods. Larger storms have correspondingly higher flow rates, depths, and velocities, resulting in decreasing travel times. The peak flow rate of the June 29, 1982, storm was roughly one-fourth that of the 10-year event reported in flood insurance studies at the Dutton Mill and Moylan gages. The travel time for this smaller event would be expected to be longer than the 10-year travel time. The travel times in the main stem stream reaches were increased by thirty percent over the 10-year travel times obtained from the HEC-II output. The resulting peak flow (721 cfs) was again very close to the recorded peak flow (709 cfs), and the time to peak (7.5 hours) closer to the recorded 9.5 hours. Figure IV-9 shows the recorded and computer hydrographs for the storm. The remaining error in total travel time was approximately twenty percent, while the error in peak flow remained within two percent. Further adjustments to travel times to better match the times to peak were considered unnecessary.

The adjustments in travel times required to calibrate to the June 29, 1982, storm in comparison with those obtained from the FEMA HEC-II output pointed out a need to use different travel times for respective storm frequencies. To verify the model, runs were made using as input the 10- and 100-year Type II rainfalls and the respective HEC-II travel times for comparison of peak flow rates from those simulations with values used in FEMA flood insurance studies at the County boundary, the Moylan gaging station, and the mouth of Ridley Creek. As shown in Table IV-2, the resulting peak flow rates agreed favorably with the flood insurance values.

FIGURE IV-9

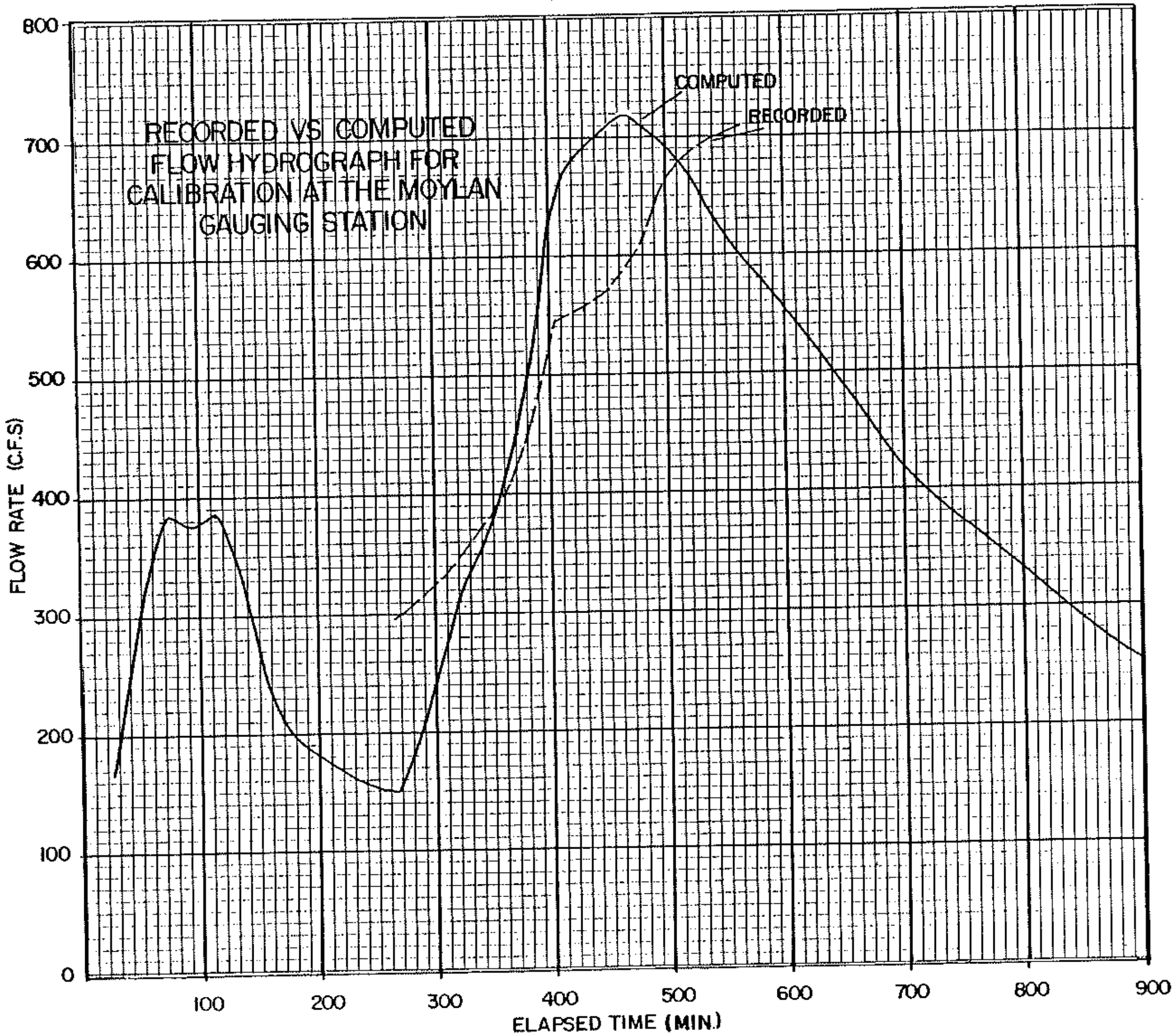

RECORDED VS COMPUTED
FLOW HYDROGRAPH FOR
CALIBRATION AT THE MOYLAN
GAUGING STATION
COMPUTED
RECORDED
FLOW RATE (C.F.S)
0
100
200
300
400
500
600
700
800
100
200
300
400
500
600
700
800
900
ELAPSED TIME (MIN.)

TABLE IV-2

PEAK FLOW RATES ALONG RIDLEY CREEK

Location	Penn State Runoff Model Simulation Results (cfs)		FEMA Flood Insurance Study Values (cfs)	
	10-year	100-year	10-year	100-year
Chester/Delaware County Boundary Line	3200	6023	2800	5800
Moylan Stream Gage	4005	7597	3000-3400[1]	7000-8800[1]
Mouth of Ridley Creek at Chester	4319	8156	3700-4150[1]	7900-9500[1]

1 Flow rates found to differ in flood insurance studies for several municipalities

Agreement with the flow rates in the flood insurance studies was felt to be acceptable for the model of existing conditions to be considered valid and compatible with Pennsylvania's Floodplain Management Program.

The compatibility with the flood insurance study peak flow values for similar design storms is a very important factor in this study. That is, by being compatible with the flood insurance studies, this watershed plan is consistent with existing floodplain management plans and zoning ordinances in the Delaware County portion of the Ridley Creek watershed.

Tidal Effects

An important factor affecting flooding potential for the City of Chester, the Borough of Eddystone, and the Townships of Ridley and Nether Providence are high tides from the Delaware Estuary. The tidal portion of Ridley Creek extends upstream from the mouth approximately two miles to Irving's Mill Dam, just downstream from the Route 320 bridge. Flooding in this area can result from fluvial flows (watershed runoff), high tides, or a combination of the two events. A recently completed study by the U.S. Army Corps of Engineers examined the impacts of those three flooding cases on Ridley Creek from the mouth up to the Route 320 bridge, above which tidal effects are considered negligible (U.S. Army COE, 1982[10]).

10 U.S. Department of the Army, Corps of Engineers, "Local Flood Problem Investigation, Ridley Creek, City of Chester, Delaware County, Pennsylvania," Draft Reconnaissance Report, Philadelphia District, Philadelphia, Pennsylvania, June, 1982.

TABLE IV-4

EXISTING AND FUTURE SUBAREA CHARACTERISTICS

Subarea No.	Area (Acs.)	Existing Land Cover % Impervious	Existing Land Cover Curve No.	Future Land Cover % Impervious	Future Land Cover Curve No.
3	312	4	65	8	64
4	208	1	65	7	62
5	150	1	71	8	66
6	217	3	64	8	62
7	105	0	61	8	63
8	46	4	64	9	64
9	242	1	65	7	66
11	219	1	68	6	64
12	233	3	72	7	65
14	56	33	67	33	67
16	193	15	63	25	64
17	63	10	62	10	62
18	50	0	67	15	63
19	77	0	61	6	64
20	397	0	61	0	61
21	594	0	65	4	65
22	235	0	61	0	61
23	184	1	62	6	59
24	125	3	60	3	60
25	105	0	60	2	60
26	541	0	58	0	58
27	393	3	60	3	61
28	59	8	59	9	60
29	284	0	57	0	57
30	97	13	62	17	63
31	262	9	61	13	62
32	227	0	59	1	59
33	79	0	59	0	59
34	238	11	68	11	68
35	204	2	64	4	64
36	226	17	62	17	63
37	96	12	62	14	63
38	254	8	63	13	64
39	257	7	68	14	67
40	261	10	62	12	62
41	148	12	62	16	63
42	402	8	61	11	62
43	352	25	65	25	66
44	80	33	62	33	62
45	308	12	63	12	63
46	0	0	62	0	62
47	332	24	65	24	65
48	145	44	66	44	66
49	151	31	62	31	63
50	207	14	66	14	66
51	226	10	61	10	62
52	131	29	62	31	60
53	240	18	62	19	62
54	446	12	61	12	61
55	140	25	67	38	67
56	475	18	68	19	68
57	189	26	68	26	68
58	191	36	65	37	65
59	188	18	73	19	73
60	387	30	71	30	71
61	0	0	62	0	62
62	497	19	67	19	67
63	165	23	71	24	71
64	416	34	67	35	67
65	401	59	62	62	62

TABLE IV-5

PEAK FLOW RATES AT SELECTED POINTS OF INTEREST

FUTURE CONDITIONS

Point of Interest[1]	Peak Flow in Cubic Feet Per Second Q2	Q10	Q25	Q100	Comment/Capacity
9	242	621	918	1421	Mouth of Stackhouse Mill Run
12	726	2636	3479	4990	Main stem flows below Stackhouse Mill Run
14	870	3172	4150	5976	Flow rate at County line
20	907	3356	4356	6271	State park boundary
21	925	3424	4449	6410	Gradyville Rd. bridge/ 4856 cfs
26	157	191	270	483	Mouth of unnamed tributary
27	957	3560	4626	6691	State park boundary - bridge at Sycamore Mills/unknown
33	209	332	467	754	Mouth of Dismal Run
40	154	278	395	611	Mouth of Spring Run
41	1027	3819	4981	7204	Rose Tree Rd. bridge/ unknown
46	1059	3920	5123	7410	Media Water Filtration Plant - Baltimore Pike bridge/14,860 cfs
50	1084	3989	5219	7534	USGS stream gage at Moylan - Manchester Rd. bridge/10,271 cfs
53	257	417	529	756	Mouth of Vernon Run
56	1130	4105	5527	7757	Brookhaven Road bridge/8763 cfs
62	1273	4224	6022	7963	Route 320 bridge/not applicable
65	1466	4301	6229	8095	Mouth of Ridley Creek

1 Number of subarea outlet where peak flow was computed

is slightly magnified in future conditions by the increased runoff from development in that area. While the total volume of runoff in the future conditions hydrograph is greater than that in the hydrograph for existing conditions, the hydrograph has been "stretched out," pulling the peak flows down as a result of the timing of subarea contributions in their fully developed state. Runoff from developed sites collects and runs off more quickly than prior to development. In the Ridley Creek watershed, the contributions of fully developed subareas below Ridley Creek State Park move quickly downstream. The state park remained undeveloped for the analysis of future conditions, providing a reduction in peak flows for a short time. Much of the runoff from fully developed subareas in Edgmont Township races ahead of the peak contributions from Chester County, thereby avoiding the combination of the hydrographs that would result in higher peak flow rates.

Again, it should be noted that the hydrographs from Chester County subareas were not changed to reflect any future land development conditions. If runoff from Chester County subareas is allowed to accelerate and catch up with higher flows from the upper Delaware County subareas, peak flows could increase along the main stem of Ridley Creek in Delaware County. A detailed study of runoff from future development in the Chester County portion of the watershed should address the likelihood of such an impact. Any watershed planning efforts in the Chester County portion of the Ridley Creek watershed should be coordinated with the Delaware County portion in order to update the "total" watershed stormwater management plan.

Impact of Future Development without Stormwater Management

The fact that peak flows do not increase on the main stem of Ridley Creek does not obviate the need for control of increased stormwater runoff from developing sites. As was noted from the survey of existing stormwater related problems, the majority of such problems occur off the main stem along the numerous small tributaries and existing drainage systems. Table IV-6 lists the peak flow rates of runoff from each individual subarea for both existing and future land development conditions. These flow rates represent the surface runoff resulting solely from each subarea. Table IV-7 lists the total peak flow rates at each subarea outlet. Those flow rates represent the peak rates resulting from the combination of respective subarea runoff hydrographs with the contributions from upstream subareas. Higher peak flow rates will occur due to future development in most subareas and at many points along the small tributaries, but the combined flow rates in the main stem of Ridley Creek and at other points along its tributaries in Delaware County will be lower for projected future land development conditions.

The results of modeling existing and future conditions clearly demonstrate the need for proper management of stormwater in the Ridley Creek watershed. Control of increased runoff is necessary to protect property along tributaries and drainageways between developing sites and the main stem of Ridley Creek. Once in the main stem, the timing and configuration of the watershed is such that no net increase in peak flow occurs due to the increased volume of runoff.

TABLE IV-6

SUBAREA PEAK RUNOFF FLOW RATES

Subarea No.	Existing Conditions Q_{100}[1]	Q_{25}	Q_{10}	Q_2	Future Conditions Q_{100}	Q_{25}	Q_{10}	Q_2
1	386	274	204	73	386	274	204	73
2	301	213	158	54	301	213	158	54
3	212	122	81	37	255	161	116	59
4	139	69	40	21	137	78	55	44
5	168	90	54	14	165	100	69	34
6	196	105	68	35	220	135	99	60
7	57	31	19	16	103	63	46	26
8	39	22	15	7	49	30	22	11
9	150	69	49	19	226	138	96	47
10	4396	3088	2284	649	4396	3088	2284	649
11	310	161	93	27	277	156	105	58
12	202	116	73	24	177	111	80	40
13	1047	733	543	174	1047	733	543	174
14	144	101	79	44	144	101	79	44
15	400	283	211	67	400	283	211	67
16	304	195	146	88	399	274	212	121
17	88	53	39	29	88	53	39	29
18	53	26	16	4	71	47	35	20
19	86	40	35	36	129	70	45	30
20	153	79	48	32	153	79	48	32
21	500	253	155	64	604	272	217	103
22	140	75	47	42	140	75	47	42
23	154	77	49	43	164	101	79	51
24	94	53	38	39	94	53	38	39
25	39	20	12	11	43	24	17	14
26	184	95	60	44	179	95	60	44
27	297	166	118	123	318	174	121	101
28	53	34	27	17	59	37	29	22
29	136	81	49	57	136	81	49	57
30	137	86	65	40	160	104	78	45
31	283	177	134	94	345	224	170	106
32	114	62	42	26	120	65	47	31
33	35	19	12	7	35	19	12	7
34	353	218	153	70	353	218	153	70
35	159	84	53	27	177	99	66	33
36	394	253	192	127	412	261	195	121
37	124	78	59	35	138	88	66	37
38	349	201	140	98	422	259	186	105
39	246	149	102	44	311	207	153	76
41	137	93	71	39	168	116	90	50
42	311	202	153	87	380	253	195	111
43	750	507	287	214	774	521	394	215
44	205	143	113	77	205	143	113	77
45	377	242	181	102	377	242	181	102
46	--	--	--	--	--	--	--	--
47	627	434	337	189	627	434	337	189
48	352	262	209	115	352	262	209	115
49	389	264	207	145	402	271	209	140
50	385	237	167	86	385	237	167	86
51	252	160	121	80	264	165	123	76
52	273	193	154	91	272	198	161	99
53	527	352	272	157	542	365	283	164
54	436	293	228	130	436	293	228	130
55	279	190	145	76	352	254	201	110
56	823	536	395	194	842	552	409	203
57	408	281	215	115	408	281	215	115
58	355	261	206	111	363	267	211	114
59	457	299	212	90	464	305	217	94
60	832	585	446	227	832	585	446	227
61	--	--	--	--	--	--	--	--
62	909	601	447	231	909	601	447	231
63	343	230	171	83	349	236	176	86
64	868	627	491	263	885	641	503	270
65	1170	899	730	412	1220	940	502	432

[1] All flows in cubic feet per second

considered. This is partially due to the nature of flow combinations in the watershed, i.e., the manner in which storm runoff from the individual subareas combines as it moves through the watershed.

- In the main channel of Ridley Creek, peak runoff rates were found to be slightly lower for the 10- through 100-year design storm events, considering future development conditions, as a result of the following flow-timing variations:

  a. The time of concentration (T_c) for each subarea is reduced due to increased impervious cover and hydraulic improvements in future development conditions. Therefore, peak runoff flows from developed subareas in the lower portion of the watershed enter the main drainage channel (i.e., Ridley Creek) prior to the arrival of peak flows from upper watershed areas (i.e., the flows from the Chester County portion of the Ridley Creek watershed). This is an extremely important condition to recognize, in that it illustrates a key stormwater management consideration for the Ridley Creek watershed. That is, it shows that if storm runoff flow from the Chester County portion of the watershed is allowed to speed up (i.e., to flow from land development sites without being properly controlled with respect to both flow rate and flow timing), a critical storm flooding condition could be caused in the Delaware County portion of the watershed.

  b. The future development trends logically predict no increase in impervious area throughout Ridley Creek State Park. However, the areas immediately north and south of the park are predicted to be subject to major development. This condition serves to further separate the upper and lower watershed peaks, enhancing the dual-peak configuration of the total watershed hydrograph.

  c. Future simulation conditions assumed that the shape of the hydrograph from Chester County would be the same as that utilized for existing condition simulation runs. However, when the times of concentration were reduced for those subareas in the upper watershed region of Delaware County (i.e., those subareas in Delaware County upstream of Ridley Creek State Park), the runoff combinations for future land development conditions were significantly altered. The peak flow rates were higher and occurred earlier in the storm event. Stormwater management provisions have, therefore, been included in the Delaware County Stormwater Management Plan to address this condition.

- Higher storm runoff peaks may be realized along the main branch of Ridley Creek if peak flows from the Chester County portion of the watershed are higher or if they occur earlier than at present in future developed conditions. On a watershed basis, increased stormwater runoff from developing areas in the Chester County portion of the Ridley Creek watershed needs to be managed in a manner which maintains the peak flow rates and timing of existing runoff hydrographs at the boundary of Chester and Delaware Counties. This is particularly true of the rising limb portion of the Chester County hydrographs.

Additional Uses of the Ridley Creek Watershed Model

A calibrated watershed model is a very useful "tool" for effectively managing water resources in a watershed. The calibrated PSRM for the Ridley Creek watershed can now allow for the following types of evaluations to be made which can serve as direct input into a potential water resources decision-making process.

- Flood Insurance Study Updates

  A key element of a flood insurance study is the hydrologic analysis that defines the flood flows for various sections of a stream or river. These flood flows, along with the size and shape of the stream or river, then define the "floodplain" for the flood insurance study. These floodplains are typically accepted by a municipality as "flood hazard areas" for purposes of zoning and management activities. One of the main shortcomings of some of the flood insurance studies is the fact that they were typically done for each community separately and were not fully coordinated in many instances. The resulting problem associated with this, in many cases, is that the various flood insurance study results are not consistent throughout a watershed. In some instances, flood flow and depth information do not match at adjoining municipal boundaries.

  A calibrated watershed model, as an example, the PSRM for the Ridley Creek watershed, can be used to supply consistent storm (or flood) flow information throughout a watershed for purposes of updating the existing floodplain boundaries in the various communities. This may be required for an official flood insurance study update (for the U.S. Army Corps of Engineers or the Federal Emergency Management Agency) or may be desired for an update of floodplain information by a particular municipality. In either case, the availability of the model allows for the cost-effective updating of this important municipal planning data.

- Encroachment Analyses

  In this case, the calibrated watershed model can be used by land developers or municipalities to calculate or check the impacts that a stream encroachment may have. Typically, when a stream encroachment application is made, the applicant (either a land developer or a municipality) must perform a hydraulic analysis to define the impacts that the encroachment will have on nearby properties. This involves a hydrologic and hydraulic analysis that could be extremely expensive for the applicant. The availability of calibrated information can, therefore, significantly cut the cost of making a stream encroachment application.

o Infiltration Analyses

The infiltration information that was developed for this study has shown that groundwater recharge in the Ridley Creek watershed is a critical element of the overall water resources system. A "benchmark" evaluation of infiltration characteristics in the watershed was performed for this pilot study. This initial evaluation identified the infiltration potential for the land use characteristics that were evaluated for this project. An update of this study, which would involve a new run of the watershed model to reflect new (updated) land use conditions, could then be used to reevaluate the change in infiltration potential resulting from a given amount of increased urbanization. This tool can, therefore, serve as a guide for future decision making concerning groundwater recharge and/or infiltration strategies for water resources protection in the watershed.

o Drainage Design

The calibrated watershed model can also be used to provide design level data for:

- Highway design by counties or PennDOT
- Verification of stormwater management plans for use by municipal engineers
- Storm runoff characteristics data for use by land developers in the development of stormwater management plans

CHAPTER V

STORMWATER MANAGEMENT TECHNIQUES

Underlying the goals and objectives of a comprehensive program of stormwater management are the following basic principles:

- The drainage system is a part of a larger environmental system

  Surface streams within an urban watershed can be managed solely as a drainage system or they can be managed so as to provide a broad range of benefits (e.g., water supply, recreation, aesthetic value, etc.). The influence of any new development or land use change should be analyzed, and the potential for adverse impacts on the beneficial uses should be minimized.

- Floodplains are natural storage areas

  All surface water streams have associated with them a prescribed natural easement, defined as the stream's floodplain. This area functions as a facility for the conveyance or storage of excess stormwater runoff. The act of encroaching on, or altering, the hydraulic and hydrologic characteristics of the land draining to the natural easement requires the implementation of compensating control/management measures to maintain effective operation of the natural easement.

- Stormwater requires space

  New development reduces the "space" within a watershed that is naturally allotted for stormwater runoff storage. If "artificial space" is not provided in coordination with the new development, alternate space will be claimed further downstream within the watershed.

- Stormwater has potential uses

  The "forgotten resource," stormwater, appreciates in value as existing water resources are contaminated or can no longer meet consumptive demands. The initial element of a program designed to develop this resource is storage areas from which the runoff can be withdrawn and conveyed to recharge areas. In addition, these storage areas may provide recreational opportunities.

- o Water pollution control measures are essential

  In order to derive the full potential available from streams, as well as from natural and artificial wetland areas, both point and non-point sources of pollution must be controlled.

- o Comprehensive planning and preventive measures are less costly

  Planning for the future results in lower costs to taxpayers than implementation of corrective measures.

Utilizing these principles to achieve the stormwater management goals defined for the Delaware County portion of the Ridley Creek watershed, applicable structural and non-structural stormwater management techniques were evaluated. Structural methods are those that rely on physical facilities that are designed and constructed for the purpose of controlling stormwater flows. Thus, any man-made structure or device with the intended function being to divert, detain, recycle, infiltrate, or in any way attenuate the flow of stormwater runoff is a structural control technique. Structural control techniques can be designed to achieve almost any function. The major constraints are usually cost and the physical limitations of the site.

Non-structural control techniques may be broadly classified as either floodplain management or comprehensive watershed management planning. Floodplain management is the control of land use and development within natural drainage easements or floodplains in order to minimize the potential for flood damage. Comprehensive watershed management provides for the effective coordination of development pressure, preservation of open land, and the optimization of structural stormwater techniques.

Non-Structural Stormwater Management Techniques

The actual development of this Act 167 pilot stormwater management plan for the Delaware County portion of the Ridley Creek watershed is a "first-level," non-structural stormwater management technique. The pilot study provides the framework for the development of stormwater management ordinance provisions appropriate for municipalities within the Delaware County portion of the watershed. These provisions reflect not only technical aspects, but they also define authority and responsibility and establish methods for efficient administration of stormwater management procedures. This section presents the technical evaluation of non-structural control techniques to determine if, and in what form, they are applicable for stormwater management in the Delaware County portion of the Ridley Creek watershed.

The Release Rate Percentage Concept

The use of detention facilities to control the discharge from a development site has become an accepted practice of land developers and engineers. These detention facilities are commonly designed as either a) dry basins, except during significant (2-, 10-year, etc.) rainfall events, b) wet ponds, with sufficient freeboard to provide the required storage volume during significant rainfall events, or c) underground storage tanks where land area is not available.

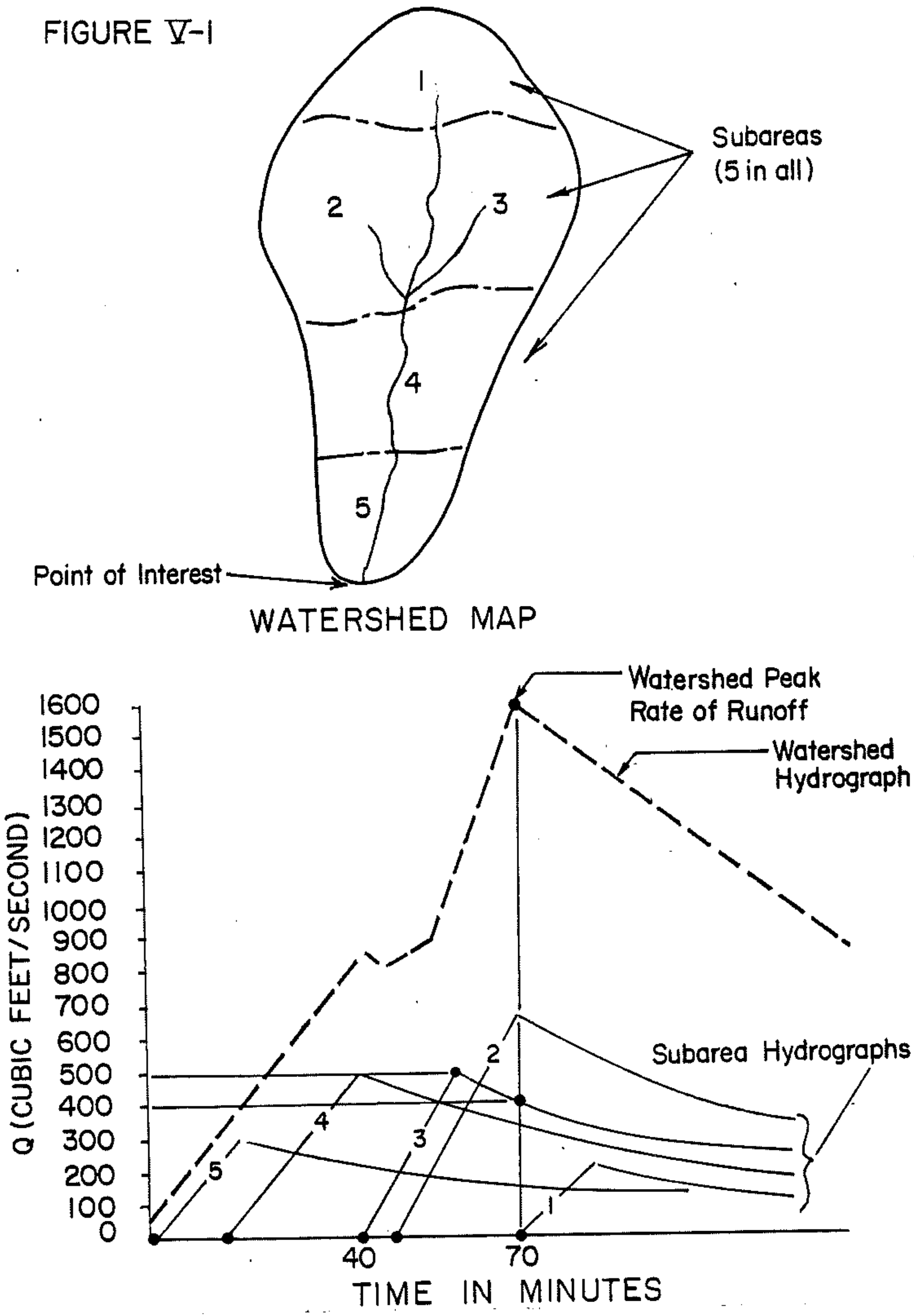
For new development sites, the most common design criterion for these facilities is control of the peak discharge rate generated by the 100-year rainfall event in a post-development land use condition to the same peak discharge rate that was generated by the same 100-year rainfall event in a pre-development land use condition. However, recent research and urban watershed simulation studies have documented the potential for an increase in peak stormwater runoff rates at downstream locations when storm runoff flows from two or more branching tributary areas combine even if stormwater runoff detention control facilities are being used. Unless the detention facility is designed with consideration for the dynamic interaction and combination of sub-drainage areas (subareas) within a watershed, these flow combinations may occur. The following example illustrates why this is so.

A sample watershed, with five subareas, is shown on Figure V-1. The figure also includes a hydrograph generated by a rainfall event on the watershed, which presents the individual hydrographs for each subarea and the cumulative rate of runoff for the total watershed. The watershed hydrograph was developed in the same manner as was described for the water tanks (Figure I-6) in Chapter I.

To further illustrate the development of the watershed hydrograph, Figure V-2 isolates the runoff from Subarea 3. As can be seen from Figure V-2, the travel time for runoff flow from Subarea 3 through Subarea Nos. 4 and 5 is 40 minutes. This represents the time at which Subarea 3 begins contributing flow to the downstream point of interest, which in this example is the outlet point of the watershed. Subarea 3's maximum discharge of 500 cfs arrives at the outlet point 60 minutes into the storm event, and the contributing rate to the watershed peak is 400 cfs, occurring at 70 minutes.

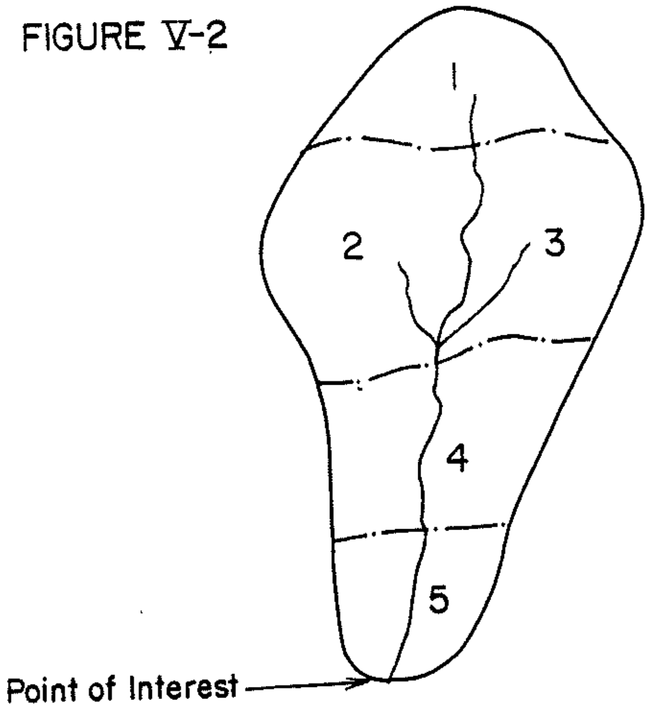
For purposes of this example, it is assumed that a new land modification or development project is proposed for the entire portion of Subarea 3 in the watershed, which increases Subarea 3's maximum discharge rate to 800 cfs (Figure V-3). After utilizing appropriate stormwater management techniques, the peak discharge rate is reduced to the pre-development peak discharge rate of 500 cfs. However, because of the attenuation of the runoff hydrograph from Subarea 3, which extends the time period during which the discharge rate is approximately 500 cfs, the combined runoff discharge peak at the point of interest is still above the pre-development peak rate of runoff at that potentially critical downstream point. Therefore, although the development design may appear to be in compliance with Act 167, the <u>actual</u> impact of the stormwater management facility in the watershed <u>is</u> to increase the peak rate of runoff at the downstream point of interest.

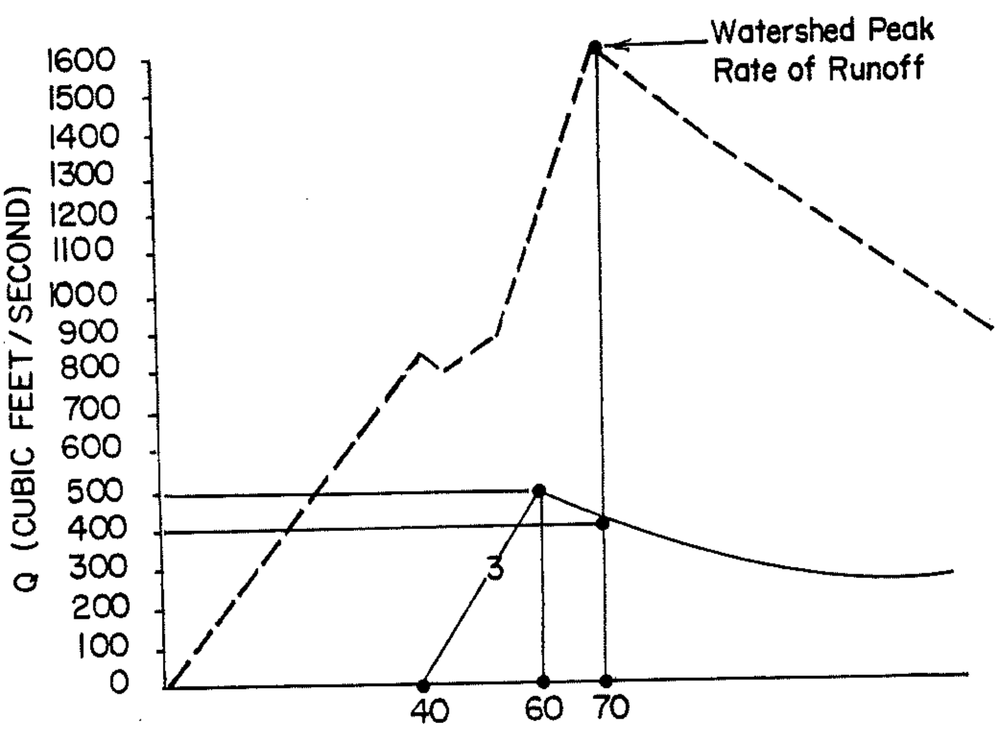
FIGURE V-1



WATERSHED AND SUBAREA HYDROGRAPHS

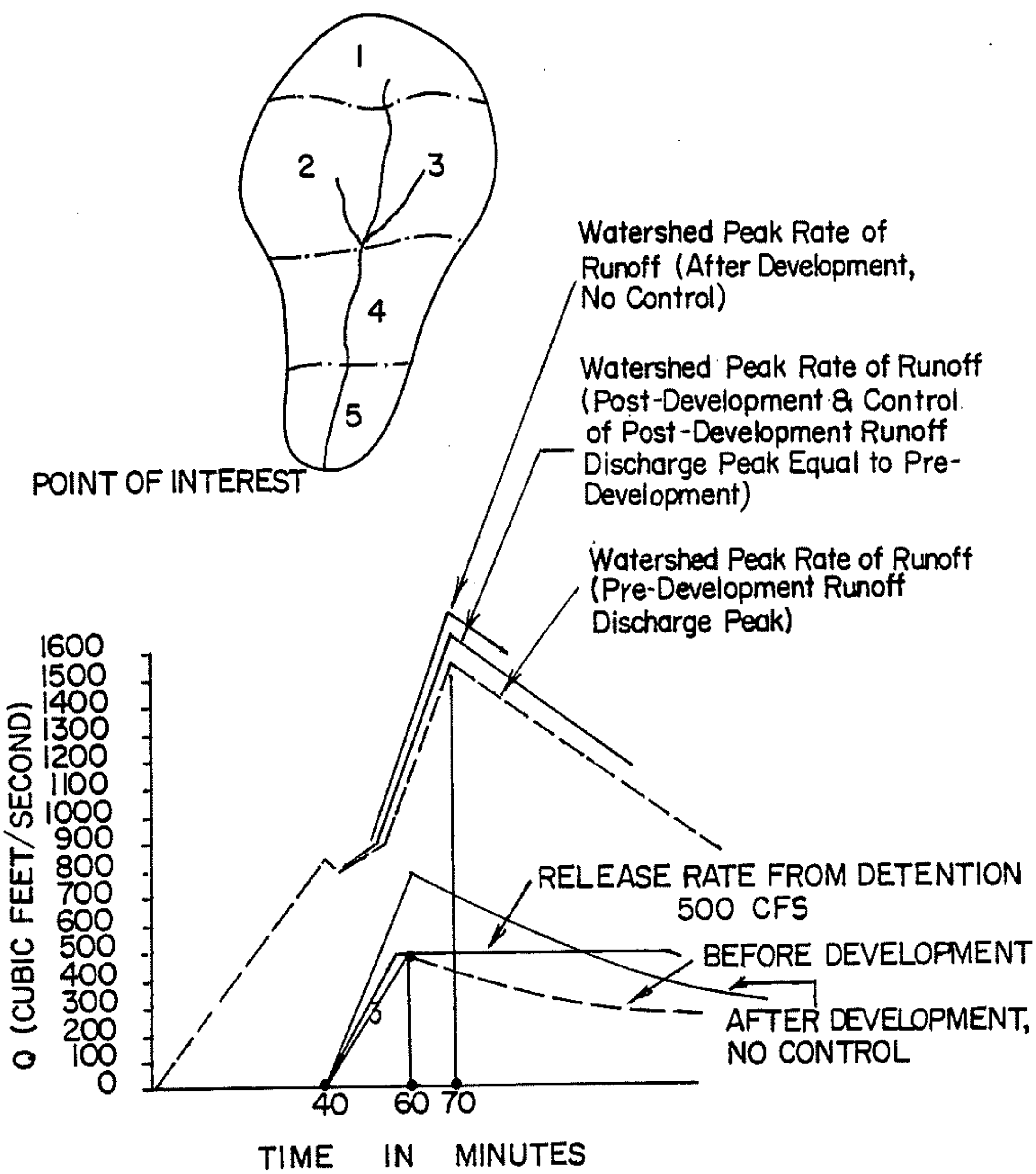
FIGURE V-2





WATERSHED AND SUBAREA HYDROGRAPHS

FIGURE V-3



WATERSHED HYDROGRAPH

The impact of a stormwater management facility designed to reduce the subarea post-development peak rate of runoff to the peak rate of runoff associated with the subarea's pre-development land condition will not be the same for all contributory subareas as was defined specifically for Subarea 3. For example, Subarea Nos. 1 and 2 generate peak rates of runoff which arrive at the point of interest at the exact time of watershed peak runoff rate occurrence or after the occurrence of the watershed peak runoff rate. Therefore, attenuation of the pre-development peak rate of runoff would not increase the peak flow rate at the watershed outlet.

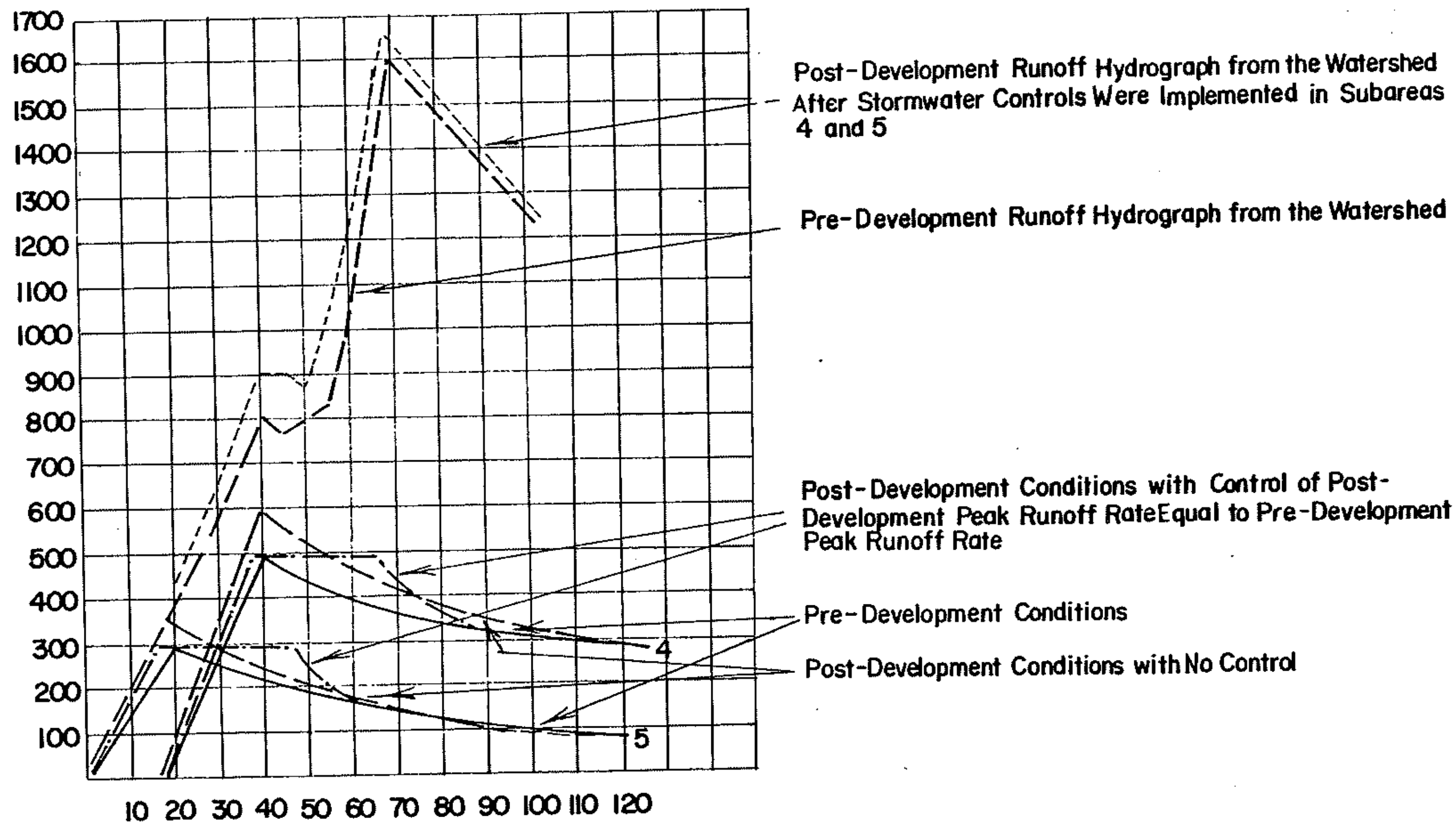
A more complex situation is created if development is proposed for Subarea Nos. 4 or 5. Figure V-4 illustrates the results of considering that a proposed development site is located in Subarea 5 which increased the peak subarea rate of runoff by 50 cfs. Also shown is the case where a potential development site is located in Subarea 4, which increases the peak subarea rate of runoff by 100 cfs. Appropriate stormwater management techniques are implemented in both development areas to reduce the post-development peak runoff rate to the pre-development peak runoff rate. Close observation of Figure V-4 indicates that the stormwater management techniques implemented in Subarea 5 have no adverse impact at the outlet from the watershed (or point of interest). However, the stormwater management techniques implemented in Subarea 4 will generate an increase in the peak rate of runoff at the watershed outlet.

In summary, the peak runoff rates from Subarea Nos. 3 and 4 with pre-development land conditions arrive at the watershed outlet (or point of interest) within a 30-minute time period prior to the occurrence of the watershed runoff peak. The peak runoff rates from Subarea Nos. 1, 2, and 5 arrive at the watershed outlet either before this 30-minute time period (Subarea Nos. 1 and 2) or at a time concurrent with the occurrence of the watershed peak runoff rate (Subarea 5).

As was illustrated, development may occur in Subarea Nos. 3 or 4 which will result in a higher peak runoff rate from either subarea during a rainfall event. The use of stormwater management techniques to reduce the post-development peak runoff rate from the subarea to the pre-development peak runoff rate may increase the peak runoff rate at the watershed outlet. However, comparable alterations to Subarea Nos. 1, 2, and 5 should not increase the watershed peak runoff rate.

During the 30-minute period of time prior to the occurrence of the watershed peak runoff rate, the projected post-development peak runoff rates from Subarea Nos. 3 and 4, if attenuated by the use of stormwater management techniques designed to lower subarea post-development peak runoff rates to the subarea pre-development peak runoff rates, will result in an increase of the peak runoff rate at the watershed outlet. This same condition will occur in most watersheds. However, the duration of this sensitive time period prior to occurrence of the watershed peak runoff rate will vary for each watershed de-

FIGURE V-4 WATERSHED IMPACT WITH CONTROL OF POST-DEVELOPMENT PEAK EQUAL TO PRE-DEVELOPMENT PEAK IN SUBAREAS 4 AND 5



pending on its shape, size, slope, terrain, current land use, and projected development trends.

The release rate percentage was developed as a potential method for managing the stormwater runoff rates from subareas within a watershed having runoff timing impacts similar to Subarea Nos. 3 and 4 illustrated in the example. A safe release rate for Subarea 3 is determined by computing the ratio of the subarea rate of runoff that is contributing to the peak at the downstream point of interest to the pre-development peak rate of runoff for the subarea itself.

$$\frac{\text{subarea contributing rate}}{\text{subarea pre-development peak rate of runoff}} = \text{release rate percentage}$$

$$\frac{400 \text{ cfs}}{500 \text{ cfs}} \times 100\% = 80 \text{ percent}$$

The effect of designing the stormwater management facility based on the release rate percentage is shown on Figure V-5.

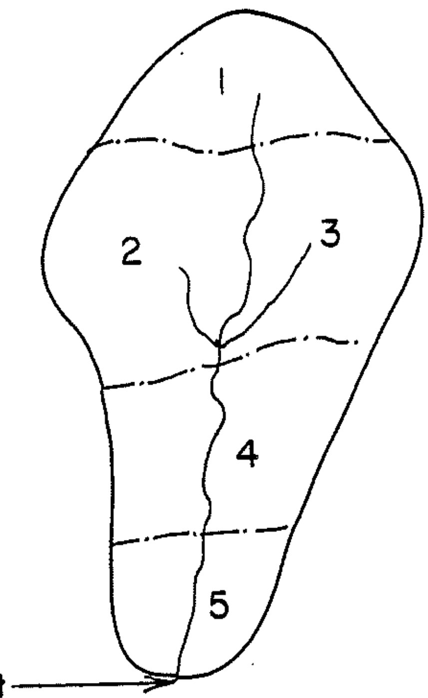
Application of the Release Rate Percentage Concept

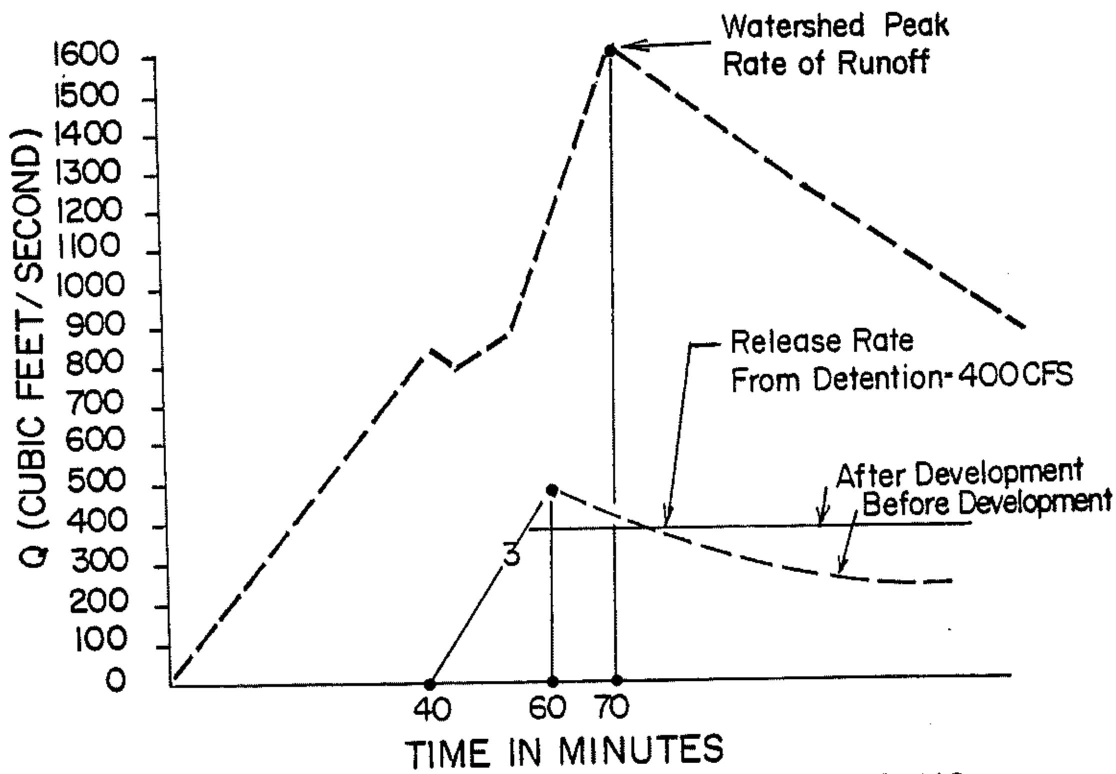
The release rate percentage concept has been developed to satisfy the stormwater management objectives of Act 167 for watershed-level stormwater management plans. Specific requirements of the Pennsylvania Stormwater Management Act (Act 167) include an assessment of projected and alternative land development patterns in the watershed, the potential impact of development patterns on runoff quantity, and the assurance that the maximum rate of stormwater runoff is no greater after development than prior to development activities.

Future land use conditions for the simulation of stormwater runoff quantity and flow rates in this study were based on the zoning maps of the respective municipalities within the Delaware County portion of the watershed. However, this potential land use condition will not occur simultaneously within the watershed. Only a few isolated areas may, in fact, be affected by land use alteration during the next three to five years. Therefore, the release rate percentage concept was developed to control stormwater runoff rates as they would be impacted by sporadic land use alteration.

As illustrated in the previous example, only one area of the hypothetical watershed was initially influenced by development. If all of the subareas within the hypothetical watershed were developing uniformly over the exact same time period, the application of the release rate percentage concept would yield overly conservative results at the downstream point of interest. That is, the peak runoff rate at the point of interest would be below that which would be generated when evaluating existing conditions. However, when only one subarea develops with no land use change in the other subareas, the application of the release rate percentage is required to control

Figure V-5





WATERSHED AND SUBAREA HYDROGRAPHS

an anticipated increase in the peak runoff rate at the downstream point of interest.

In order to illustrate not only this potential for conservatism but also the actual process of developing release rate percentages in the Delaware County portion of the Ridley Creek watershed, the procedure that was used for analyzing the Stackhouse Mill Run tributary area will be described. Stackhouse Mill Run begins just northwest of the Chester/Delaware County line near Tanguy. The confluence of Stackhouse Mill Run with Ridley Creek is near the Chester/Delaware County line, midway between West Chester Pike and Stackhouse Mill Road, near Willistown. The area draining to Stackhouse Mill Run was divided into nine subareas, which are the first nine subareas shown on the Ridley Creek watershed map (see Plate No. 2).

Table V-1 lists the peak runoff rates that would be generated by the 25-year rainfall event (the maximum design rainfall event for this watershed) from each subarea, for both present and future land use conditions.

TABLE V-1

PEAK RUNOFF RATES FROM SUBAREA
NOS. 1 THROUGH 9
(25-Year Rainfall Event)

Subarea No.	Existing Land Use Conditions Peak Runoff Rate (cfs)	Future Land Use Conditions Peak Runoff Rate (cfs)
1	274	274
2	213	213
3	122	161
4	69	78
5	91	100
6	106	135
7	31	64
8	22	31
9	69	138

Current stormwater management design practices would be based on reducing the post-development peak runoff rate to the pre-development peak runoff rate in each subarea. However, as was shown in the previous hypothetical illustration, only certain subareas will develop within the next three to five years, as opposed to the complete build-out as simulated. The hypothetical illustration (Figures V-1 through V-5) showed the impact of this staged development, along with the results of designing stormwater management facilities to reduce the post-development peak runoff rate to the pre-development peak runoff rate. An adverse impact is observed at the downstream point of interest, i.e., the peak runoff rate for this point of interest (Subarea 5 in the hypothetical example) remains above the pre-development peak runoff rate.

The primary element of the release rate percentage concept is selection of the points of interest in the watershed. The overriding justification for the selection of points of interest is the desire to provide overall watershed storm runoff management through effective control of individual subarea storm runoff. Overall comprehensive control of storm runoff for the Ridley Creek watershed in Delaware County can be achieved if each individual tributary or branch of the major drainage system is controlled. Therefore, primary points of interest for this study were established at the confluence points of tributaries and branches of the main stream within this watershed.

Release rate percentages for the subareas draining to Stackhouse Mill Run (i.e., Subarea Nos. 1 through 9) were determined by reviewing the Peak Flow Presentation Table (Table V-2) for the selected point of interest. The point of interest for Stackhouse Mill Run is the outlet of Subarea 9, or the confluence point of Stackhouse Mill Run with Ridley Creek. The Peak Flow Presentation Table is a direct output of PSRM and is described in the PSRM User's Manual.[11]

On Table V-2, the peak rate of runoff for Stackhouse Mill Run at the confluence with Ridley Creek (i.e., 874.8 cfs) occurs at a time of 360 minutes after the beginning of the design rainfall event. Listed directly above this value in the Peak Flow Presentation Table are the individual subarea contributions that are arriving at the point of interest during the 360-minute time interval after the beginning of the rainfall event. Table V-3 lists these contributory flow rates, along with the peak runoff rate generated from each individual subarea for existing land use conditions. The ratio of the contributory flow rate to the individual peak runoff rate generated from each subarea is used to develop the resultant release rate percentage for the subarea.

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11 Lakatos and Aron, loc. cit.

TABLE V-2

PEAK FLOW PRESENTATION TABLE

*** SUBWATERSHED CONTRIBUTIONS TO PEAK FLOWS AT INLET NO. 9[3] ***

SUBWATERSHED ID[1]	TT[2]	FLOWS ARRIVING AT SPECIFIED TIME: 285	300	315	330	345	360	375	390	405[4]	420	435	450	465	480	495
1	53.2	4.8	7.7	12.3[6]	73.5	202.9	255.0	213.0	159.6	92.6	51.5	41.5	34.2	30.2	26.6	23.
2	37.3	6.5	10.2	63.8	164.3	200.7	176.2	141.9	98.4	66.2	45.2	32.9	28.4	24.5	20.9	18.
3	31.6	16.9	15.8	50.9	114.5	106.4	103.8	97.0	92.5	86.9	82.5	77.4	73.1	68.1	63.7	60.
4	31.6	8.1	5.9	17.9	63.8	61.6	56.9	47.8	41.2	35.2	31.0	27.1	24.2	21.2	19.0	17.
5	18.6	4.2	23.3	75.8	87.9	85.7	78.4	71.0	63.8	57.7	52.0	47.3	42.6	38.6	35.3	32.
6	22.1	16.4	30.0	76.2	98.0	90.5	84.7	76.6	69.7	63.2	57.6	52.4	47.6	43.2	39.6	36.
7	22.1	11.1	9.2	18.3	27.9	29.8	29.8	28.4	26.7	25.0	23.4	21.7	20.1	18.6	17.3	16.
8	18.6	3.3	8.4	19.1	19.2	18.0	16.6	15.3	14.0	12.9	11.8	10.9	10.0	9.1	8.4	7.
9	.0	26.6	77.0	77.5	81.2	77.0	74.0	69.3	65.6	61.1	57.4	53.0	49.4	40.3	43.7	41.
TOTAL OUTFLOW		97.5	177.0	393.3	723.2	870.3	874.8	760.2	631.9	501.2[5]	412.5	364.2	329.6	299.5	274.5	254.

Major Components of the Peak Flow Presentation Table:

1. Subarea identification numbers
2. Travel time for a particular subarea - time required for flow to travel from the particular subarea to the point of interest
3. Point of interest - point in the watershed for which the table is being presented
4. Time steps in minutes - time periods for the hydrograph at the point of interest
5. Calculated total flows for the point of interest - includes overland flow for the subarea at the point of interest, plus upstream flow contributions
6. Calculated flow for the particular subarea (ID) for the time when this flow reaches the pont of interest

SOURCE: Taken directly from the PSRM computer print-out

TABLE V-3

RELEASE RATE PERCENTAGES FOR SUBAREA NOS. 1 THROUGH 9

Subarea Number	Contributory Flow Rate[2] (cfs)	Peak Subarea Runoff Rate[3] (cfs)	Ratio of Column 2 to Column 3	Release Rate Percentage
1[1]	--	--	--	--
2[1]	--	--	--	--
3	103.8	121.6	0.85	85%
4	56.9	69.1	0.82	80%
5	78.4	90.5	0.87	85%
6	84.7	105.5	0.80	80%
7	29.8	30.6	0.97	95%
8	16.6	21.9	0.76	75%
9	74.0	81.2	0.91	90%

1 Release rate percentages were not developed because of their location in Chester County

2 The flow rate arriving at the point of interest from the indicated subarea when the peak runoff rate occurs at the point of interest

3 The peak runoff rate generated during the design rainfall event from the indicated subarea

Given the example presented above, the specific steps in determining release rate percentages for subareas in a watershed are:

1. Model the entire watershed using the PSRM.

2. Evaluate the output and select points of interest, points where existing flow rates are critical and are to be preserved at their existing values.

3. Identify overall watershed runoff flows and the combination and/or interaction of these flows using the Peak Flow Presentation Table.

4. Identify the actual flow value (in cfs) that a particular subarea contributes to the downstream point of interest.

5. Develop release rate percentages that are calculated to be the individual subarea contribution to the peak flow rate at the point of interest, divided by the individual subarea peak flow rate.

The release rate percentage concept has been developed to specifically provide for stormwater management control when the natural timing of runoff flow becomes altered as a result of non-uniform development. As a recommendation, every three to five years depending on the rate of development, all new land use conditions should be added to the data base and stormwater runoff simulation runs made to determine if new development patterns have any impact on the assigned release rate percentages. As land use is constantly varying within an urban watershed, hydrologic conditions are also changing, thereby requiring scheduled review of the release rate percentage delineations.

In addition to Subarea Nos. 3 through 9 draining to Stackhouse Mill Run, two other major tributaries to Ridley Creek exist within the Delaware County portion of the Ridley Creek watershed. The drainage areas of these two tributaries are also suitable for comprehensive stormwater management through the application of the release rate percentage concept. The one tributary is an unnamed stream draining Subarea Nos. 23 through 26. Dismal Run is the second tributary, which drains Subarea Nos. 28 through 33. Table V-4 lists the release rate percentages developed for these subareas, based on points of interest at Subarea Nos. 26 and 33, respectively.

TABLE V-4

RELEASE RATE PERCENTAGES FOR SUBAREA NOS. 23 THROUGH 33

Subarea Number	Release Rate Percentage
23	95%
24	100%
25	85%
26	100%
28	75%
29	100%
30	70%
31	80%
32	100%
33	100%

Using the Release Rate Percentage

In order to demonstrate specifically how the release rate percentage is applied during the design of a stormwater management system for a new development site, an example is most effective. The hypothetical situation serving as the example occurs in Subarea 25, which, from referring to Table V-4, has been assigned a release rate percentage of 85 percent.

A person interested in developing a tract of land located in Subarea 25 desires to preliminarily design his stormwater management system. From the stormwater management ordinance or stormwater management section of the subdivision ordinance of the municipality in which Subarea 25 is located, the person should review the criteria appropriate for the design of stormwater management systems. One important criterion would be the 85 percent release rate assigned to the subarea in which he is planning his development.

The next step in the design of the stormwater management system is to determine the pre-development peak runoff rates for all design rainfall events (in the Ridley Creek watershed these are the 2-, 10-, and 25-year rainfall events). The release rate percentage in a decimal form (0.85) is then multiplied by the pre-development peak runoff rates from all design rainfall events to define the maximum allowable peak runoff rates from the development site after development. A stormwater management site is, therefore, required to reduce the post-development uncontrolled peak runoff rates from the three design rainfall events to 85 percent of the pre-development peak runoff rates prior to leaving the development site.

The Direct Discharge Concept

The shape of the Ridley Creek watershed can be identified or described on the basis of its width in relation to its overall length. In fact, the length of the Delaware County portion of the Ridley Creek watershed is approximately six times the average width. Therefore, only a limited number of major tributaries to Ridley Creek exist, as defined in the previous section of this chapter.

As a result, many subareas are situated adjacent to, or a short distance from, Ridley Creek. All of these subareas have been given 100 percent release rate percentages. However, depending on the location of a proposed development site within these subareas, a performance standard has been defined, the "direct discharge concept," which provides for an alternative to normal on-site stormwater management standards, that is, the standard whereby the post-development peak rate of runoff is limited to the pre-development peak rate of runoff.

The timing characteristics of peak runoff rates for the lower section of the Ridley Creek watershed are presented in Table V-5 below. As can be seen from a review of Table V-5, the time (after the beginning of a rainfall event) at which the peak runoff rate is generated from any subarea in the lower portion of the watershed, occurs at least 225 minutes prior to the time at which the peak flow occurs in Ridley Creek at the outlet of the subarea. The direct discharge concept was developed as a result of this lengthy period of time separating peak runoff rates.

TABLE V-5

TIMING OF PEAK RUNOFF RATES
IN THE LOWER SECTIONS
OF THE RIDLEY CREEK WATERSHED
(For the 25-Year Rainfall Event
and Existing Land Use Conditions)

INDIVIDUAL SUBAREA FLOWS			COMBINED WATERSHED FLOWS	
Subarea Number[1]	Peak Runoff Rate Generated from the Subarea (cfs)	Time of Occurrence[2] (minutes)	Peak Flow Rate (cfs) in Ridley Creek[3]	Approximate Time of Occurrence[2] (minutes)
34	218	300	4825	525
35	84	300	4854	540
38	201	300	4925	540
41	93	300	5021	540
42	202	300	5068	555
47	434	300	5203	570
50	237	300	5259	585
51	160	300	5275	600
54	293	300	5368	600
56	536	300	5539	660
57	281	300	5600	675
62	601	300	6035	675
63	230	300	6076	690
64	627	300	6167	705
65	899	300	6242	720

1 See Plate No. 2 for an identification of subarea locations.

2 Zero minutes is defined as the beginning of the 25-year rainfall event.

3 The combined peak flow rate in the main portion of Ridley Creek that results from flow contributions from upstream subareas.

The direct discharge concept relates to those proposed development sites that are to be located adjacent to Ridley Creek, such that all stormwater runoff drains through a storm drainage system directly into Ridley Creek. In these development sites, stormwater runoff may be conveyed directly to Ridley Creek, via the storm drainage system and the outfall, without alteration of the post-development peak runoff rate. The outfall structures, however, need to be properly designed and constructed so as to prevent scour and erosion of the Ridley Creek channel, which could result from the velocity of the stormwater runoff.

The Downstream Impact Evaluation

Many private developers feel that excessive regulations limit the potential for innovative site planning and create a significant economic burden. In response to this potential concern for future development in the Delaware County portion of the Ridley Creek watershed, an alternative performance standard has been developed for this pilot stormwater management plan. The performance standard permits the party interested in land development to have a professional engineer, experienced in stormwater management planning and design, define the level of stormwater runoff control required for the proposed land development site. This evaluation is, therefore, the individual land developer's attempt at taking "reasonable" steps to limit the downstream impacts from the proposed development site. This level is to be defined by one of the following criteria:

a. In those areas of the watershed where man-made stormwater conveyance channels (i.e., closed storm sewers, concrete-lined channels, rip-rap protected channels, etc.) discharging directly into Ridley Creek exist or will be constructed, the total stormwater runoff flow during the design rainfall events may be directed through these channels without alteration of the post-development peak runoff rate _if_ sufficient capacity in the conveyance channel is available. This criterion can allow for a condition where the post-development peak runoff rate from a site does, in fact, exceed the pre-development value--when it can be shown that reasonable steps are being taken to reduce the potential for downstream storm runoff impacts, utilizing acceptable data and calculation procedures.

b. In any area of the watershed, a post-development discharge rate which is greater than the prescribed release rate percentage may be allowed if it can be reasonably shown (again, through the use of acceptable engineering data, analysis, and design) that the potential for storm runoff damage to downstream areas of the watershed is minimal. An evaluation (i.e., the downstream impact evaluation) must be performed which demonstrates that at any point in time, the flow rates on the existing conditions runoff hydrograph at the outlet of the subarea(s) in which the development site is located are not increased by more than five percent for storm discharges resulting from future conditions runoff (with stormwater management provisions) for the 2-, 10-, and 25-year rainfall events. Existing conditions shall be those land use conditions that were considered for this pilot plan. Existing condition runoff hydrographs for all subareas resulting from the watershed modeling completed for this study are available from the Delaware County Planning Department.

Not only does this performance standard give the engineer greater flexibility, but it also:

- o Fulfills the perceived intent of Section 13 of Act 167

- o Advises the party that is interested in development of a particular property of potential downstream impacts for which responsibility and liability for storm runoff damages may exist if measures are not taken to eliminate the potential impact

- o Allows for maximum use of the information compiled from the watershed modeling procedures, i.e., the watershed land use characteristics, peak stormwater runoff rates, and subarea hydrographs

Using the Downstream Impact Evaluation Option

One method for completing Item b of the downstream impact evaluation involves the following steps:

1. Identify the subarea in which the proposed development site is located.

2. Calculate the full stormwater runoff hydrographs from the proposed development site (2-, 10-, and 25-year design rainfall events) for the following conditions:

   - o pre-development conditions

   - o post-development conditions

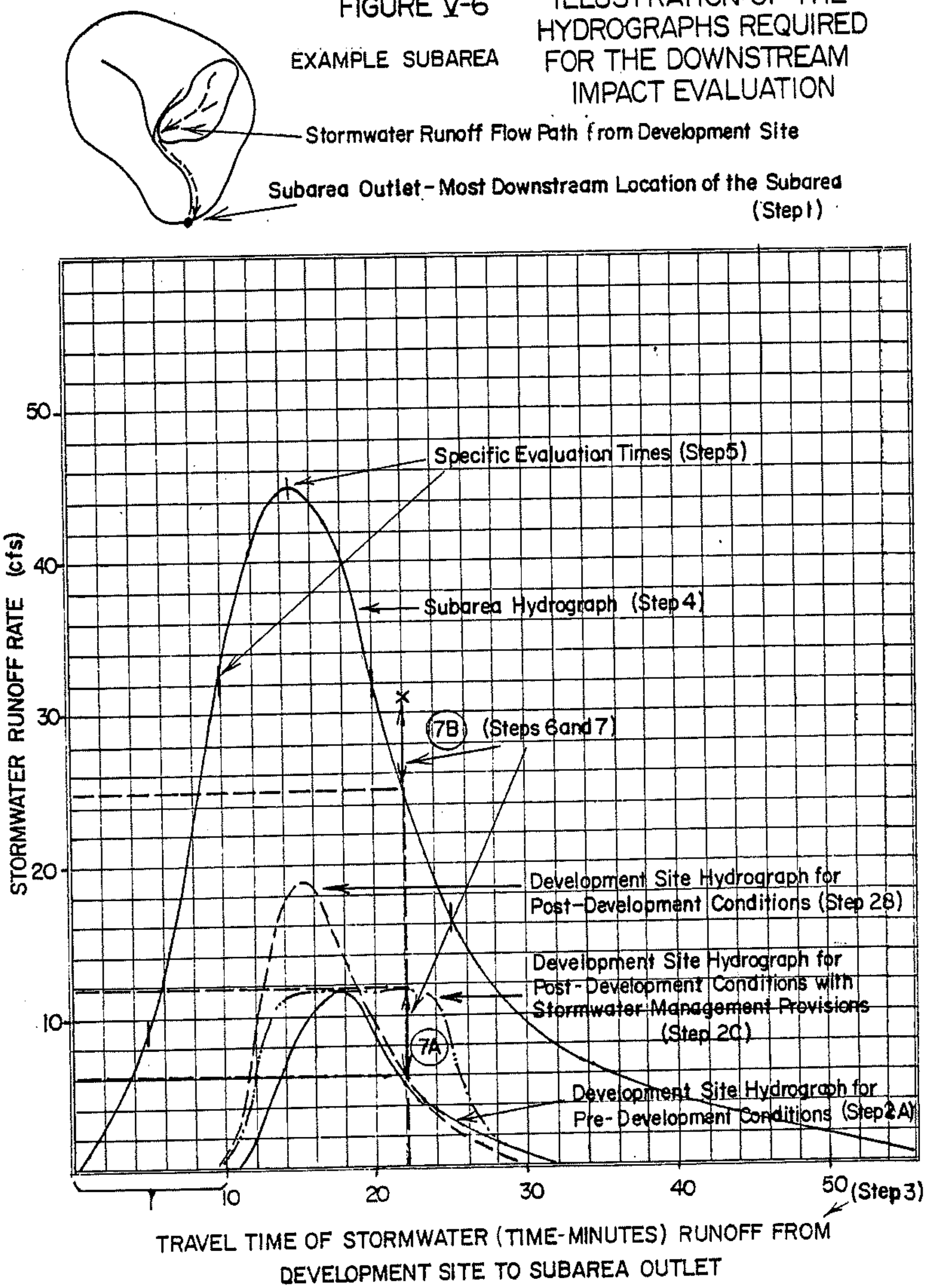
   - o post-development conditions with a proposed stormwater management system

   A recommended method for developing these hydrographs is provided in SCS's "Urban Hydrology for Small Watersheds" (TR-55).

3. Determine the time required (i.e., the "travel time") for a unit of volume of stormwater runoff to flow from the outlet point of the proposed development site to the outlet point of the subarea in which the site is located.

4. Prepare a graph that includes the runoff hydrographs for the proposed development site developed in Step 2 above. In addition, obtain the runoff hydrographs for the subarea in which the proposed development site is located for the 2-, 10-, and 25-year rainfall events from the Delaware County Planning Department (see Figure V-6). The subarea runoff hydrographs are a direct output of the watershed model that has been developed and calibrated for this pilot study.

FIGURE V-6 ILLUSTRATION OF THE HYDROGRAPHS REQUIRED FOR THE DOWNSTREAM IMPACT EVALUATION



5. Calculate the difference in runoff rates, if any, between the pre- and post-development hydrographs for the development site (with a proposed stormwater management system) for at least five specific times spaced evenly throughout the duration of the design rainfall/runoff events (see Figure V-6).

6. If, at any specific time, a runoff rate on the development site post-development hydrograph (with a stormwater management system) is greater than the runoff rate at the same time on the pre-development hydrograph, this increase should be added to the subarea hydrograph at that specific time (see Figure V-6).

7. If, at any specific time, the increase in runoff rate is calculated to be greater than five percent of the original runoff rate on the subarea hydrograph, then the proposed stormwater management system should be modified to reduce the increase to less than five percent.

Example Computation:

A. At a point 22 minutes after the beginning of the runoff event, the contribution to the stormwater runoff rate from the development site has increased above pre-development conditions by approximately 6 cfs (with stormwater management provisions):

- The pre-development stormwater runoff rate from the development site that has traveled to the subarea outlet point 22 minutes after the beginning of the runoff event = 6 cfs.

- The subarea stormwater runoff rate 22 minutes after the beginning of the runoff event prior to new development conditions = 25 cfs.

- The post-development (with stormwater management provisions) stormwater runoff rate from the development site that has traveled to the subarea outlet point 22 minutes after the beginning of the runoff event = 12 cfs.

B. The increase in the subarea stormwater runoff rate at 22 minutes is 6 cfs with the proposed stormwater management provisions in place. Therefore, the percent increase in the subarea stormwater runoff rate at 22 minutes is greater than five percent above the pre-development stormwater runoff rate:

$$\frac{6 \text{ cfs}}{25 \text{ cfs}} \times 100\% = 24 \text{ percent}$$

In this illustration, the downstream impact criterion has not been attained and adjustments to the stormwater management system are required.

8. When the increase in the subarea runoff rate is below five percent for the post-development condition (with the stormwater management system) at all five specific times during the rainfall/runoff event, the downstream impact evaluation standard is achieved.

The procedure described above is one of many appropriate engineering analyses for completing the downstream impact evaluation. Other procedures include computer modeling of the subarea divided into "sub-subareas," or the Tabular Method presented in SCS Technical Release No. 55, etc. The main objective of presenting this specific procedure was to better illustrate the general content of the downstream impact evaluation.

On-Site Infiltration

An extremely important requirement within the Delaware County portion of the Ridley Creek watershed is the continued availability of a high quality water resource. The Borough of Media provides water service to the Boroughs of Media and Rose Valley, Ridley Creek State Park in Edgmont Township, and portions of Upper Providence, Nether Providence, Middletown, and Aston Townships and Chester Heights Borough. The sources of supply for the Borough are Ridley Creek (3.0 MGD allocation), Chester Creek (3.0 MGD allocation), and a well (capable of supplying 0.25 MGD). In addition, water is also purchased from the City of Chester Water Authority at the rate of 100,000 gpd, up to a maximum peak rate of 150,000 gpd. The water from the Chester Water Authority is considerably more expensive per 1,000 gallons than the cost required for the Borough of Media to withdraw water from Ridley Creek and treat that water for distribution to its service area.

Yield Deficiencies in the Media Borough System

Available water resource information was found in the August, 1982, "Report on the Application for Water Allocation by the Borough of Media," prepared by the Bureau of Resources Programming, Division of Comprehensive Resources Programming, PA DER. Table V-6 lists the magnitude and frequency of annual low flow for Ridley Creek at the Media Borough intake.

TABLE V-6

MAGNITUDE AND FREQUENCY OF ANNUAL LOW FLOW
RIDLEY CREEK AT MEDIA BOROUGH INTAKE (Proportioned)[1]

Period: 1933 to March 31, 1979
(Drainage Area 30.0 Square Miles)

Period of Consecutive Days	Discharge, in Cubic Feet Per Second, for Indicated Recurrence Interval in Years 2	5	10	20	50	100
1	9.7	6.1	4.7	3.7	2.8	2.4
3	10.1	6.6	5.3	4.2	3.3	2.8
7	10.9 (10.6)[2]	7.3 (6.3)	5.8 (4.5)	4.8 (3.3)	3.9 (2.2)	3.3
14	12.1 (11.6)	8.1 (6.8)	6.4 (5.0)	5.3 (3.8)	4.2 (2.7)	3.5
30	14.0 (14.5)	9.4 (8.2)	7.4 (5.9)	6.0 (4.2)	4.7 (3.0)	3.9
60	16.5 (16.4)	11.2 (9.6)	9.1 (7.8)	7.5 (6.1)	6.0 (4.6)	5.2
90	18.5	12.8	10.5	8.9	7.3	6.4
120	20.5 (20.3)	14.4 (13.5)	12.0 (10.6)	10.3 (8.9)	8.6 (7.2)	7.7
183	25.0 (25.1)	18.0 (18.3)	15.3 (15.4)	13.4 (13.5)	11.6 (10.6)	10.6
365	40.1	31.0	27.2	24.1	21.6	20.0

1 Proportioned using Chester Creek at Chester, 1933-3/31/79

( )[2] Proportioned using Ridley Creek at Moylan, 1933-1954, from "Bulletin No. 12-Low Flow Characteristics of Pennsylvania Streams"

From Table V-6, the Q_{7-10} flow (the average low flow that will occur over a seven-day period, once every ten years) of Ridley Creek is 3.8 MGD (5.8 cfs).

Downstream from the Media Borough intake, two municipal wastewater treatment plants (Media Borough and Rose Valley) with treatment capacities of 1.8 MGD and 0.13 MGD respectively discharge their effluents into Ridley Creek. The Bureau of Water Quality Management, PA DER, requires a minimum of 1.9 MGD (3 cfs) to pass the intake for adequate assimilation of the sanitary wastewater effluents. However, following normal PA DER procedures, a conservation release or low flow pass-by of 0.15 cubic feet per second per square mile (csm) is required. The low flow pass-by, using this criterion, is 2.9 MGD (4.5 cfs). Therefore, during the most frequently evaluated low flow event, i.e., the Q_{7-10}, if PA DER requires a pass-by flow of 2.9 MGD (4.5 cfs) and the Q_{7-10} is 3.8 MGD (5.8 cfs), the difference between these, or only 0.9 MGD, can be withdrawn from Ridley Creek. This flow is far less than that which is necessary to supply the Media system.

In order to thoroughly analyze the availability of flow based on the required low flow pass-by, the relationship between flow rates and the percent of time a specific flow rate will be exceeded was developed (Table V-7) for Ridley Creek at the Media Borough intake. Table V-7 indicates that the flow in Ridley Creek at the Media Borough intake is greater than or equal to 5.9 MGD (9.1 cfs) 95 percent of the time. During this condition, 3.0 MGD (5.8 cfs) can be withdrawn and still allow for the low flow pass-by of 2.9 MGD (4.5 cfs). However, for the remaining five percent of the year, or eighteen days, the Borough of Media may not be able to withdraw the required 3.0 MGD because of the infringement on the PA DER low flow pass-by. For example, if the flow in Ridley Creek drops to 4.2 MGD (6.5 cfs), 2.9 MGD should be maintained as the low flow pass-by, leaving only 1.3 MGD for withdrawal by the Borough of Media.

TABLE V-7

OCCURRENCE OF DAILY FLOW - RIDLEY CREEK
AT BOROUGH OF MEDIA INTAKE
Period of Record: 1932-1954

Discharge Which Was Equaled or Exceeded for Indicated Percent of Time

Percent:	2	5	10	20	30	40	50	60	70	80	90	95	98
cfs	169	103	75	53	41	34	29	24	21	17	12	9.1	6.5
MGD	109	67	48	34	26	22	19	16	14	11	8	5.9	4.2

In order to define a potential yield deficiency for the overall Media Borough system, a mild drought condition reflecting the seven-consecutive day, five-year (Q_{7-5}) low flow condition was analyzed, and the results are presented in Table V-8.

TABLE V-8

YIELD DEFICIENCY IN THE MEDIA BOROUGH WATER SUPPLY SYSTEM DURING A MILD DROUGHT (Q_{7-5} Flow)

	Ridley Creek cfs		Chester Creek cfs
Total flow available at intake	7.3		13.5
Less: Conservation release pass-by	4.5		10.8
	2.8		2.7
Flow available for withdrawal	2.8 + 2.7	=	5.5 cfs = 3.55 MGD
Add: Withdrawal from well			.25 MGD
Add: Contract limit on water purchased from Chester Water Authority			.15 MGD
Total water supply available for delivery to water system			3.95 MGD
3 year average of average daily demand (1978, 1979, 1980)			4.44 MGD
Yield Deficiency (Q_{7-5} flow)			.49 MGD

It can be seen from Table V-8 that during the mild drought situation that was considered for this evaluation, either the Borough would have to increase its purchases from Chester Water Authority or cut into the flow that is dedicated to instream needs or downstream uses.

The Impact of Future Development on Baseflow in Ridley Creek

The information presented above illustrates the imperative need for conservative and efficiently managed utilization of all water resources within the Ridley Creek watershed, including the "forgotten resource," i.e., stormwater runoff. In almost all comprehensive stormwater management programs, little or no thought is given to the beneficial use of stormwater runoff. Techniques for controlling the peak runoff rates and the potential for an increase in the frequency of flooding typically are the only types of management approaches evaluated. However, by using PSRM to simulate the quantity of stormwater that will infiltrate or pond in surface depressions during frequently occurring rainfall events, the potential loss of stormwater for infiltration during these events was simulated for existing and future land use conditions.

A definite relationship exists between rainfall, stormwater runoff, groundwater, and streamflow in the Ridley Creek watershed. The bedrock underlying this area consists of metamorphic and igneous rock types. Groundwater within the bedrock is obtained from fractures and along "secondary openings" in the rock, i.e., planes of schistosity and foliation in the bedrock. The size, number, and orientation of these secondary openings determine the quantity, depth, rate, and direction of movement of groundwater within the consolidated rock.

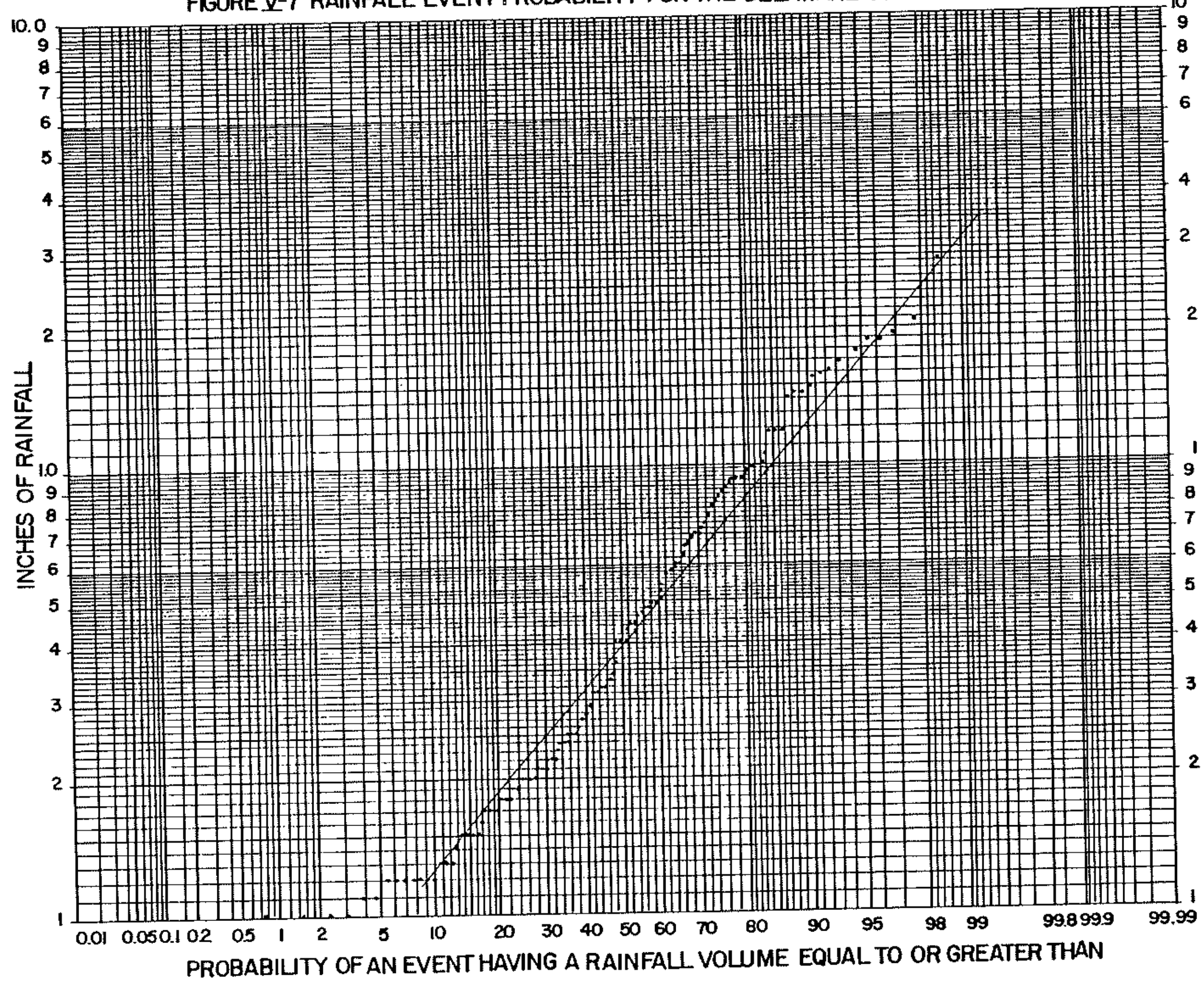
The flow of groundwater in the soil and weathered rock zone, however, is primarily dependent upon the groundwater levels and gradients in any given area. In southeastern Pennsylvania, the groundwater surface is generally similar to and may be considered to be a subdued reflection of land topography. That is, the direction of groundwater flow typically follows the slope of the land surface until reaching a point where the groundwater flow discharges into the regional surface water flow pattern (such as streams and drainage swales). Since the groundwater flow direction is a reflection of the topography, topographic divides are generally equivalent to hydrogeologic divides. The topographic divides can, therefore, be inferred to define the boundaries of a groundwater or hydrogeologic system. The groundwater surface is, therefore, exposed as baseflow in the stream within the Ridley Creek watershed.

Currently in most areas of the Ridley Creek watershed, stormwater generated during any rainfall event is permitted to run off into streams and, within 24 hours, washes into the Delaware River. However, if the stormwater flows are directed to infiltration devices or collected, stored, and conveyed to specially prepared infiltration areas, the stormwater will augment the groundwater in the unconsolidated soil and weathered rock zone. Later, during drought conditions, the baseflow of streams will ultimately be higher.

The Process for Determining Watershed Stormwater Infiltration Volume

The first step in the investigation of stormwater volumes being lost to runoff during any year was to define rainfall volumes which represent frequently occurring rainfall events in Delaware County. Rainfall data for 1980 and 1981, as recorded by the rainfall gage at Philadelphia International Airport, was analyzed as a part of the stormwater infiltration element of the overall work program for this pilot plan. A specific rainfall event was defined to have a total volume of 0.10 inches or more. In addition, at least three hours of elapsed time without rainfall were necessary in order to separate consecutive rainfall events. The number of total events in the two-year analysis period, based on these criteria, was 130. All rainfall events were ranked and assigned plotting positions for purposes of developing a rainfall event probability graph for the Delaware County area (Figure V-7). A cumulative frequency distribution plot (i.e., the percentage of the total number of recorded rainfall events with a given storm duration) of the duration of these rainfall events was then developed (Figure V-8). The rainfall event duration that is equal to, or greater than, fifty percent of all events was determined to be six hours.

FIGURE V-7 RAINFALL EVENT PROBABILITY FOR THE DELAWARE COUNTY AREA



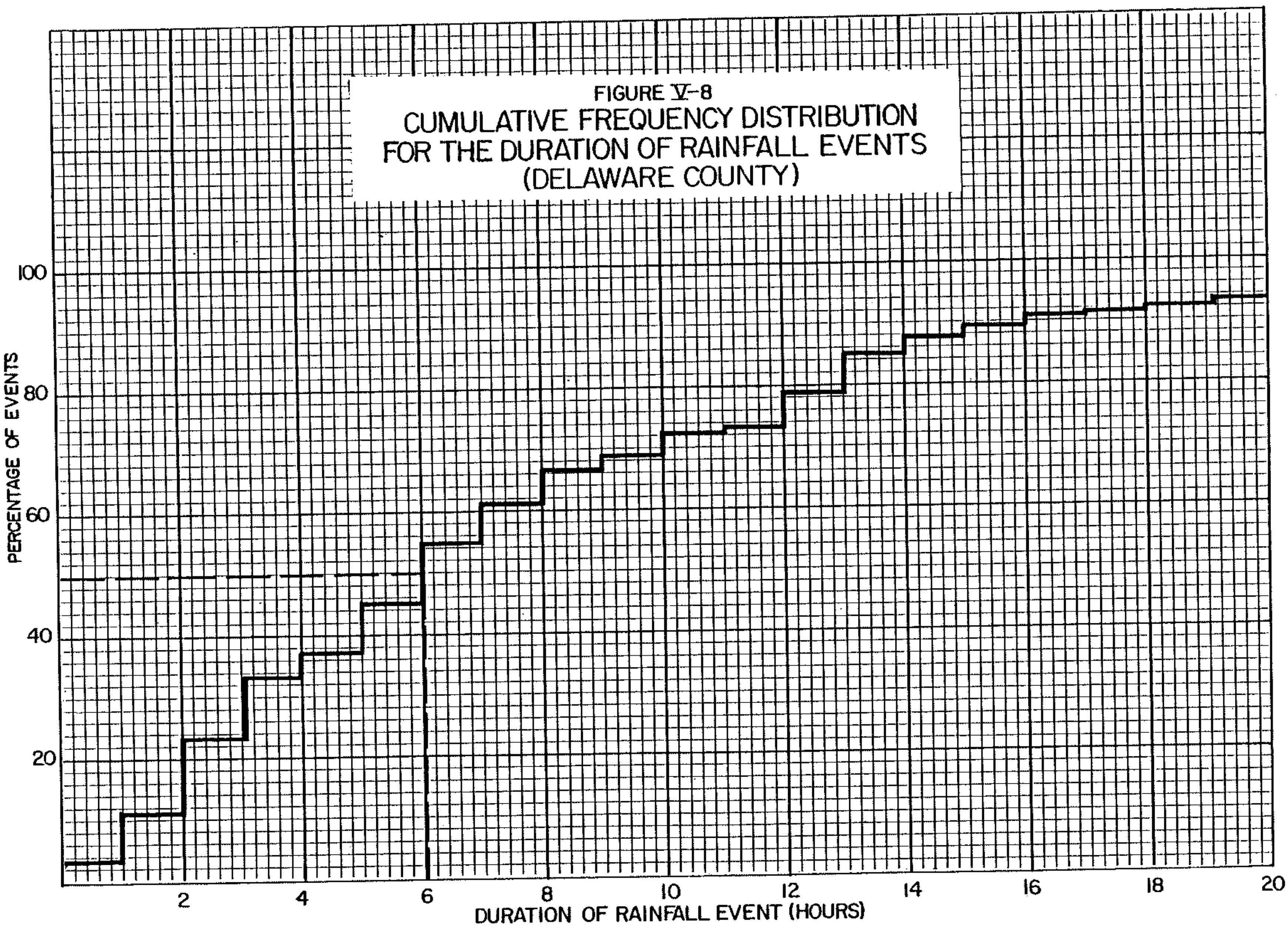


FIGURE V-8
CUMULATIVE FREQUENCY DISTRIBUTION
FOR THE DURATION OF RAINFALL EVENTS
(DELAWARE COUNTY)

The rainfall volume of the mean event was determined to be 0.57 inches. In order to determine an approximate average number of rainfall events per year, the long-term average yearly rainfall volumes were developed from information for three rain gages (Marcus Hook, West Chester, and Philadelphia International Airport) surrounding the Ridley Creek watershed. An average of the information from the three gaging stations was 41.5 inches per year. Therefore, the number of rainfall events per year was assumed to be 41.5 inches divided by 0.57 inches per event, or an average of 73 events per year for the Ridley Creek watershed.

Four rainfall events were selected for use in simulating the quantity of stormwater that would potentially be available for infiltration considering both existing and future land use conditions. These four statistical events were:

Statistical Event[1]	Total Inches of Rainfall For the Statistical Event
50%	0.40
80%	0.84
90%	1.26
99%	3.00

1 Probability of any rainfall event being equal to or less than this particular event

The rainfall volumes listed above were distributed over the six-hour event duration using the SCS Type II distribution (discussed in greater detail in Chapter IV). These rainfall volumes were then used as direct input to the PSRM that was calibrated for simulation of storm events in the Ridley Creek watershed. The results of the eight simulation runs specifically relating to the quantity of rainfall which will potentially infiltrate to the groundwater are given in Table V-9.

TABLE V-9

THE QUANTITY OF RAINFALL THAT WILL POTENTIALLY INFILTRATE TO THE SHALLOW GROUNDWATER (First 42 Subareas)

Rainfall Event and Land Use Condition	Rainfall for Event	Quantity of Rainfall that Will Potentially Infiltrate to the Shallow Groundwater in:			Loss Resulting from Increased Impervious Area[1]
	Inches	Inches	Acre-Inches	Million Gals.[1] Per Event	Million Gals. Per Event
50 Percent:					
Existing	0.40	0.39	3,018	82	
Future	0.40	0.38	2,940	80	2

TABLE V-9

THE QUANTITY OF RAINFALL THAT WILL POTENTIALLY INFILTRATE TO THE SHALLOW GROUNDWATER (First 42 Subareas) (CONTINUED)

Rainfall Event and Land Use Condition	Rainfall for Event	Quantity of Rainfall that Will Potentially Infiltrate to the Shallow Groundwater in:			Loss Resulting from Increased Impervious Area[1]
	Inches	Inches	Acre-Inches	Million Gals.[1] Per Event	Million Gals.[1] Per Event
80 Percent:					
Existing	0.84	0.80	6,191	168	
Future	0.84	0.78	6,036	164	4
90 Percent:					
Existing	1.26	1.06	8,203	220	
Future	1.26	1.00	7,739	210	10
99 Percent:					
Existing	3.00	2.44	18,883	510	
Future	3.00	2.38	18,419	500	10

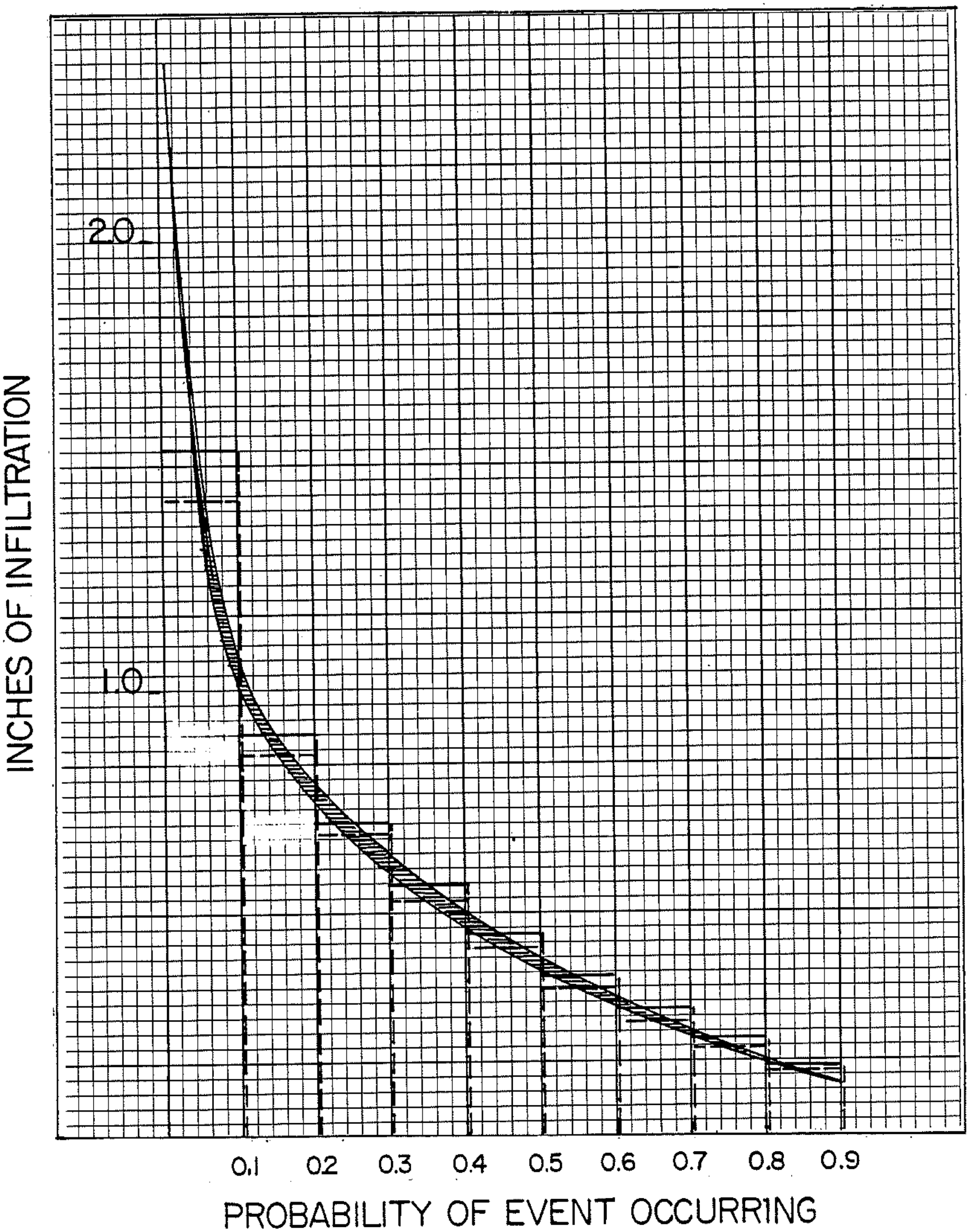
1 Values, in million gallons, are for each individual rainfall event. Considering 73 events per year will allow for the identification of average annual shallow groundwater recharge, or loss.

Potential Streamflow Loss Resulting from Future Development

In order to determine the reduction in the quantity of infiltration that would be expected in the Ridley Creek watershed if development occurs, as projected, in Subarea Nos. 1 through 42, the inches of infiltrated rainfall were plotted against the probability of an event's occurrence for both present and future land use conditions (Figure V-9). The area under both the curves, i.e., for existing (the upper curve) and future land use conditions (the lower curve), were calculated in order to define the mean (average) quantity of rainfall which will infiltrate during any rainfall event during any year.

The shaded area between the upper and lower curve (Figure V-9) represents the quantity of rainfall that will not infiltrate, considering future land use conditions, resulting from an increase in impervious area in Subarea Nos. 1 through 42. This quantity of rainfall will be lost to runoff (i.e., will not serve to augment shallow groundwater) unless physical infiltration techniques are implemented. These can be used in new development sites, if applicable, or may consist of a more

FIGURE V-9


2.0
1.0
INCHES OF INFILTRATION
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
PROBABILITY OF EVENT OCCURRING

regional recharge scheme, as will be illustrated in a later section of this chapter. Table V-10 lists the estimated quantity of rainfall that is lost to runoff during the mean event, as well as the potential total quantity of water that is lost to runoff over the entire year, if new land development were to occur and natural infiltration is not augmented.

TABLE V-10

ESTIMATED INCREASE IN RAINFALL LOST TO STORMWATER RUNOFF[1]

	Runoff Naturally Infiltrating During the Mean Rainfall Event[2]		
	Inches	Acre-Inches	Million Gals.
Existing land use conditions	0.510	3,947	19
Projected future land use conditions	0.485	3,753	18
Loss, for "average" rainfall event	0.025	194	1

Total loss per year: $\frac{\text{1 million gallons}}{\text{average rainfall event}} \times \frac{\text{73 average rainfall events}}{\text{year}}$

= 73 million gallons per year

1 If projected future development occurs without applying infiltration techniques

2 Considers the land area within Subarea Nos. 1 to 42 (see Plate No. 2)

A Non-Structural Planning Recommendation for Integrating Infiltration Facilities in New Development Sites

In the previous sections of this chapter, the potential loss of rainfall to stormwater runoff resulting from the imperviousness created by potential new land development was illustrated. The evaluations that were conducted for this pilot project indicate that if future development in the first forty-two subareas in Delaware County were to occur as projected, a total of 73 million gallons of rainfall (which naturally would have the opportunity to infiltrate) would be lost to direct stormwater runoff.

The need for maintaining an adequate minimum streamflow in Ridley Creek in order to satisfy the water supply requirements of the service area was presented in a previous section of this chapter. As described, a majority of the rainfall which normally infiltrates will ultimately become normal flow (baseflow) in Ridley Creek. Therefore, a direct correlation exists between stormwater infiltration and the flow in Ridley Creek during drought conditions. That is, if rainfall were entirely lost to direct stormwater runoff, the potential exists that the Media Water Authority would not be able to withdraw the needed 3 million gallons per day from Ridley Creek.

As a result of this high priority for maintaining a readily available water resource (that is, maintaining baseflow conditions in the streams) within the Delaware County portion of the Ridley Creek watershed, a procedure has been developed to identify a reasonable amount of stormwater infiltration that could be readily implemented on new development sites in those subareas tributary to the Media Borough intake on Ridley Creek (Subarea Nos. 1 through 42, not including Chester County subareas).

The procedure that has been identified (described below) for promoting continued infiltration of stormwater was developed on the basis of the following very important considerations:

- The calculations that are required to determine the infiltration volume are, basically, those that are now being used in many areas of the County, i.e., the SCS technique and/or procedure.
- The infiltration volume that is being pointed out as being realistic is based entirely on the soil conditions found at a particular site in its existing condition.
- The typical amount of infiltration that would be identified for a site could be realistically handled by "standard" infiltration devices, such as small subsurface seepage pits.
- The anticipated cost for the infiltration systems would be low.

The calculation procedure for determining a realistic quantity for infiltration on any specific development site was developed utilizing widely used stormwater runoff equations derived by the United States Department of Agriculture, Soil Conservation Service (SCS). This calculation base is a part of a widely known SCS publication, "Urban Hydrology for Small Watersheds," Technical Release No. 55 (TR-55). The step-by-step method for calculating a realistic quantity of stormwater infiltration on a new development site is presented below:

1. Use Table V-11 to determine the runoff curve number for the various pre-development land use areas on the proposed development site.
2. Compute the weighted runoff curve number as illustrated in the following example:

TABLE V-11

Runoff curve numbers for selected agricultural, suburban, and urban land use. (Antecedent moisture condition II, and $I_a = 0.2S$)

LAND USE DESCRIPTION	HYDROLOGIC SOIL GROUP A	B	C	D
Cultivated land[1/]: without conservation treatment	72	81	88	91
: with conservation treatment	62	71	78	81
Pasture or range land: poor condition	68	79	86	89
good condition	39	61	74	80
Meadow: good condition	30	58	71	78
Wood or Forest land: thin stand, poor cover, no mulch	45	66	77	83
good cover[2/]	25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.				
good condition: grass cover on 75% or more of the area	39	61	74	80
fair condition: grass cover on 50% to 75% of the area	49	69	79	84
Commercial and business areas (85% impervious)	89	92	94	95
Industrial districts (72% impervious).	81	88	91	93
Residential:[3/]				
Average lot size — Average % Impervious[4/]				
1/8 acre or less — 65	77	85	90	92
1/4 acre — 38	61	75	83	87
1/3 acre — 30	57	72	81	86
1/2 acre — 25	54	70	80	85
1 acre — 20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5/]	98	98	98	98
Streets and roads:				
paved with curbs and storm sewers[5/]	98	98	98	98
gravel	76	85	89	91
dirt	72	82	87	89

1/ For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Section 4, Hydrology, Chapter 9, Aug. 1972.

2/ Good cover is protected from grazing and litter and brush cover soil.

3/ Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

4/ The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

5/ In some warmer climates of the country a curve number of 95 may be used.

SOURCE: Soil Conservation Service, "Urban Hydrology for Small Watersheds," Technical Release No. 55 (TR-55), U.S. Department of Agriculture.

In its pre-development condition, a 100-acre site proposed for development is 50 percent woodland with poor cover, 25 percent meadow in good condition, and 25 percent cultivated land without conservation treatment. All the soils are in hydrologic soil group C.

Example Computation:

Land Use	Percent		Runoff Curve Number (Table V-10)		Product
Woodland with poor cover	50	x	77	=	3,850
Meadow in good condition	25	x	71	=	1,775
Cultivated land without conservation treatment	25	x	88	=	2,200
	100				7,825

$$\text{weighted CN} = \frac{7,825}{100} = 78$$

3. Use the following equation relating the "potential maximum retention" (the potential maximum retention includes the total rainfall volume which can be intercepted by vegetation, infiltrates into the ground, and/or is stored in natural or man-made surface storage features over an area with specific land use conditions) to the weighted CN value for pre-development conditions in order to calculate the potential maximum retention for a particular site:

$$S = \frac{1,000}{\text{weighted CN}} - 10\text{, or, for this example,}$$

$$S = \frac{1,000}{78} - 10$$

S = 2.82 inches of "potential maximum retention" for the characteristics of the site being considered for this example

4. Determine the initial abstraction (the initial abstraction is that portion of the potential maximum retention which must be filled before surface runoff begins) for the physical characteristics of the site, which includes all the storm rainfall occurring before surface runoff starts, by using the relation developed by SCS:

Ia = 0.2 x potential maximum retention, or, for this example,
Ia = 0.2 x (2.82)
Ia = 0.56 inches

5. Compute the weighted runoff curve number for the proposed post-development land use conditions. For the example being used here, this involves the consideration that all the cultivated land and meadow is converted to a townhouse development with 1/8-acre lot sizes and half the woodland is converted to single family homes with 1/2-acre lots.

Example Computation:

Land Use	Percent		Runoff Curve Number (Table V-10)		Product
Townhouse development (1/8-acre lots)	50	x	90	=	4,500
Single family homes (1/2-acre lots)	25	x	80	=	2,000
Woodland with poor cover	25	x	77	=	1,925
	100				8,425

Thus: weighted CN $= \frac{8,425}{100} = 84$

6. Calculate potential maximum retention as in Step 3:

$$S = \frac{1,000}{84} = 10$$

$$S = 1.9$$

7. Calculate the initial abstraction as in Step 4:

$$Ia = 0.2 \times (1.9)$$
$$Ia = 0.38$$

8. Determine the realistic quantity of infiltration on the proposed development site, equal to the initial abstraction (Ia) determined for pre-development conditions minus the Ia determined for the proposed land use conditions, or:

Ia (existing) - Ia (future) = realistic infiltration quantity
For this example: 0.56 - 0.38 = 0.18 inches

9. Therefore, design physical stormwater infiltration techniques that will adequately provide for the recommended minimum infiltration with positive overflow to the other on-site stormwater management facilities. For the example:

$$\frac{0.18 \text{ inches} \times 100 \text{ acres} \times 43,560 \text{ feet}^2/\text{acre}}{12 \text{ inches/foot}} = 65,340 \text{ ft}^3$$

Structural Stormwater Management Techniques

Structural stormwater management control techniques can be either on-site (serving one particular site) or off-site (serving more than one site collectively). This section includes a short discussion of on-site techniques which are applicable for use in the Ridley Creek watershed. The potential use of three particular off-site systems will be discussed in detail later in this chapter.

The designer is not restricted to the listed on-site techniques and is encouraged to apply more elaborate techniques when appropriate and feasible, particularly in unique situations. A process for designing a coordinated on-site stormwater management system for a development site, incorporating the non-structural elements of the pilot study, is also presented.

On-Site Control Techniques

Table V-12 presents a list of on-site stormwater management techniques that were evaluated and found to be appropriate for controlling increases in peak runoff rates and decreases in infiltration resulting from urban development in the Delaware County portion of the Ridley Creek watershed. The reader is encouraged to refer to other texts and manuals for specific design details and limitations characteristic of each of the proposed techniques.

When evaluating the potential use of any of the infiltration systems, detailed soil and geologic investigations are required to define their applicability for any development site.

TABLE V-12

ON-SITE STORMWATER CONTROL TECHNIQUES
FOR THE DELAWARE COUNTY PORTION
OF THE RIDLEY CREEK WATERSHED

Type of Control Provided	Technique
Infiltration of precipitation 'at source' prior to concentration	Dutch drains, gravel-filled ditches with optional drainage pipe in base
	Porous paving - asphalt
	Precast concrete lattice blocks and bricks
Increase time of concentration by increasing length of overland flow	Terraces, diversions, runoff spreaders, etc.

TABLE V-12

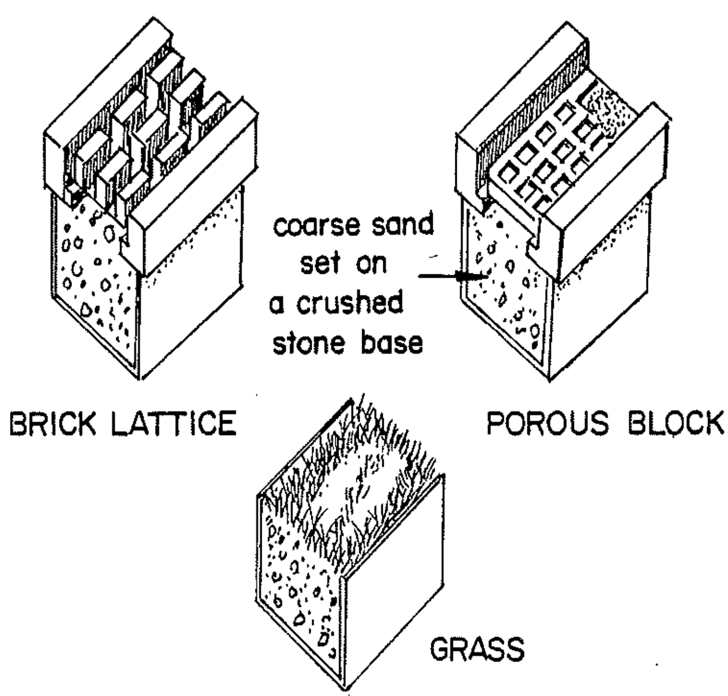
ON-SITE STORMWATER CONTROL TECHNIQUES
FOR THE DELAWARE COUNTY PORTION
OF THE RIDLEY CREEK WATERSHED
(CONTINUED)

Type of Control Provided	Technique
Infiltration of runoff after preliminary concentration	Seepage pits or dry wells, pits usually filled with gravel or rubble, sometimes cased
	Seepage beds or ditches
	Seepage areas (multi-use)
Peak runoff rate reduction	Detention basins
	Parking lot storage

Dutch Drains

Dutch drains are simply gravel-filled ditches. The ditch may be entirely gravel-filled or covered with topsoil and seeded. When the top surface area of the drain is very wide, the drain usually is covered with brick lattice or porous block (Figure V-10).

FIGURE V-10 DUTCH DRAINS



Dutch drains are suggested for use as dividing strips between areas of impermeable paving to collect sheet runoff. Another location where Dutch drains are implemented is parallel to sidewalks which are gently sloped to the drain.

If tile drains are set at the base of Dutch drains and connected into the storm sewer system, an effective reduction of peak runoff rates will result during intense storms. This same benefit will result from providing longitudinal fall along the Dutch drain, allowing runoff to other facilities in the development site's stormwater management system during excessively heavy rainfall.

Porous Paving - Asphalt

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 coarsely graded stone which supplies a large amount of void space for runoff storage capacity. Table V-13 is included to indicate normal requirements for surface and subbase thicknesses. This table provides a guide for estimated runoff storage capacity. Figure V-11 shows a typical porous pavement cross-section and design elements.

FIGURE V-11

TYPICAL CROSS-SECTION OF POROUS PAVEMENT

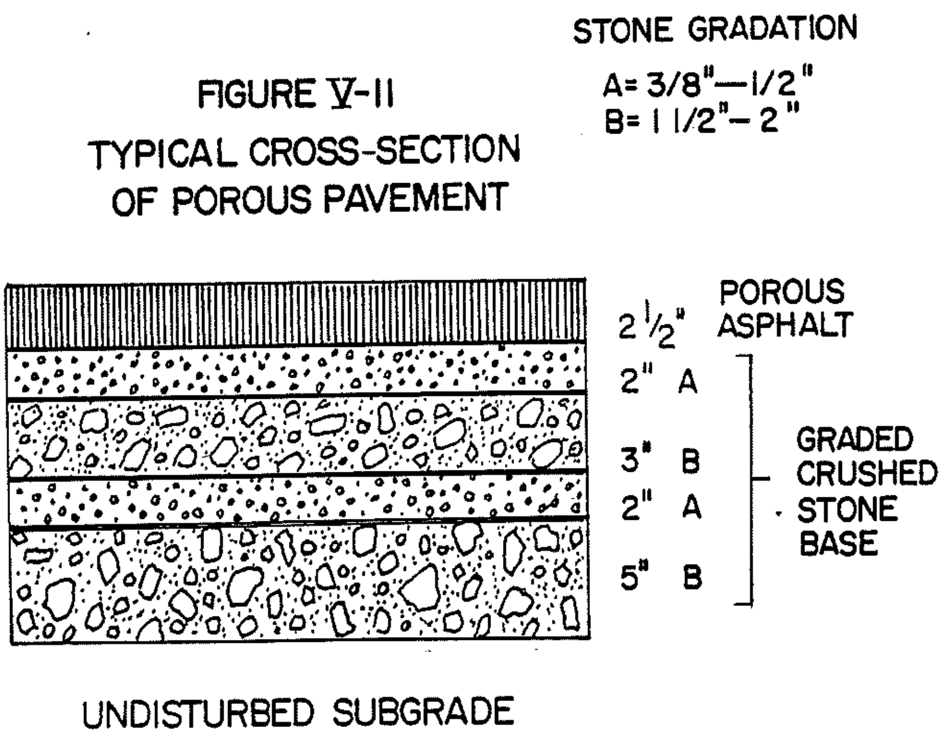


TABLE V-13

REQUIREMENTS FOR SURFACE AND BASE COURSE WHEN APPLYING POROUS ASPHALT PAVING

Traffic Load	CBR	DTN	Surface Thickness (in.)	Base Thickness (in.)	Reservoir Capacity In. of Rainfall Surface	Base	Total
	2	1	4	6	.60	1.80	2.40
Light	2	10	4	12	.60	3.60	4.20
	2	20	4.5	13	.66	3.90	4.56
Medium	2	50	5	14	.75	4.20	4.95
	2	100	5	16	.75	4.80	5.55
Heavy	2	1,000	6	20	.90	6.00	6.90
	2	5,000	7	22	1.05	6.60	7.65

CBR = California Bearing Ratio
DTN = Design Traffic Number

Note:

(1) A minimum surface thickness of 4 inches is used regardless of DTN.

(2) The estimated volume of voids in the base aggregate is 40%.

(3) Frost heaving: if the combined surface and base thickness is less than anticipated frost penetration, additional base is required.

SOURCE: University of Delaware, Water Resources Center, April, 1974.

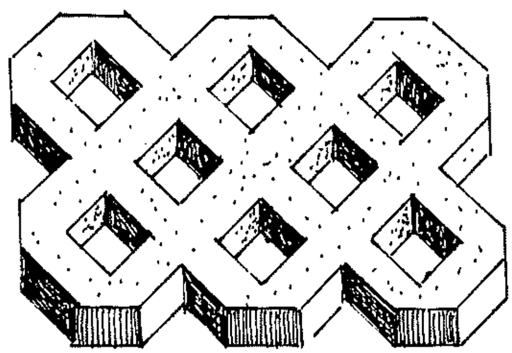
The rapid passage of runoff through porous pavement can greatly reduce runoff from paved areas. High infiltration rates have been reported through new porous pavement surfaces. Pavement and subbase storage may provide for over seven inches of runoff.

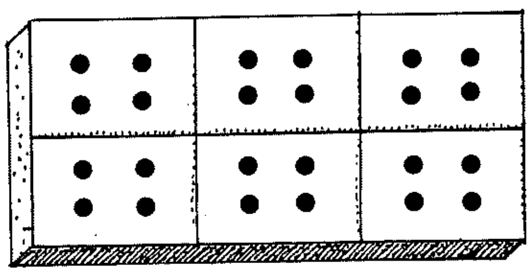
Special attention must be given to maintaining the porous pavement. Under certain circumstances the surface may become clogged and its permeability reduced. Inadequate maintenance, rain on a frozen surface, and certain conditions during snow melt may all result in runoff, even though porous paving is being used.

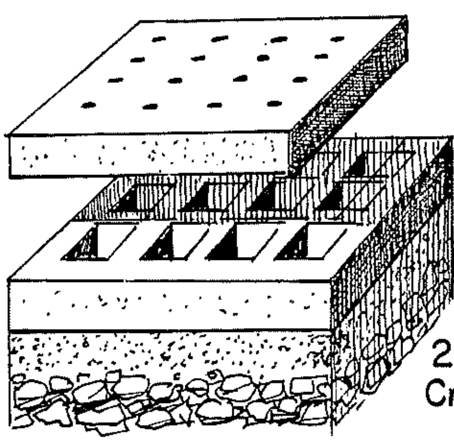
Pre-Cast Concrete Lattice Blocks and Bricks

There are various types of pre-cast paving slabs which provide a hard surface and yet are porous to varying degrees. Perforated slabs may be used to cover Dutch drains between areas of impermeable paving (making a lattice of permeable paving through a parking area). Tree pits covered with brick strips may be used in a similar way. Various types are shown in Figure V-12.

FIGURE V-12


CONCRETE
LATTICE
BLOCK


MODULE
PAVERS


1" Sand
2-5"
Crushed Stone
CONCRETE PAVER
LAID OVER
CONCRETE
LATTICE BLOCK

Terraces, Diversions, and Runoff Spreaders

By increasing the time of concentration of runoff (that is, increasing the overland flow time), the runoff hydrograph from a development site can be flattened, thereby reducing peak runoff rates. This can be achieved by spreading runoff or by directing it into a system of trenches. The increased overland flow time may also significantly increase the infiltration of runoff, particularly on well-drained sites.

Seepage Pits or Dry Wells

Seepage pits collect runoff and store it until it infiltrates into the soil. However, unlike Dutch drains, seepage pits do not conduct water along their length when filled. Unless the seepage pit is designed to take the total amount of anticipated runoff for a design storm, some provision for "positive" (i.e., directed toward some other source of defined discharge) overflow must be made. In order to have the maximum benefit in reducing peak runoff rates, the pit should overflow during intense storms before its capacity is reached (Figures V-13 and V-14).

FIGURE V-13

Illustrating a system where a seepage pit receives runoff from a roof and parking lot.

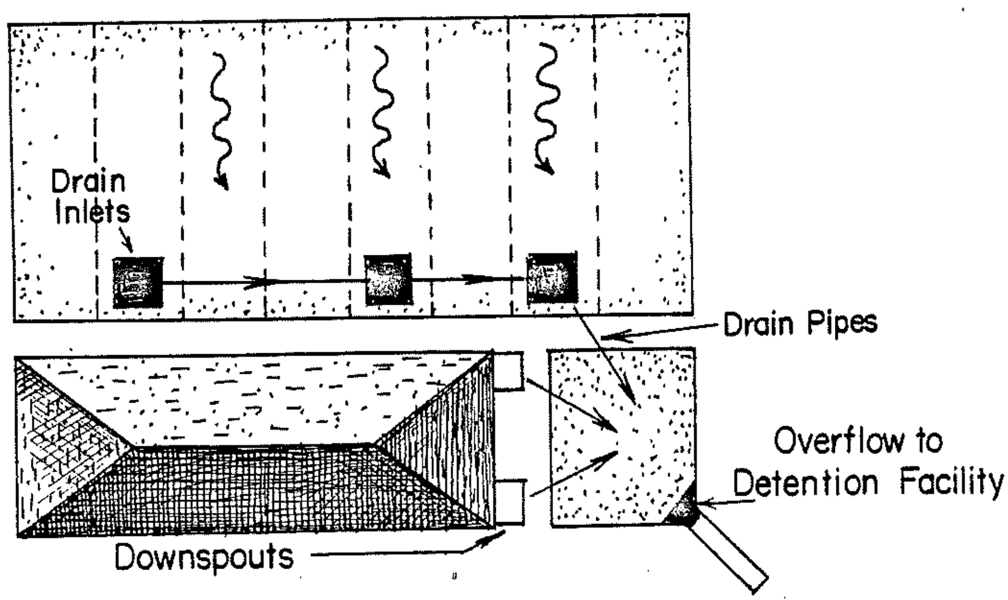
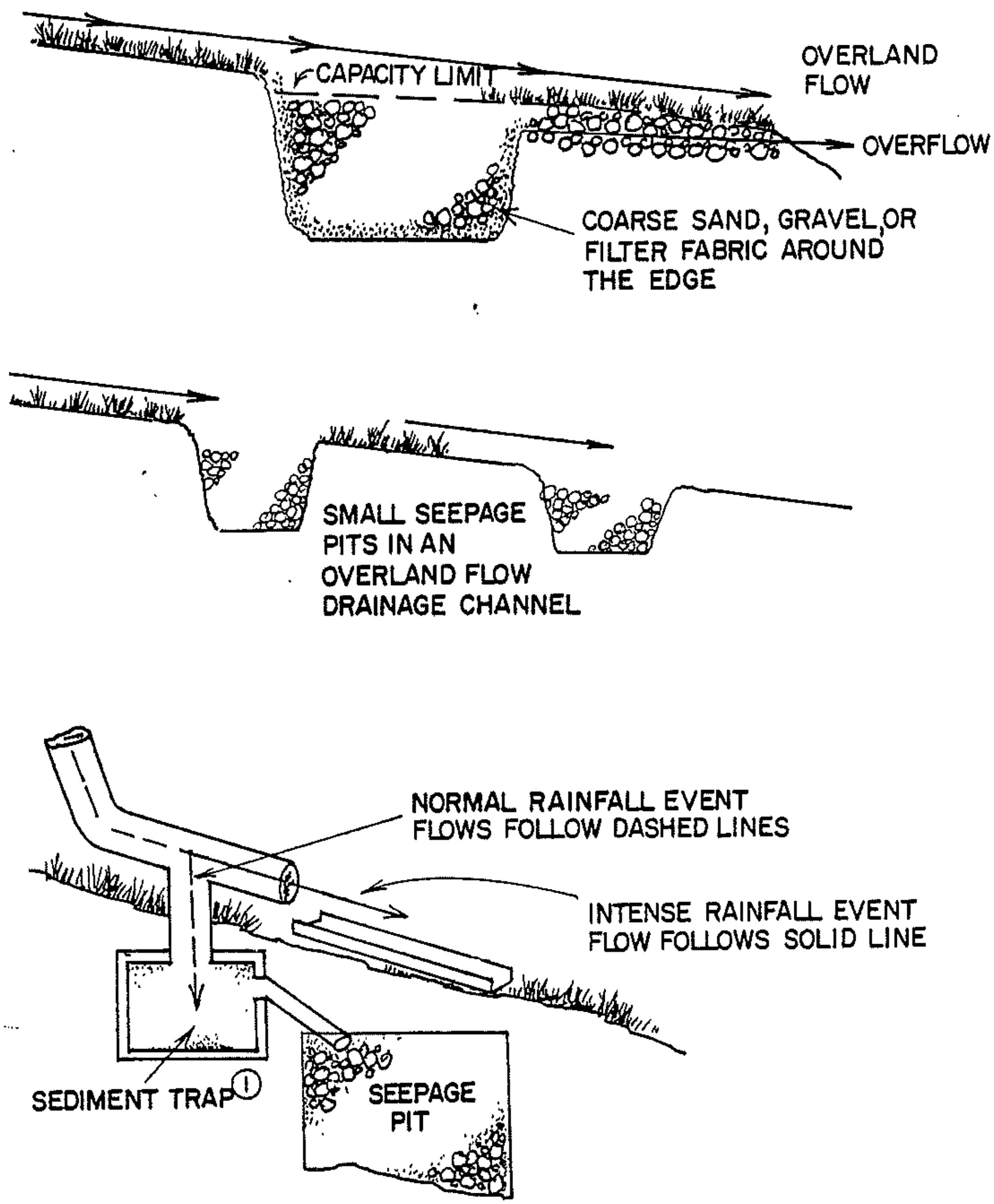


FIGURE V-14
SEEPAGE PIT CONFIGURATIONS

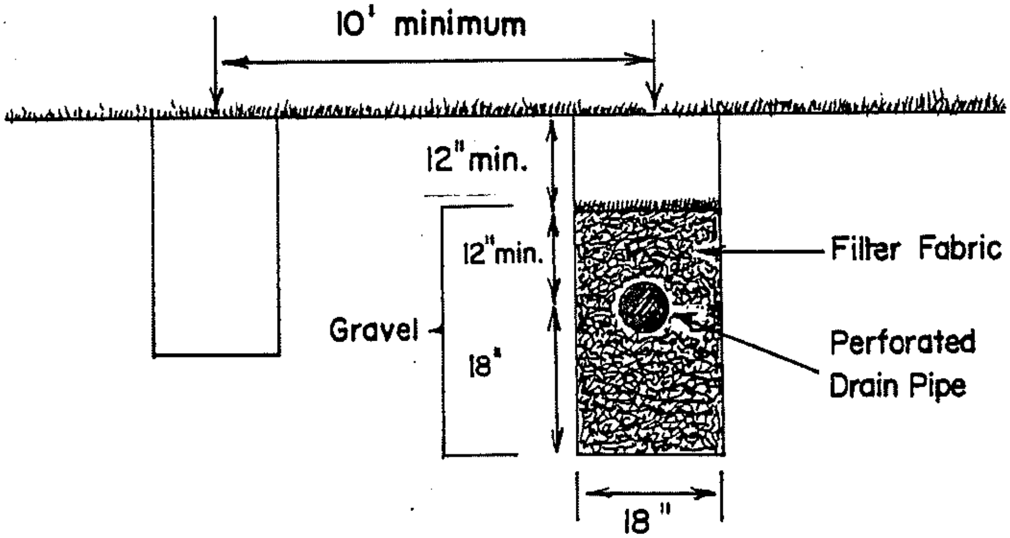


① EASY ACCESS TO THE INSIDE OF THE SEDIMENT TRAP SHOULD BE PROVIDED FOR PERIODIC CLEANOUT

Seepage Beds or Ditches

Seepage beds (Figure V-15) provide for infiltration of runoff into the soil via a system of drains set in ditches of gravel. These systems only reduce the volume and velocity of runoff and, therefore, require a positive overflow system for excess runoff. There are several advantages to seepage bed systems resulting from the fact that they distribute water over a larger area than can be achieved with other infiltration techniques. As a result, a lower potential exists for clogging. In fact, a seepage bed system may be placed under paved areas if the bearing capacity of the pavement is not affected.

Figure V-15
SEEPAGE BEDS
(Typical Dimensions)



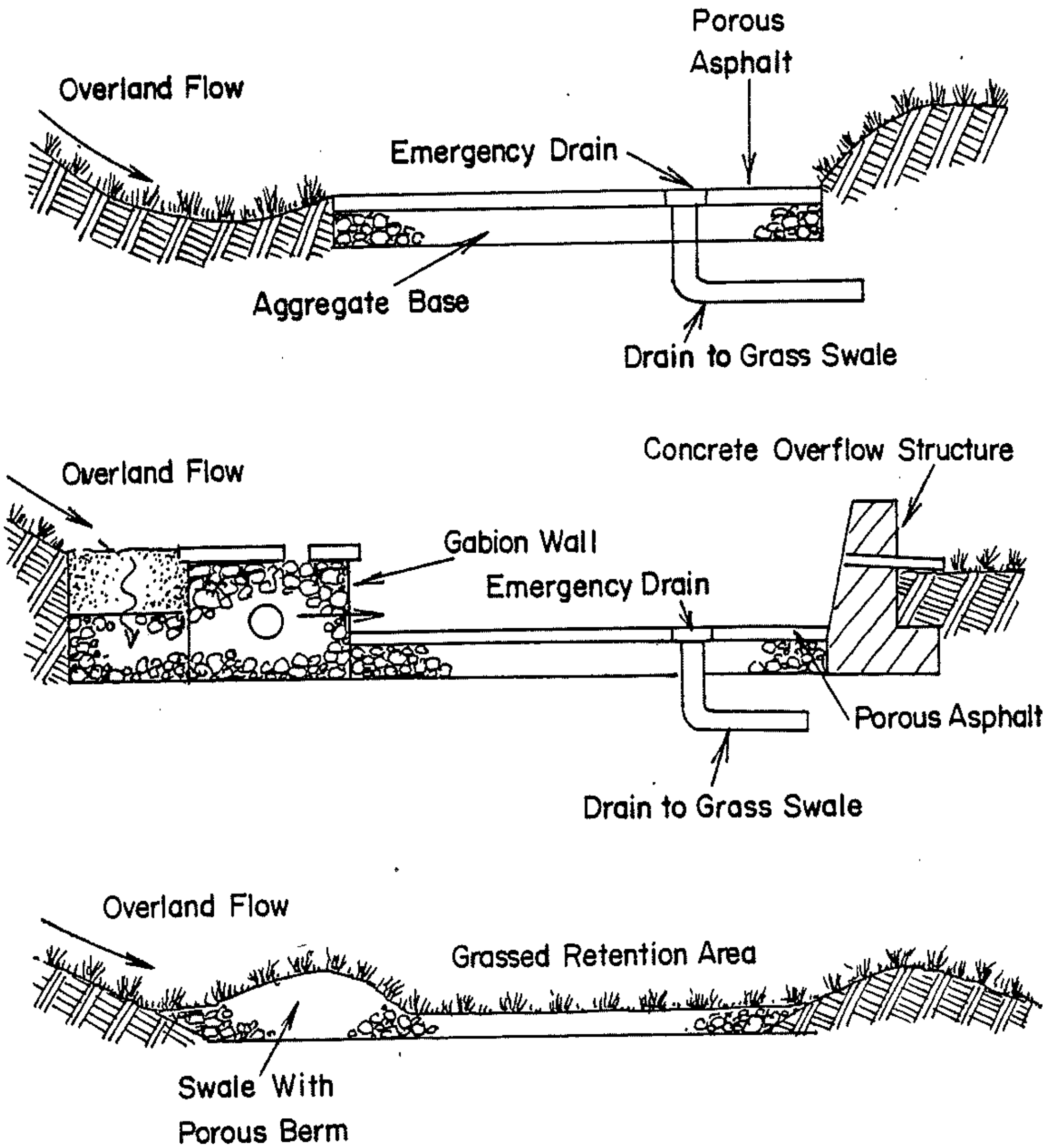
Seepage Areas (Multi-Use)

Seepage areas allow for a percentage of annual rainfall to infiltrate into the ground, thereby recharging the groundwater system. Seepage areas serve to store excess runoff and to provide for multi-purpose use of such a facility through careful design for recreational use, parking, or open space (Figure V-16).

Detention Basins

Detention basins, when adequately designed, reduce the peak rate of runoff discharging from a developed area by storing a portion of the stormwater runoff and attenuating the hydraulic response of the developed area. A term often confused with detention basins is

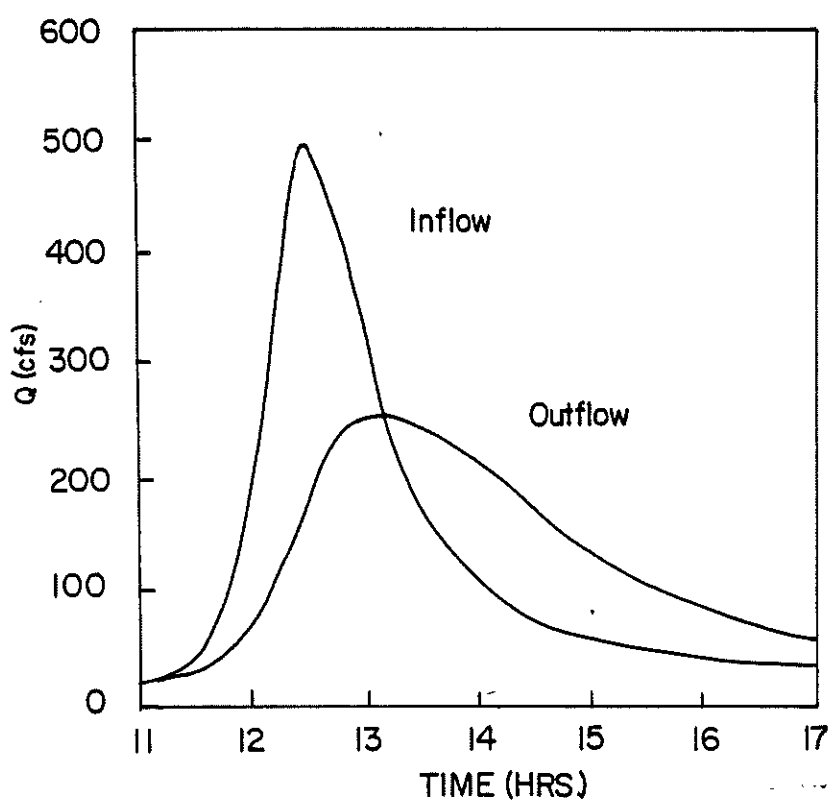
FIGURE V-16 MULTI-
PURPOSE SEEPAGE AREAS



retention basins. Retention basins involve a much larger impoundment volume permitting permanent storage of stormwater. A retention basin is defined as any type of detention facility not provided with a positive outlet. The water that is stored in a retention facility either infiltrates or evaporates but is not discharged.

Therefore, detention is defined as delaying a portion of the stormwater runoff associated with a storm for a period of time that is in excess of the natural runoff duration. The ultimate objective of this type of stormwater management technique is to reduce the peak discharge rate by storing a certain amount of storm runoff and allowing it to be released at a flow rate that is designed to not cause injury (see Figure V-17).

FIGURE V-17 DETENTION BASIN INFLOW AND OUTFLOW HYDROGRAPHS



Because a detention basin or other facility providing similar runoff control is used as an element in most stormwater management plans for new development sites, additional information concerning their design and use in the Delaware County portion of the Ridley Creek watershed is provided. The typical design procedure (Appendix D provides a more detailed discussion) is as follows:

1. Define the site conditions (pre- and post-development).

2. Determine the total quantity of stormwater runoff that will arrive at the entrance of the detention facility for the 2-, 10-, 25-, and 100-year rainfall events. (Note: the post-development runoff quantity can be reduced by the amount proposed for on-site infiltration, where applicable.)

3. Develop runoff hydrographs (i.e., full hydrographs, as opposed to only peak flow rates) for the 2-, 10-, 25-, and 100-year rainfall events (pre- and post-development).

4. Determine a preliminary basin size and develop a depth vs. storage relationship for the proposed basin configuration.

5. Select an outlet control structure for the proposed detention basin (e.g., an outlet pipe and riser), and define its hydraulic characteristics (i.e., a headwater depth vs. discharge relationship).

6. Using the information developed in Step Nos. 4 and 5 (i.e., the relationship between storage and discharge), route the inflow hydrographs through the basin and develop outflow hydrographs. An example of a technique for doing this is provided in "Introduction to Hydrology," Viessman, et al. (Intext Educational Publishers, 1972).

7. Evaluate the basin design, considering the impacts that the proposed basin will have on downstream areas.

If a detention basin is an element in the stormwater management plan for any new development in the Delaware County portion of the Ridley Creek watershed, the following criteria should be used for the evaluation of the basin design:

- The peak discharge from the basin shall be no greater than the pre-development peak runoff rate from the development site during the 2-, 10-, and 25-year design rainfall events. (A person involved in the site design should be certain that all site runoff for these rainfall events is conveyed to the detention basin via storm sewers or other appropriate surface drainage channels.) This identifies a need for detention basin outlet structures to have multiple control capability. One method of providing multiple control capability for a detention basin is to use multiple pipe/riser outlet structures.

- For development sites located in subareas for which release rate percentages of less than 100 percent were assigned, the peak discharge from the basin for post-development conditions shall be no greater than the peak runoff rate defined by applying the appropriate release rate percentage to the pre-development peak runoff rate from the development site during the 2-, 10-, and 25-year design rainfall events.

- For storms in excess of the 25-year design rainfall event up to the 100-year rainfall event, the stormwater detention basin shall have the capability of safely passing the peak stormwater runoff rate through an emergency spillway (see Appendix D for details). "Safely" is being used here to mean "in a manner that will not result in physical damage" to the detention basin. In that the discharge facilities in the detention basin are to be sized so as to control the 25-year design storm event, some form of protection needs to be provided for the occurrence of the 100-year design storm event. The typical approach that is used to provide this additional level of protection is to install an "emergency spillway." For example, the peak flow rate associated with the 100-year design rainfall event should be able to pass through the emergency spillway of a detention basin without overtopping the embankment of the basin.

  That is, the water surface elevation in the detention basin during the 25-year rainfall event shall be designed to be at the crest of the emergency spillway. A minimum of two additional feet of embankment shall be provided above the crest of the emergency spillway to pass the 100-year design storm flows "safely" through the detention basin without overtopping the detention basin embankment.

Prior to selecting the 25-year rainfall event as the maximum stormwater management design event for the Delaware County portion of the Ridley Creek watershed, the potential impact of detention basins designed to meet this criteria was analyzed. Detention basins sized to accommodate a 25-year design storm event were conceptualized in Subarea Nos. 3, 5, 9, 23, 25, 28, and 31 through 33 for simulation and evaluation of their potential for impact during the 100-year rainfall event at selected downstream locations. Table V-14 lists the results of this evaluation.

The information in Table V-14 illustrates that detention basins that are designed according to the proposed criteria do not create any significant increase in peak runoff rates during the 100-year rainfall event. In fact, at some locations the simulated peak runoff rates generated by the 100-year rainfall event are projected to be somewhat below the peak runoff rates simulated on the basis of existing land use conditions.

TABLE V-14

PSRM DETENTION BASIN STUDY RESULTS[1]
AT POINTS OF INTEREST IN THE WATERSHED

Drainage Outlet from Subarea	Peak Runoff Rates-Existing Land Use Conditions (cfs)	Peak Runoff Rates-Future Land Use Conditions with Detention Basins Sized to Reflect the Proposed Criteria (cfs)
3	837	849
5	1,072	1,054
9	1,445	1,445
12	5,038	5,018
20	6,330	6,299
25	288	250
26	471	435
31	339	346
32	452	457
33	671	657
46	7,473	7,459

1 PSRM evaluation of watershed stormwater runoff rates generated by the 100-year design rainfall event with future land use conditions and simulated detention basins based on the proposed design criteria in Subarea Nos. 3, 5, 9, 23, 25, 28, and 31 through 33.

Overall, the results of this analysis indicate that the detention basins simulating the use of the proposed criteria were very effective in providing the desired level of stormwater management for the Delaware County portion of the watershed. That is, post-development peak runoff rates generated by the 25-year rainfall event can be controlled to the peak runoff rate defined by the applicable release rate percentage. Simulating the use of the proposed design criteria for safe passage of peak runoff rates generated by rainfall events in excess of the 25-year event (i.e., up to the 100-year rainfall event) indicates only a minor reduction, if any, in the degree of protection during the 100-year rainfall event.

Parking Lot Storage

Parking lot detention involves the design of pavement surfaces, curbing, and stormwater inlet structures to temporarily store and release stormwater runoff. Initial construction costs for implementing these measures are only a small percentage above the costs of constructing conventional parking lots. These measures should be designed to control runoff from the particular parking area only and to avoid handling any additional runoff. The facility should be designed to drain completely and avoid the formation of ice.

Summary

In order to summarize the previous discussion on the use of on-site (i.e., within a new land development project) stormwater management techniques, a "flow diagram" is presented in Figure V-18. This diagram illustrates the points in the flow path of stormwater runoff where various types of on-site stormwater management techniques should be used in order to provide for optimum and cost-effective control of stormwater runoff from a new land development project in the Delaware County portion of the Ridley Creek watershed. In addition, the diagram illustrates the emphasis that is being placed on the use of infiltration techniques for accomplishing two critical functions--stormwater runoff control and baseflow augmentation.

The diagram in Figure V-18 also illustrates the emphasis on controlling stormwater runoff as close to its point of origin as possible. This helps ensure that effective stormwater runoff control is provided in a cost-efficient fashion and helps promote infiltration of stormwater in the watershed.

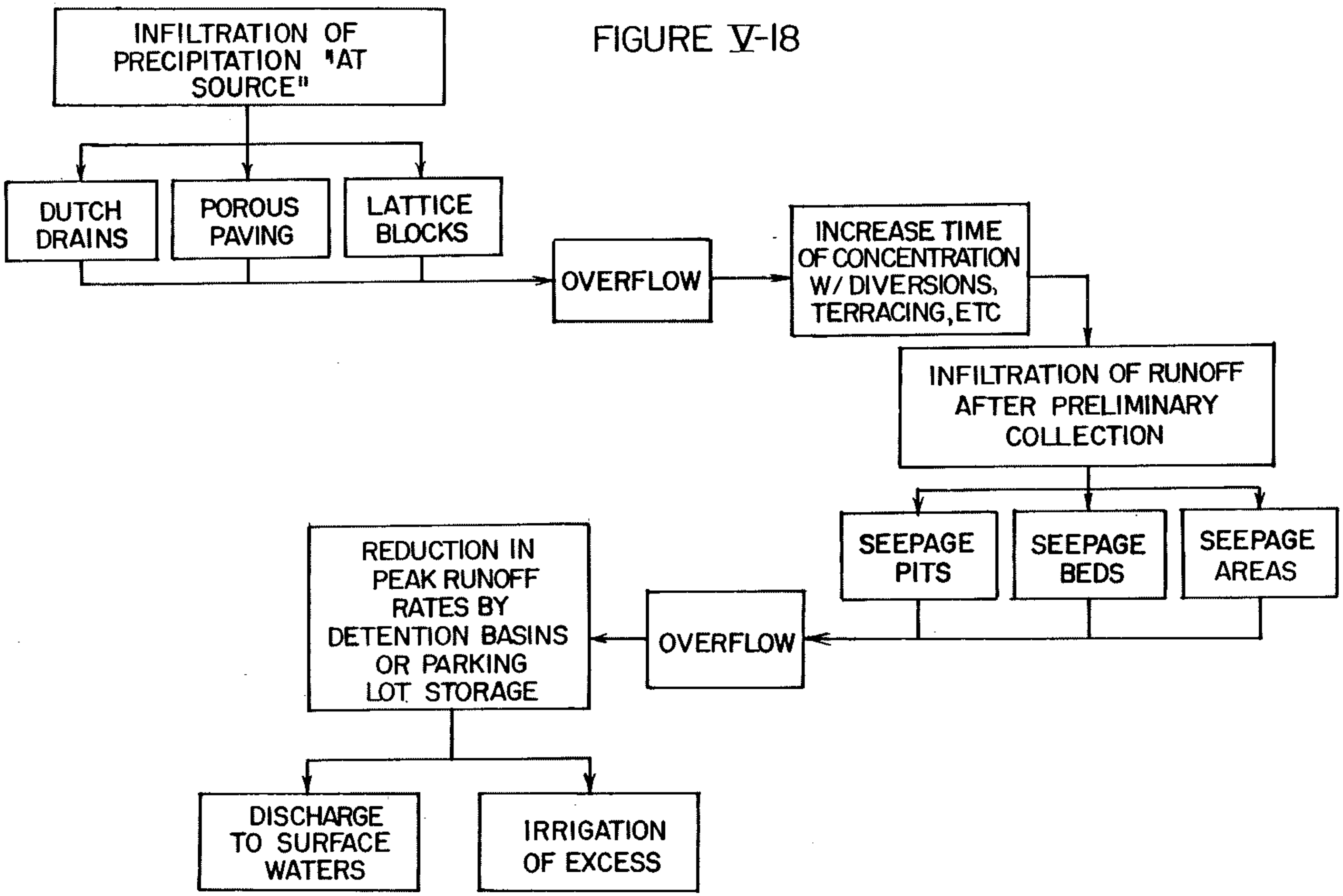
Watershed-Level Stormwater Management Techniques

Watershed-level stormwater management systems represent a new direction for stormwater management and one that may be used more frequently in the future. One very key aspect of a watershed-level stormwater management alternative lies in its ability to effectively locate and design a coordinated system of runoff control facilities that is responsive to the specific hydrologic characteristics and needs of the total watershed.

Two types of watershed-level stormwater management systems were evaluated for their potential application in the Delaware County portion of the Ridley Creek watershed. The first type of system responds to the important phenomenon of timing of runoff flows within a watershed. That is, the various sections (subareas) of a watershed generate and contribute storm runoff to a critical downstream point at varying times during the total runoff event. By defining the interaction of the flow-contributing subareas, "logical" locations for regional stormwater runoff storage facilities can be identified. This approach, termed the "distributed storage concept," has recently been incorporated in the pilot comprehensive stormwater management plans (Act 167) for four watersheds in another section of Pennsylvania.

The second type of watershed-level stormwater management system was developed specifically to respond to conditions within the Ridley Creek watershed. As was discussed in a previous section of this chapter, a significant concern for water resource availability exists in the Ridley Creek watershed. The "normal" (as well as the extreme condition, i.e., drought) baseflow in a stream is a critical factor in determining the amount of water that can be withdrawn for water supply. Low baseflow is often a very critical "limiting condition" with respect to water supply withdrawal from a stream.

FIGURE V-18


INFILTRATION OF PRECIPITATION "AT SOURCE"
DUTCH DRAINS
POROUS PAVING
LATTICE BLOCKS
OVERFLOW
INCREASE TIME OF CONCENTRATION W/ DIVERSIONS, TERRACING, ETC
INFILTRATION OF RUNOFF AFTER PRELIMINARY COLLECTION
SEEPAGE PITS
SEEPAGE BEDS
SEEPAGE AREAS
OVERFLOW
REDUCTION IN PEAK RUNOFF RATES BY DETENTION BASINS OR PARKING LOT STORAGE
DISCHARGE TO SURFACE WATERS
IRRIGATION OF EXCESS

As a result of specific limitations controlling the quantity of water which the Borough of Media is permitted to withdraw from Ridley and Chester Creeks (i.e., because of low baseflow in Ridley Creek), the Borough frequently has to rely on water supplies purchased from the Chester Water Authority. The cost for purchasing this water is equal to or greater than the amount that is charged to consumers within the Borough's service area. As the water supply needs grow with increased population and water use, this situation may become a critical constraint on water supply for the area. Therefore, a watershed-level stormwater management system which will provide both reduction of stormwater runoff rates and augmentation of baseflow was developed as an alternative for this study. This "water resource" management system is referred to as the "watershed baseflow augmentation concept." Each of these watershed-level stormwater management systems is described in greater detail in the following sections of this chapter.

Evaluation of the Distributed Storage Concept in the Ridley Creek Watershed

The distributed storage concept, which has recently been developed for the control of flood flow peaks (i.e., runoff flows generated by the 25-year and larger volume rainfall events), was evaluated for potential implementation in the Delaware County portion of the Ridley Creek watershed. The distributed storage concept for watershed-level stormwater management relies on the selection of detention facility locations by analyzing the specific characteristics of stormwater flow routing in the watershed. The trend of stormwater management in many locations has resulted in the construction of detention facilities in coordination with most new development sites. These facilities are commonly designed to control runoff flow rates generated by the 100-year rainfall event. The projected impact of these "randomly" located detention facilities is that an increase in flood flows may occur at downstream locations, i.e., at locations that are downstream from the development sites with the detention facilities.

In order to reduce the possibility of runoff flows from randomly placed detention facilities combining, the selection of sites that are hydraulically "most appropriate" for off-site (i.e., regional) detention facilities must be made. The ultimate selection of any stormwater storage area, however, requires a detailed assessment of potential advantages and disadvantages of the identified storage locations.

In light of these facts and information, potential locations for distributed storage basins in the Delaware County portion of the Ridley Creek watershed were determined by analyzing the flow routing characteristics of the watershed, selecting sites where streams join (i.e., confluence points), and then reviewing the potential for combinations of peak runoff rates at the particular confluence points.

This analysis indicated very little potential for using distributed storage for the control of runoff flows generated by severe rainfall events in the Delaware County portion of the Ridley Creek watershed. This is primarily the result of two factors:

- o The shape of the Delaware County portion of the Ridley Creek watershed

  The long, narrow shape of this portion of the watershed creates a condition characterized by short, steeply sloped tributaries that feed directly into Ridley Creek. The use of the distributed storage concept is most effectively utilized where runoff flows combine at the confluence of major tributaries. Without these conditions, distributed storage detention facilities cannot be located so as to "interrupt" flow combinations at confluence points.

- o The location of the Delaware County portion of the Ridley Creek watershed

  The Delaware County portion of the Ridley Creek watershed is the bottom half of the total watershed. As a result, any attenuation of runoff flows along the short tributaries in the bottom half of the watershed may cause these flows to combine with those generated by the upper portion of the watershed.

The discussion should not imply that the use of "shared" detention facilities, i.e., facilities serving more than one development, is not feasible. That is, if two or more development sites are located adjacent to each other and have a common point to which the stormwater runoff generated during rainfall events will flow, a common detention facility can be implemented in conformance with the standards and criteria developed for this stormwater management plan for the Delaware County portion of the Ridley Creek watershed.

Development of a Watershed Baseflow Augmentation System

The Delaware County portion of the Ridley Creek watershed has many characteristics which lead one to initiate a study evaluating the potential for a "watershed baseflow augmentation" system. Of primary importance is an established need for such a system. As previously discussed, Media Borough needs to withdraw 3.0 MGD from Ridley Creek to satisfy the potable water supply demands of its service area. However, on many days during low flow conditions, it is not permitted to withdraw this amount because of a minimum pass-by flow requirement of 2.9 MGD. This condition, i.e., where water cannot be withdrawn from the creek because of low baseflow conditions, will potentially occur more frequently as additional impervious land area is generated by future development in the upper portions of the County. Impervious land cover reduces natural infiltration and promotes excess storm runoff, both of which are critical water resource impacts for a watershed.

The baseflow augmentation system that was evaluated for this study will require storage provided by construction of above-ground stormwater impoundments. In addition, the system utilizes the natural capacity of the "subsurface reservoir," i.e., that in the upper, unconsolidated geologic horizons. The above-ground impoundments are required for the initial storage of stormwater diverted from Ridley Creek during periods of stormwater runoff flow. Between the periods of stormwater runoff flow, the impounded stormwater will be conveyed to infiltration areas recharging the subsurface reservoir.

Therefore, to provide the required storage for the initial surface impoundment of runoff flows, land has to be available adjacent to surface streams. Public land administered by PA DER Bureau of State Parks borders Ridley Creek within the confines of Ridley Creek State Park. If the extensive research and testing required to define the overall effectiveness of a watershed baseflow augmentation system were accomplished, administrative arrangements could be pursued for multi-use (recreational, stormwater infiltration, and storage) land areas adjacent to Ridley Creek within Ridley Creek State Park.

On Figure V-19, the boundaries of some limited use areas in Ridley Creek State Park which may be suitable for application of stormwater by an "infiltration trench system" are shown. The outlined areas include approximately 563 acres (0.88 square miles). The cross-hatched areas designate a location where a conceptual baseflow augmentation system using an infiltration trench approach has been identified for preliminary analysis as a part of this pilot study. An example of a watershed baseflow augmentation system utilizing impoundments and infiltration trenches is conceptually described as follows:

1. Adjustable streamflow diversion structures would need to be built at locations along Ridley Creek. These diversion structures would be connected to nearby storage impoundments (Figure V-20).

2. A pump placed in the impoundment would be activated during selected periods to convey the impounded stormwater to the infiltration trench application areas.

3. The stormwater would be pumped to the highest elevation of each separate infiltration trench area. The stormwater would then flow downslope through a distribution main with feed lines to each trench. The distribution system would be designed to deliver a specified application rate to each trench.

4. Each trench would have a mild slope, permitting movement of stormwater along the entire length of the trench. As the stormwater flows along the trench, it will infiltrate through the gravel bottom into the shallow groundwater found in the upper soil/unconsolidated rock area (Figure V-21).

Figure V-19
RIDLEY CREEK STATE PARK

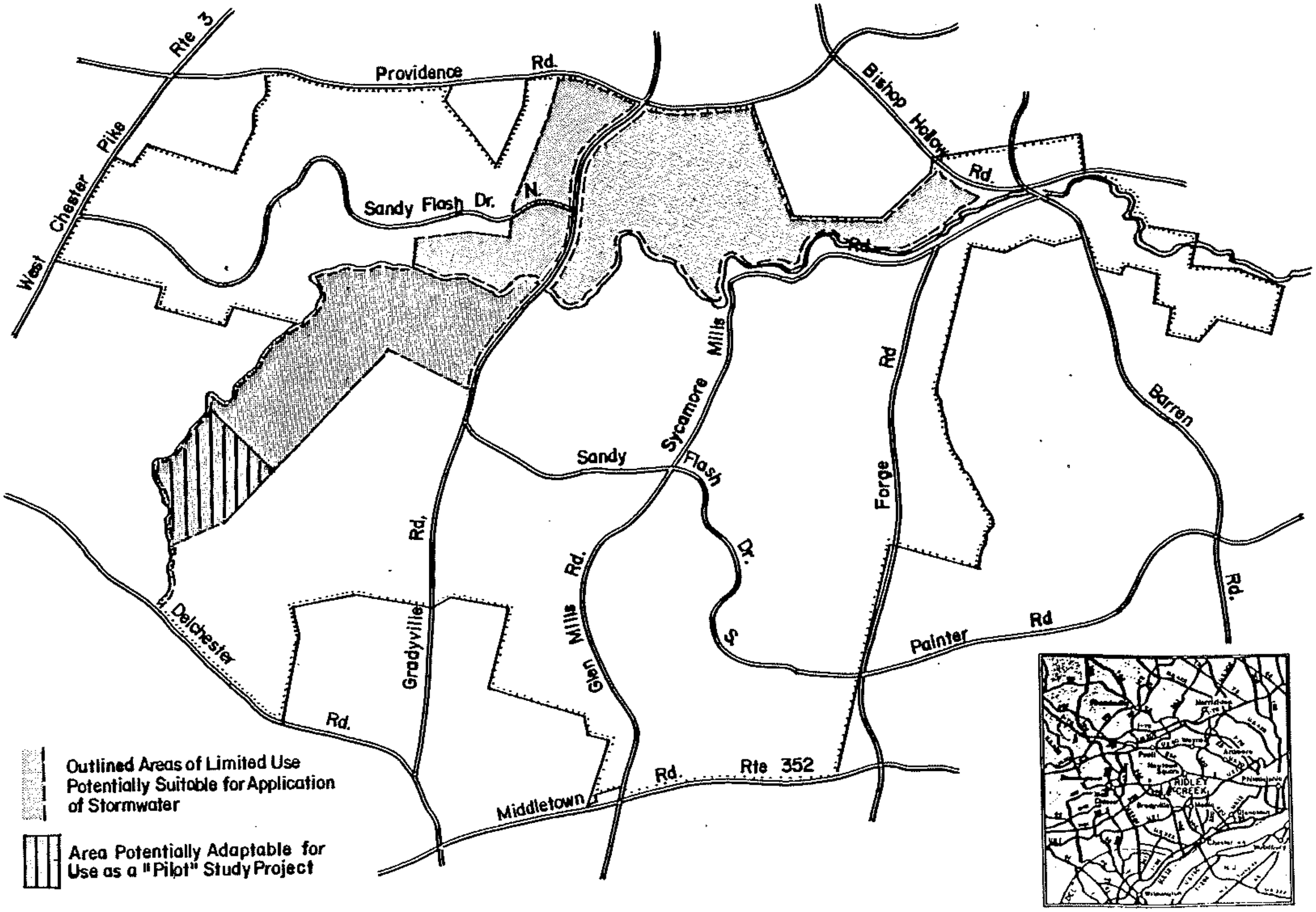
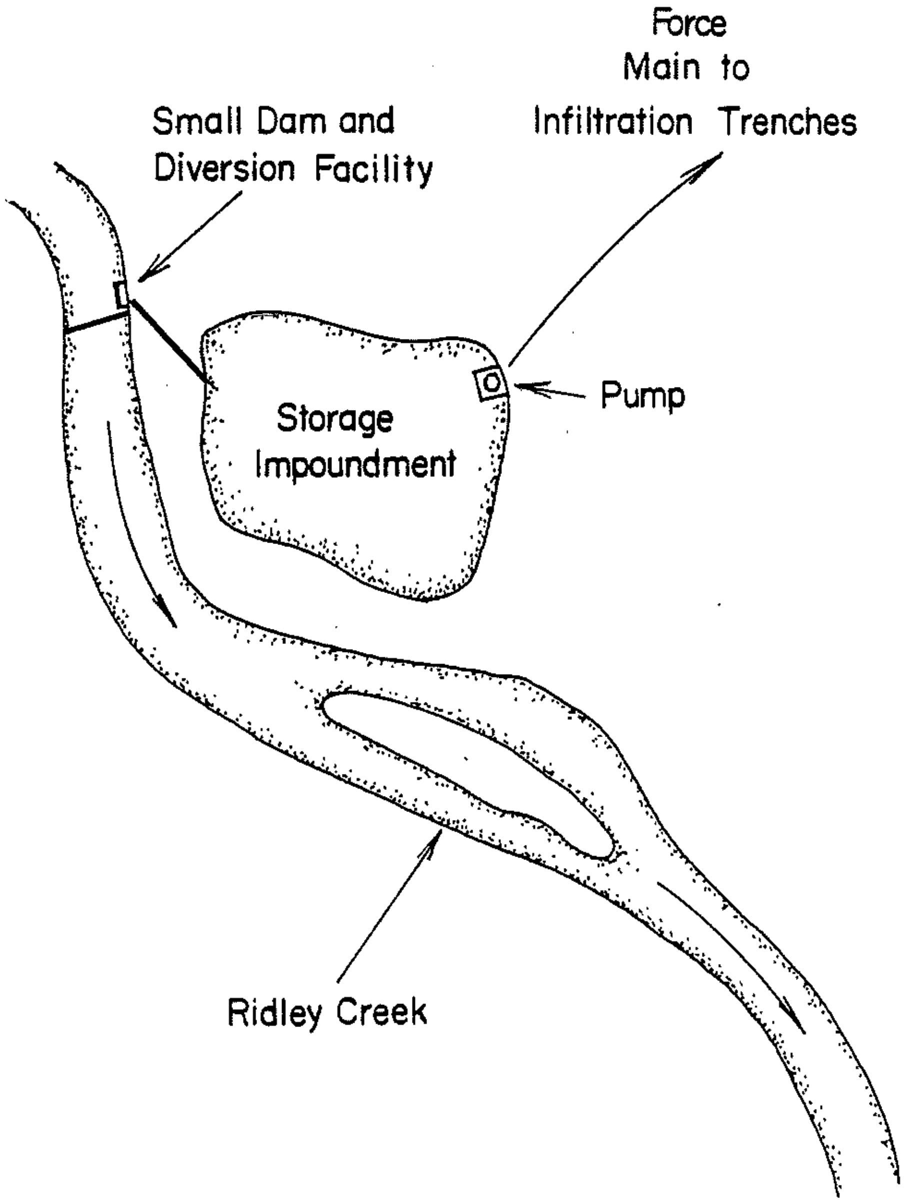
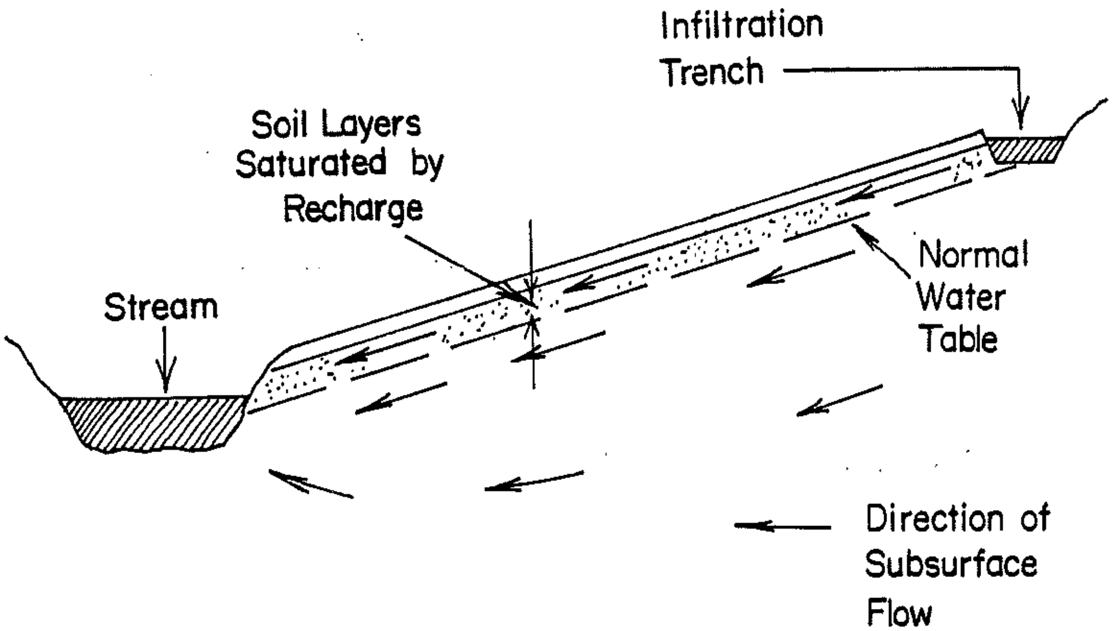


FIGURE V-20



GENERAL CONFIGURATION OF DIVERSION STRUCTURES
AND STORMWATER IMPOUNDMENTS

FIGURE V-21
IDEAL REPRESENTATION OF PROPOSED INFILTRATION TRENCH



The resulting process of infiltration and underground flow toward the stream is, of course, highly complex and non-uniform. Nevertheless, during the description of a potential pilot system, an analysis utilizing idealized conditions was performed in order to estimate the increase in baseflow of Ridley Creek if a full-scale system were developed.

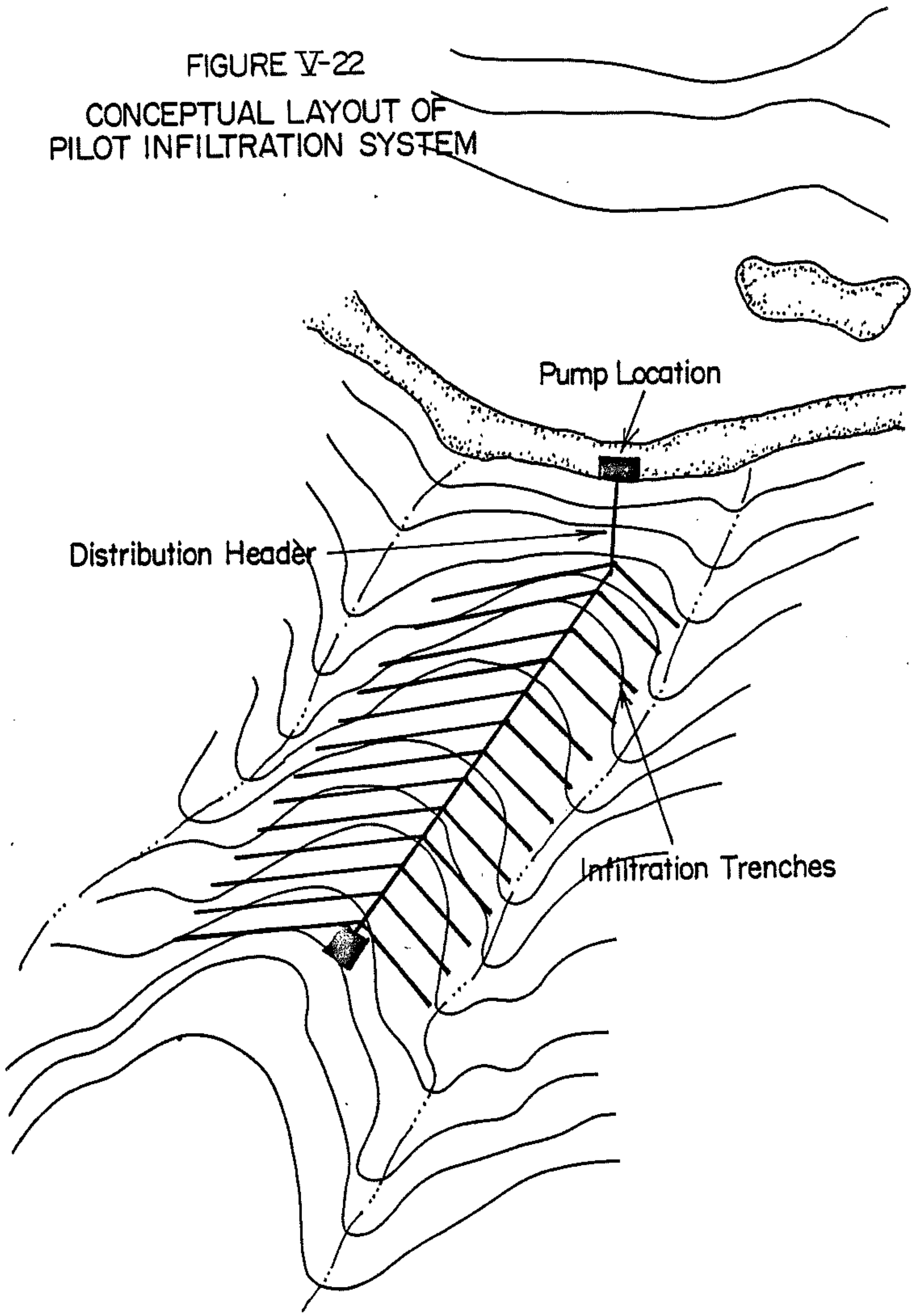
A Conceptual Pilot Baseflow Augmentation System for the Ridley Creek Watershed

The cross-hatched portion of Figure V-19 is the area of Ridley Creek State Park in which the conceptual pilot system was evaluated to determine the potential benefits. Figure V-22 shows a potential layout of the trench system between two small tributaries of Ridley Creek. Some of the assumptions used for the development of this system are:

1. Water would be pumped directly from Ridley Creek without impoundment. For this analysis, only the benefit of the increase in seasonal low flows was evaluated. Therefore, the optimum size and operation of an impoundment to provide storage and regulate peak runoff rates was not determined.

FIGURE V-22

CONCEPTUAL LAYOUT OF PILOT INFILTRATION SYSTEM



The primary process that was of concern for this analysis was the ability to use the shallow groundwater horizon as a non-structural reservoir for providing a "known" level of discharge to Ridley Creek.

2. Water would be pumped to the highest elevation in the infiltration trench system. The trenches would be fed as the water moves back downslope. The trench centers would be spaced approximately fifty feet apart, on both sides of the hill.

3. The trenches were considered to average 180 feet in length on one side of the hill and 250 feet on the opposite side (based on specific site conditions).

4. The trenches would be approximately 1.5 feet deep in the center, with 2:1 side slopes. For protection of the bottom surface of the trench, a gravel layer should be provided.

5. A daily application period of eight hours was considered for this analysis to determine the significance of "over-saturation." This rate could be varied throughout the testing of the pilot system.

6. In order to monitor the impact of the infiltration system on the flow in Ridley Creek, two flow measuring stations should be placed in the creek. One station would be placed immediately upstream of the infiltration system and the second immediately downstream of the system. Each station should employ a continuous flow recorder. An increase in normal stream flow in the downstream station relative to flows recorded by the upstream station would indicate the benefit of the infiltration system.

Utilizing a system layout as described, the hydraulic capacity (i.e., the rate at which stormwater would be applied to the trench system) of the entire system was calculated by using Darcy's Law:

$$Q = K \times i \times b \times l \times n$$

where:

Q = hydraulic capacity or the infiltration rate of a group of trenches

K = hydraulic conductivity of 1.32 inches/hour (assumed to represent a median value for Glenelg soils as reported by the Department of Agriculture's Soil Survey for Chester and Delaware Counties)

i = land slope below trench (a field measurement made on-site; assumed to represent the shallow groundwater surface gradient)

b = saturated thickness of soil (taken to four feet, as an approximate median depth to bedrock for Glenelg soils)

l = length of trench (either 180 or 250 feet)

n = the number of trenches for which the values defined above remained constant

The hydraulic capacity was calculated to be approximately 55 gpm, or if applied at that rate for eight hours per day, a total of 0.25 acre-feet. Of course, this infiltrated water will not instantly arrive at the small tributaries. Therefore, the travel time required for the infiltrated flow to begin to discharge into the tributaries was approximated by:

$$V = \frac{K \times i}{n}$$

where:

V = the velocity of the infiltrated water downslope to the tributaries

K = 1.32 inches/hour, or the same hydraulic conductivity as before

i = as before

n = soil porosity assumed to be 0.451

An average flow velocity for the entire system was estimated to be 0.9 feet/day. Therefore, the average time for the water infiltrated through the system to ultimately discharge into the tributaries was estimated to be 134 days. Therefore, after only 134 days of application for this conceptual baseflow augmentation system, discharge to the tributaries would develop.

Some estimates are presented below to provide an understanding of the increase (in cubic feet per second per square mile, csm) in Ridley Creek baseflow that a full scale watershed baseflow augmentation system could potentially provide. The pilot system is estimated to infiltrate 0.25 acre-feet during eight hours of application utilizing only 7.5 acres. The 0.25 acre-feet of infiltrated runoff is equivalent to 3.5 csm of infiltration area. If the 0.88 square miles (shown on Figure V-19) of the thirty square mile drainage area to the Media water treatment plant intake were utilized as infiltration trench area, the low flow (i.e., $Q_{7\text{-}10}$ low flow) in Ridley Creek could increase to 0.25 csm or an increase of 67 percent over the present low flow value. The $Q_{7\text{-}10}$ low flow would, therefore, increase to 7.5 cfs (4.9 MGD) at the Media intake. Therefore, even during this severe drought, the Borough could withdraw 2.0 MGD and still allow for the required

2.9 MGD pass-by flow. Without the watershed augmentation system, this analysis indicates that the water authority cannot withdraw any flow during Q_{7-10} low flow conditions.

CHAPTER VI

EXISTING INSTITUTIONAL/REGULATORY SYSTEMS

This chapter covers two major topics: a review of existing municipal ordinances and a review of existing agencies and organizations and their current stormwater management functions. This information provides useful background on how stormwater runoff control is presently being approached in the Ridley Creek watershed and what agencies and levels of government are involved. The first section reviews the stormwater provisions in the existing municipal land use and development ordinances. This analysis points out the areas where additions or changes to the ordinances will be required to implement the watershed plan. The second section provides a description of the agencies and organizations, public and private, that are involved directly or indirectly in stormwater management programs affecting the watershed.

Review of Existing Ordinances

As a prelude to developing regulatory measures to implement the watershed plan, the stormwater provisions in the existing municipal ordinances were collected and reviewed. All of Delaware County's Ridley Creek municipalities have some type of stormwater control provisions in one or more of their land use or development ordinances, and Delaware County includes stormwater standards in its S/LD ordinance. There is a wide diversity in the current ordinance provisions. While there are a few common approaches and sometimes similar language, there is no consistent pattern to the level of control or the particular type of regulatory approach taken to stormwater management.

Table VI-1 indicates the types and variety of ordinances currently enforced by the watershed municipalities. As shown by the table, all the municipalities have zoning and S/LD controls although three of the smaller boroughs, Brookhaven, Eddystone, and Parkside, use the County's S/LD ordinance rather than having their own. The municipalities all enforce floodplain management controls, but some have these as separate ordinances while others include provisions in their zoning or building codes. The majority of the municipalities, especially the larger, developing communities, also have grading and erosion and sedimentation (E/S) ordinances.

In terms of stormwater management controls, the existing municipal ordinances range from minimal standards for storm sewers to fairly complex ordinances even incorporating some of the Act 167 standards. Several municipalities have stormwater provisions in more than one of their ordinances, but they are usually included in their S/LD, E/S, grading, zoning (particularly for multi-family districts or planned developments), or building ordinances.

TABLE VI-1

INVENTORY OF EXISTING REGULATORY CONTROLS
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Zoning	Subdivision/ Land Division	Grading	Erosion/ Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Brookhaven Borough	P & Z Code Title 4 - Zon. 1974 Chap. 1270 - Floodplain District	Del.Co.Ord. #78-5 1978 Sec. 307.3 308 - 310	B & H Code Chap. 1432[1] 1972 - all Del.Co.Ord. #78-5 1978 Sec. 308.3	B & H Code Chap. 1432 1972 - all Del.Co.Ord. #78-5 1978 Sec. 308	P & Z Code Title 4-Zon. Chap. 1270 B & H Code Chap. 1420 - Flood Haz.	B & H Code Chap. 1432 1972 Grading Drainage & Erosion Con.	B & H Code Chap. 1432 1972 - all Del.Co.Ord. #78-5 1978 Sec. 309		P & Z Code Title 2 - LandPln.1962 Chap. 1222 Development Plans Del.Co.Ord. #78-5 1978 Sec. 310 Natural Features Preservation
Chester City	P & Z Code Titles 3,5,7 1948 Art 1367 1979 Floodplain	P & Z Code Title 1 1965 Art 1307.03 c.e.g.h. Art 1309.02.04s Art 1309.08c			P & Z Code Art 1367 1979 - all	BOCA 1979			
Eddystone Borough	Ord. #402 Chap. 128 1967	Del.Co.Ord. #78-5 1978 Sec. 307.3 308-310	Del.Co.Ord. #78-5 1978 Sec. 308.3	Del.Co.Ord. #78-5 1978 Sec. 308	Ord. #444 Chap. 41 Art.II - 1976 Flood-Prone Areas	Ord. #444 Chap. 41 Art.II - 1976 Flood-Prone Areas	Del.Co.Ord. #78-5 1978 Sec. 309	Ord. #402 Chap. 128 1967 Sec. 2.4 PUD	Del.Co.Ord. #78-5 1978 Sec. 310 Natural Features Preservation Chap. 112 Art. IV Sec. 112.18 Road Construction Drainage

[1]All sections of ordinance relevant to stormwater/drainage management

P = Planning   Z = Zoning   B & H = Building and Housing

TABLE VI-1
(Continued)

Municipality	Zoning	Subdivision/ Land Division	Grading	Erosion/ Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Edgmont Township	Zoning Ord. 1956 - none Ord. #37 1971 Floodplain Districts - all Ord. #5 1976 - multi.d well. Sec.537, 546, d.e. Ord. #60 1979 - all Floodplain	Ord. #61 1977 Floodplain Districts - all Ord. #70 1980 Sec. 706-709 811, 818	Ord. #70 1980 Sec. 706		Ord. #61 1977 Floodplain Districts - all	Ord. #59 1977 Floodplain Districts - all BOCA 1978	Ord. #70 1980 Sec. 707	Ord. #35 1971 - none Ord. #48 1975 - Sec. 323 d2, d6 Ord. #66 1980 - none	Ord. #30 1967 - Road and Drainage Construction Sec. 6 Ord. #70 1980 Sec. 708 steep slopes
Media Borough	Ord. #625 1973 - none Ord. #726 1982 - cluster dvm.	Ord. #495 1965 Sec. 8 Sec. 10.2, 10.3, 13			Del.Co.Ord. #77-5 1977 - all				
Middletown Township	Chap. IX - Zoning 1979 Sec. 307 R-4B- Residential District Sec. 308 APT - Apt. District Sec. 309 PRD District Sec. 317 Floodplain Districts Sec. 321 Gen. Prov.	Ord. #296 1981 Sec. 305, 307 Sec. 402b, 15d Sec. 403a, 9d 11,12,14,15 Sec. 502 b, d Sec. 512, 513, 515, 517, 518, 521	Ord. #224 1978 - all Ord. #296 1981 Sec. 517	Ord. #224 1978 - all Ord. #296 1981 Sec. 513	Chap. IX Zoning 1979 Sec. 317 Floodplain Districts	BOCA 1978 Building Code Chap. VII Sec. 101	Ord. #224 1978 - all Ord. #296 1981 Sec. 512, 515	Chap. IX Zoning 1979 Sec. 309 PRD District	Ord. #296 1981 Sec. 518 Natural Features Preservation& Tree Planting

TABLE VI-1
(Continued)

Municipality	Zoning	Subdivision/ Land Division	Grading	Erosion/ Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Nether Providence Township	Ord. #225 1940 - none Ord. #434 - 1970 Apt. District - Sec. 704A2 Sec. 705Bld,e Ord. #454 1973 Prof. Off. District Sec. 802aAl Ord. #463 1974 multi. dwell. 703cj-l District Sec. 703g Sec. 705c2 Sec. 712cld-f Sec. 7123	Ord. #270 1949 Sec. 3A Sec. B8, 9, 12, 13, 14 Sec. C2,3,4,6 C2d5 Sec.C3cle, 2d Sec. D4b, El, E4, F2 Ord. #509 1981 Sec. 1E	Ord. #478 1976 Sec. 4d	Ord. #478 1976 - all Ord. #487 1978 Sec. 8	Ord. #487 1978 - all Ord. #496 1980 - all	BOCA 1978	Ord. #478 1976 Sec. 6		
Parkside Borough	Ord. #167 1949 - none	Del.Co.Ord. #78-5 1978 Sec. 307.3, 308, 309, 310	Del.Co.Ord. #78-5 1978 Sec. 308.3	Del.Co.Ord. 78-5 1978 Sec. 308	Ord. #278 1977 - all	BOCA 1981	Del.Co.Ord. #78-5 1978 Sec. 309	Ord. #250 1969 Sec. 7(13) Sec. 12(2)	Del.Co.Ord. #78-5 1978 Sec. 310 Natural Features Preservation
Ridley Township	Ord. #1441 1977 Sec. 10.200 Sec. 16.1001	Ord. #524 1950 Sec. 6e-g Sec. 7 Ord. #825 1955 Sec. 1 Ord. #913 1956 Sec. 1	Ord. #1362 1973 Sec. II		Ord. #1441 Sec. 10.200	Ord. #497 1949 - none		Ord. #1441 Art. XIV	

TABLE VI-1
(Continued)

Municipality	Zoning	Subdivision/ Land Division	Grading	Erosion/ Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Rose Valley Borough	Ord. #156 1954 Sec. 1004	Ord. 191 1964 Sec. 506C Sec. 609			Ord. #234 1977 - all	Ord. #182 1961 - none	Ord. #191 1964 Sec. 609		
Thornbury Township	Chap. XXVII 1977 Sec. M 500 Ord. #5 1982 Mobile Home Parks	Chap. XXII 1977 Sec. 21B Sec. 31B Sec. 33A Sec. 46 Sec. 51B, C Sec. 72 Sec. 76E	Chap. IX 1975 - all	Chap. IX 1975 - all	Chap. XXVII 1977 Sec. M	BOCA 1975	Chap. IX 1975 Sec. 41 Chap. XXII Sec. 72	Chap. XXVII 1977 Sec. 500	
Upper Providence Township	Chap. 80 1975 Art. X Apt. District Sec. 80-56 Art. XA Twnhous.Dist. Sec. 80-58.7 Sec. 80-58.10 Art. XIV Floodplain Art. XVIII 1979 Cluster	Ord. #118 1978 Art. III Sec. 81-8DB Sec. 81-9B Sec. 81-11B, 10ab Sec. 81-11B, 12g,k,l Sec. 81-11B13f Art. IV Sec. 81-22 (Easements) Art. V Sec. 81-27C (Bonds) Sec. 81-32 (Storm Sewers) Sec. 81-38-40 (Natural Conditions Bonds) Art. VI Grading Art. VIII Sec. 81-65AC Sec. 81-65D5C Mobile Homes Art. IX Bonds	Ord. #118 1978 Art. VI Grading	Ord. #118 1978 Art. VI Grading	Chap 80 1975 Art. XIV Floodplain	BOCA	Ord. #118 1978 Sec. 81-32 Storm Sewers Sec. 81-55 Drainage Chap. 34 1982 - all		Ord. #118 1978 Sec. 81-38 Existing Natural Conditions

Source: Delaware County Planning Commission, June 1982

It appears that often a municipality's approach to stormwater management has evolved over a period of years, typically starting with design standards for storm sewers and/or some general language on providing "adequate drainage" and later adding standards controlling the maximum rate of runoff from the development site and more detailed design standards. Generally, the older developed communities have fewer stormwater standards, while the newer suburban municipalities have the more comprehensive stormwater controls. Possibly as a result of this evolutionary pattern, inconsistencies were often noted within individual ordinances and among different ordinances. This is a problem that will have to be addressed in the ordinance revisions that implement the watershed plan.

The review of existing ordinances looked at several elements: the types of ordinances used by the municipalities, the stormwater management standards (both general performance and specific design standards), the administration and enforcement procedures (including plan reviews and fee schedules), and the provisions for continuing maintenance of stormwater management facilities. Only a brief overview of the current regulatory practices is provided here, primarily to identify the range of regulatory approaches to stormwater in the watershed and to determine how applicable they may be after the watershed stormwater management plan is completed. Table VI-2 summarizes the results of the ordinance review for each study area municipality.

Stormwater Management Standards

The municipal ordinances, as a rule, contain one or two types of standards. The first is the general performance standard which describes the end result that the municipality desires to achieve. These statements may be very broad, such as the development shall "provide adequate drainage," or more definite, such as "no increase in the peak rate of runoff." The second type of stormwater standard is the technical design standard which specifies exact conditions to be met. Examples are the storm frequency (e.g., 25-year) for which facilities must be designed or the method to be used to calculate runoff.

In addition to the "provide adequate drainage" standard, some of the other general performance standards presently used in the ordinances are:

- drainage shall be approved by the municipal engineer,
- show existing and proposed drainage facilities,
- take measures to prevent excess drainage onto adjacent or adjoining properties, and
- prevent damage to persons, other property, and drainage structures.

TABLE VI-2

REVIEW OF EXISTING MUNICIPAL ORDINANCES
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

	Municipality			
	Brookhaven Borough	Chester City	Eddystone Borough	Edgmont Township
Stormwater Control Documents	1. Grading, Drainage, Erosion Control Ord. (Chp.1432) applies to nonresid. & resid. if other permit req. 2. Co. S/LD[1]	1. S/D Regulations	1. Co. S/LD 2. Road Construction Drainage Ord.	1. Borough S/LD (Ord.#70) 2. Zoning: Ord.#48- PRD's 3. Zoning: Ord.#54- Multip.Dw. Dist. 4. Bldg.Code (Ord.#59 for Floodplain Dist. 5. Road Construction Ord. (Ord.#30)
Design Standards for Storm Sewers	No (see Co. S/LD)	Minimal - City Engineer sets standards	No (see Co. S/LD) (Road Const. Ord. - carry SW from a str.in accord. with Nat'l.Plumbing Code)	Min. size (15"); follow PennDOT Manual; size to accommodate max. potential flow
Specify Design Storm	No	No	No	Retnt.Fac.- accom. 100-yr. run-off assoc. with 2-50-yr. freq. storms
Specify Calculation Method	No (see Co. S/LD)	No	No (see Co. S/LD)	No (Runoff calcul.based on 100-yr.,24-hr. storm. If farm or disturbed earth, assume meadow as existing condition)
Uses Rate of Runoff Standard	No	No	No	Post-dvm.rnf.rate = rnf.from site in natural condition (S.707.3)
Emphasizes Groundwater Recharge;On-site Infiltration	No	No	No	Encourages recharge; maintain stream's natural character; Lakes,ponds,wetlands,water-courses stay permanent open space except for req. roads.

1 See review of Co. regulations at end of table

TABLE VI-2(Continued)

Design Standard Detention Facility Other SW Management Techniques	No (see Co. S/LD)	(S.1309.8- gen'l.refr.to "SW drainage facil." in accord. with Boro Engineer's specif.)	No	Retnt.basins- utilize natural contours or mntn.shallow slopes; use USDA Manual (S.707.10)
Uses Co. Conserv.Dist. or refers to SCS Stnd.	Refr. SCS Standards	No	No (see Co. S/LD)	Refr.Co. Conserv. Dist.Handbook
Plan Review SW Management, E/S Controls	Bldg.insp.issues permits; Boro Eng. reviews & approves	Rev.storm sewer plans during S/D rev.; No E/S rev.	No (see Co. S/LD)	1. SW & E/S rev. during S/LD plan rev. 2. Req.site plan, grading & landscaping plan, E/S plan, imprvm. constr. plan. 3. Rev. by Twp.Eng., E/S plan rev. by Co. Conserv. Dist. & approved by Twp.
Fees	1. Permit: $/acre 2. Security deposit for cost of work 3. Cost of insp.	Set fee schedule	Set fee schedule	Dev. agrm. to cover plan rev. & insp.
Regular Inspection Schedule	Set sched.for dvm. < 10 sf. homes & for all other dvm. insp. by bldg. insp. &/or Boro Eng.	No (insp. by Eng. during progress)		Prior to start of each const. phase & final insp.; Insp. by Twp. Eng.
Maintenance Provisions	Owner respns.for str., graded surf.,anti-eros. measures (S. 1432.08)	No (2-yr. mntn.bond for pub. improv.)	No	Owner respns.for 2 yrs. after completion of drng.fac. & storm sewers (S. 901.3); 1-yr. mntn. bond for improv.accepted by Twp. (S. 901.5)
Land Use Planning Controls				
-Permits PRD, Cluster, etc.	No	No	PRD (resid. only)	PRD (incl.eros.control stnd.; sewers to minz. eros.& flooding)
-Steep Slope, Soils Stnd.	No	No	No	S/LD- slopes 15-25% - dev. no more than 50% of area; slopes over 25% - no more than 30% of area
-Impervious Cover Limits	No	No	No	No
Misc.Comments, Observations on Ordinances				SW stnds.in zoning for PRD, MF should reference to S/LD ord.

	Municipality		
	Media Borough	Middletown Township	Nether Providence Township
Stormwater Control Documents	1. S/LD Ord. (#495) 2. Cluster Zng. (#726)	1. S/LD (#296- S.512) 2. E/S Control (#224) 3. Zng. (Chp.9) req.storm drng. plans for Apt.(ATT) Dist. & R-4B Dist.	1. E/S Control Ord. (#478) 2. S/LD Ord. (#270) (covers storm sewer primarily) 3. Zng. (#434) (R-5A,multip.dw. & prof. off.dist.)
Design Standards for Storm Sewers	Mentions stnd. & spec.of Boro but none in ord.	Detail stnd. for design, sizing, etc. (S.512d)	S/LD - min.size 15", loc.etc. (S.3B-12)
Specify Design Storm	No	S/LD- Runoff comput - 100-yr. storm (S.512-c); Strg. Comput- (S.512-0) 100-yr.,24-hr.	E/S Ord.- 100-yr.,24-hr. design criteria for storm drng. (only if detailed drng. study req. - S.6)
Specify Calculation Method	No	1. S/LD: Storm sewer- Rat'l.Meth.; Strg. fac.- SCC Meth. 2. E/S Ord.- use SCC Meth.if detailed drng. study prepared (S.301H)	E/S Ord.-calcul."based on guidelines from SCS" (only if detailed drng.study req.- S.6)
Uses Rate of Runoff Standard	No	S/LD- (S.512-a) post-dvm.peak discharge no greater than pre-dvm.; S-512.0- use perm. strg. to "attain zero inc.in peak runoff"	No (E/S Ord.- perm.& temp.SW management fac.designed so that velocity & volume of runoff into any stream not inc'd. S.6b3)
Emphasizes Groundwater Recharge; On-site Infiltration	No	S/LD (S.502)- preserve nat. drgn.; Zng.- R-4 Dist.- retain nat.drng. & identify in SW plan for site	No (Zng.- multip. dw. dist.- retain nat. features, do not pipe streams except for culverts & roads)
Design Standard Detention Facility Other SW Management Techniques	No	S/LD- Detnt.fac. (S.512-0) (detail stnd.) SW str.- ref. to PennDOT & DER stnd.	S/D - adeq.cap.stnd. for bridges & culverts (gen'l. lang. S.3B-13,14); No stnd. for detnt. fac.
Uses Co. Conserv. Dist. or refers to SCS Stnd.	No	1. S/LD- S.513 2. E/S- accord.with Co.,Twp.,& state reg. (S.J(q)- plans conform to spec. of Co. Conserv. Dist.	E/S Ord.- Co. Conserv.Dist. (S-5-a4)
Plan Review SW Management, E/S Controls	(SW & E/S Plans for Cluster Zng.)	1. S/LD- submit SWM & E/S plans with S/LD plans 2. E/S Ord.- Req.E/S plan for land alt. except agric.,driveway,septic tank mntn; submit E/S permit with prelim. rev.of S/LD plan if over 5 ac.; rev. by Co. Conserv. Dist. at Twp's. discretion	1. E/S Ord.- submit applic.for E/S permit with prelim. S/LD plan; req. E/S permit if > 1/2 ac. or bldg.a dw.or "will cause sediment"; Detail drng.study if site has stream with base flow or "where nec." by Twp. Eng.; E/S plan rev.by Twp.Eng.& approv.by Bd.of Comm. opt.rev. of plan by Co. Conserv. Dist. & N.Prov.Env. Adv. Council. 2. Zng.- R-5A, off, multip.dw.dist. submit SW plans, & E/S plan in Mltip. Dw. Dist.- must be rev.by Co.Conserv.Dist.

TABLE VI-2(Continued)

Fees	Set fee schedule	1. S/LD- Dev.Agm.to pay costs for rev. & insp. 2. E/S Ord.- set permit fee & insp. fees are reimbursable	1. S/D- set applic. fee; insp. fee ($10/day); mat'l.testing. 2. E/S Ord.- permit ($ /ac.); if site >1 ac., $5,000 min. bond or escrow before permit
Regular Inspection Schedule	Notify 24 hrs. before each constr. opera.	1. S/LD- Dev.Agm. sets up insp. schedule 2. E/S Ord.- random insp. by Twp.Eng. & submit as-built plans certified by P.E.	1. S/D- Notify 24 hrs.before each constr. phase; insp. by Twp. Eng. 2. E/S Ord.- random basis & submit as-built plans certified by P.E.; insp. by Twp.Eng.
Maintenance Provisions	No	1. S/LD (S.305-a-27)- 18 mo.bond for ded. pub. improv. 2. E/S Ord.- S-301(11)- applic.respn. to mntn.swales, eros. control, etc.; S.301(j)- owner provide cont.mntn. for drng.fac.- ditches, str., pipes, culverts, eros. control. 3. Zng.- R-4B Dist. (S.307-H-4) homeown. assoc.respns. for op.sp.& improv.,Twp. must approv. mntn. provisions	1. S/D Ord.- None 2. E/S Ord.- (S.8d & e)- owner respn. for cont. mntn. & opera.
Land Use Planning Controls			
-Permits PRD, Cluster, etc.	Cluster zoning (req.SWM & E/S Plans for cluster zng. applic.)	PRD Dist. in Zng.; R-4B- Twh.cluster zone	No
-Steep Slope, Soils Stnd.	No	No	No
-Impervious Cover Limits	No	No	Multip. Dw. Dist.- no more than 15% area covered by bldg.& 40% covered by paved areas (ex. bldg.) (Zng. S.703c)
Misc. Comments, Observations on Ordinances	1. Ords. provide minimal stnd.; no specific req.or perfm. measures 2. Mentions permit from Water & Power Res.Bd.- out of date.	1. Ords.contain detailed stnd.,but may be overlap,duplic.,contradict.btw.ord., should be cross-ref. 2. S/LD (S.305-5)- gen'l.stnd.- SW comply to Twp. Ord. & Act 167. 3. E/S Ord.- (S.301-J)- gen'l.stnd.for no harm & no damage to property, persons, drng. etc. 4. Refer to req. DER permits. 5. S/LD (S.305-19)- hold Twp.harmless from damage suits from drng. water.	Drng.prov.in zng. should be consistent with E/S ord.; clearer stnd.of when detailed drng. plan required; E/S Ord.- permittee respns. for preventing harm or damage from any activ. (S.8); E/S Ord.- no inc. in rnf. volume (S.6b3), not consistent with Act 167 that controls rate of runoff.

	Municipality		
	Parkside Borough	Ridley Township	Rose Valley Borough
Stormwater Control Documents	1. Co. S/LD 2. PRD Ord. (#250) (incl.drng. plan in PRD applic.)	1. S/D Reg. (#524) 2. Grading (#1362) 3. PRD (#1441)	1. S/D Reg. (#191) 2. Zng. (#156)
Design Standards for Storm Sewers	(See Co. S/LD)	S/D- refers to Twp. specific but not in Ord.	S/D- min. 18", grade etc.
Specify Design Storm	(See Co. S/LD), No	No	No
Specify Calculation Method	(See Co. S/LD), No	No	No
Uses Rate of Runoff Standard	(See Co. S/LD), No	No	No
Emphasizes Groundwater Recharge: On-site Infiltration	(See Co. S/LD), No	No	No
Design Standard Detention Facility Other SW Management Techniques	1. PRD Ord. (S.8-5)- Estm.amt. of rnf. & show SWM system (sewers, drng.basin, swales, etc. (See Co. S/LD)	No	No (S/D)- adeq.cap. for bridges & culverts) (S.609K)
Uses Co. Conserv. Dist. or refers to SCS Stnd.	(See Co. S/LD), No	No	No
Plan Review SW Management, E/S Controls	(See Co. S/LD) 1. PRD - rev. drng. plan	1. PRD- Twp.Eng. rev. for adequacy of proposed drng.	Rev. drng. in S/D plan; Boro Eng. reviews
Fees	No	1. Grading - $5.00 permit fee	1. Dev. pay expenses incurred for eng., insp., & legal
Regular Inspection Schedule	No	No	Notify 24 hr. before each const. phase
Maintenance Provisions	1. PRD Ord.- submit mntn.plan for nonpub. op.sp. & fac. with PRD applic.	1. S/D- 2-yr.mntn. bond for dedic. fac.	No (2-yr.mntn.bond for dedic.fac.
Land Use Planning Controls			
-Permits PRD, Cluster, etc.	PRD (#250)	PRD (#1441)	No
-Steep Slope, Soils Stnd.	PRD- no bldg. on slopes 25% or more	No	No
-Impervious Cover Limits	No	No	No

TABLE VI-2(Continued)

	Municipality		
	Thornbury Township	Upper Providence Township	Delaware County
Stormwater Control Documents	1. Eros.Sedm.,& Grading Ord.(Chp.9) 2. S/LD (Chp. 22) 3. Zng. (Chp. 27). PRD & mobile homes	1. SWM, E/S Control Ord. (Chp.34) 2. S/D Reg. (#118, Chp. 81) 3. Zng. (Chp. 80- Apt., Twh. Resid.Dist.)	1. S/LD Ord. (#78-5) (contains min. E/S, grading, & storm drain stnds.)
Design Standards for Storm Sewers	1. S/LD- req.storm sewer where rnf.can't. be handled in str.cartway; design drng. facil. to handle anticip.inc. in rnf. from upstream areas	1. S/D- connect to storm sewer if within 1,000 ft.; grade, 18" min.; approve by Twp. Eng.	Min. 15", grade, placement, depth, manholes, inlets
Specify Design Storm	1. E/S & G- sewers- 25 yrs., culverts- 50 yrs.,watercourses, swales- 100 yrs.	1. SWM - facil.accom.storm intensity of 7.3 in., 24 hr. (100-yr. storm)	No
Specify Calculation Method	1. E/S & G - SCC Meth.	1. SWM - use SCC Meth.	Rat'l. Meth. (S.309.3)
Uses Rate of Runoff Standard	Post-dvm. rate of rnf. = pre-dvm. rate for 100-yr. storm	1. SWM- No inc. in peak discharge after earth disturb.activ. (S.34-4A) 2. S/D- no inc. in predvm. discharge from site (S.81-32)	No
Emphasizes Groundwater Recharge; On-site Infiltration	No	1. SWM- mntn.streams,channels, drng.sys., & surf.waters in existing condit. unless Twp. approves alteration 2. S/D-preserve trees & nat.condit. (S.81-38) 3. Zng.- preserve nat.features incl.drng. (Twh.Res.Dist.)	1. Preserv nat.drng.patterns wherever possible (308.3); S.310- Nat.Features Preserv.- mntn.watercourses, bodies of water & wetlands
Design Standard Detention Facility Other SW Management Techniques	1. E/S & G- gen'l.stnd. for all drng.fac. (S.41B-2b) 2. S/LD- detnt.fac.in easem.or pub.Row	1. SWM (see design storm) 2. S/D- if use open watercourse, provide safety, assure capacity & appearance (S.81-32)	Swales- sodded or planted & conform to Co.Conserv.Dist. Stnd. (S.308.3) Gen'l.Stnd.for Drng.Sys. (S.309.4): -do not alter existing pts; -do not overload existing drng.system, create flooding or need for add't.drng.str. Bridges & culverts- use PennDOT Stnd. (S.311.2)

Uses Co. Conserv. Dist. or refers to SCS Stnd.	Ref. in all ordinances	1. SWM (refers to PA E/S Req. - Chp. 25) 2. S/D- follow E/S Handbook for Del.Co. for excav. (S.81-52) & for E/S (S.81-53)	Drng.sys. comply with stnd. of munic.ord. & Co. Conserv.Dist. (S.309.2); E/S meas. comply with Conserv.Dist. (S.308.1)
Plan Review SW Management, E/S Controls	1. S/LD- drng. plan in conformance with E/S & G Ord. 2. E/S & G- req. detailed drng. study where nec.by eng., P.C.or supervisors, Twp.Eng. rev. plans	1. SWM- req.plan & permit for: (1) if 70% of site already imperv.& disturbed area 400 sf. or more, (2) <70% of site imperv.& disturb. area = 20% of site or 7500 sf., (3) trees removed from >10% of site, (4) in floodplain, (5) create steep slope, (6) disturb, modify overland or subsurf.flow of SW; submit E/S plan; Twp. approve. 2. S/D- incl. grading plan 3. Zng.- Twh.Dist.- drng.plan approved by Twp.Eng.	Conserv.Plan (E/S) incl. with final S/LD plan (may not be necessary for minor s/d.); if devm.staged submit drng. plan for entire dvm. with first stage.
Fees	Yes- S/LD & E/S & G	1. SWM- none 2. S/D- set fee by # of units	
Regular Inspection Schedule	E/S & G, & S/LD- random insp. & as-built plans	1. SWM- random insp. 2. S/D- grading subj.to random insp.	Municipality respns.for insp.
Maintenance Provisions	1. S/LD (S.46 I & H)- 18 mo. mntn.bond for pub. dedic.improve.; if priv. ownership of sw retnt.fac.-estb.mntn. fund or perpetual covenants	1. SWM- owner respns.,Twp.may approve homeowner's assoc. 2. S/D- 2-yr.mntn.bond on fac.; owner respns.for cut/fill meas. (S.81-56) 3. Zng.(Twh.& cluster dev.)- owner respn. or Twp.may req.homeowners' assoc. or other entity.	No
Land Use Planning Controls			
-Permits PRD, Cluster, etc.	PRD	Cluster dvm. by spec. except.	N/A
-Steep Slope, Soils Stnd.	No	No	Nat.Features Preserv.-retain nat. terrain & minimize cut/fill
-Impervious Cover Limits	No	No	No
Misc. Comments, Observations on Ordinances		1. SWM- Twp.can attach any condition to prevent danger, etc. 2. S/D- incl.grading regul. (S.81-41) 3. Zng.- does not refer to SWM & S/D ord. Apt.Dist.(S.80-56)- assure that excessive SW does not drain onto adjac.properties- stnd too broad.	Co. Floodplain Ord.(#77-5); may req. retnt.basins in floodplain to prevent inc.in downstream flood elevation

NOTES:

alt. - alteration
cont. - continuous
Co. S/LD - County Subdivision & Land Develop.
ded. - dedicated
drng. - drainage
dvm. - development
dw. - dwelling
E/S - erosion & sedimentation
fac. - facility(s)
imperv. - impervious
inc. - increase
< - less than
MF - multi-family
mntn. - maintenance
> - more than
mltp. - multiple
nec. - necessary
op.sp. - open space
P.C. - planning commission
P.E. - Professional Engineer
PRD - planned residential
Rat'l. - Rational Method
req. - require(d)
rev. - review
rnf. - runoff
S. - section (of an ordinance)
SCC - Soil Cover Complex Method
S/D - subdivision
sf.- square feet
SF - single family
strg. - storage
str. - structure(s)
SW - stormwater
SWM - stormwater management
twh. - townhouse
Zng. - zoning

Source: Review of ordinances, Satterthwaite/Green International, Inc., September 1981

While these standards are sound in their intent, they may present problems in their application or even be inconsistent with Act 167. Who's to decide what is "adequate drainage" and by what definition? Is adequate storm drainage whatever the municipal engineer approves? What if the engineer approves an inadequate plan? Can a municipality ever reject a site drainage plan if all its ordinance says is "submit a plan showing existing and proposed facilities" without providing any standards for what is acceptable or unacceptable drainage control? Is the site developer's responsibility limited to preventing damage to only adjacent (abutting) properties? (As explained earlier in Chapter II, under Act 167, the answer is no.)

Several of the municipalities that have adopted special stormwater ordinance provisions utilize the "no increase in the peak rate of runoff" standard or some variation thereof, which is consistent with the approach taken by Act 167. However, one Ridley Creek municipality also stipulates that there shall be no increase in runoff volume between pre- and post-development conditions. As discussed previously, this regulation on total runoff volume can be more restrictive than Act 167's (Section 13) standard controlling peak rate of runoff.

A number of the watershed municipalities go beyond the general performance language to establish various design standards. At a minimum, all the municipalities regulate the installation of storm sewers in some way. Standards typically deal with sizing, location, and grade. With a couple of exceptions, the current municipal ordinances do not cover other drainage control facilities, such as detention/retention ponds. Several of the ordinances make reference to these facilities, but only one municipality provides detailed design standards. Culverts and bridges are mentioned in a few ordinances. Standards usually refer to municipal or PennDOT specifications for construction, but only two mention DER obstruction permit requirements.

For the most part, there is very little coverage for any other type of stormwater technique. One municipality specifically encourages groundwater recharge, while several have general language dealing with the preservation of natural resources including streams, ponds, and drainageways. All but three municipalities have E/S controls, and in several cases, these are also the municipality's major stormwater management control.

Only four municipalities presently specify storm frequencies for either calculating runoff or designing control measures. The most frequently used design storm is the 100-year storm although lower frequency storms (if stipulated) are applied to storm sewers and culverts. The method for calculating pre- and post-development runoff is identified in five of the municipal ordinances including the County's, which uses the rational method. Another community uses the rational method for storm sewers, and the remaining require the Soil-Cover Complex Method developed by the U.S. Soil Conservation Service (often termed the SCS method). One municipality stipulates that the antecedent condition of the site is to be assumed to be meadow land for purposes of making the runoff calculations.

Ordinance Administration and Enforcement

Administrative and enforcement provisions of the existing ordinances generally cover procedures for plan reviews and approvals, reviews by the County Conservation District (or SCS), site inspections, development fees, and facility maintenance. Most municipalities review stormwater control provisions as part of their S/LD plan review process. A few require separate E/S and stormwater plans, and one community requires the plan to be prepared by a professional engineer with experience in hydrology. The municipal engineer is usually responsible for the plan review, but the governing body maintains final approval power.

There appear to be two standard approaches to site inspections: on a random basis or at the initiation of each phase of site construction with advance notice to be provided to the municipality. One municipality defines a regular inspection schedule which is included in the developer's agreement approved prior to construction.

All the municipalities make some provision for fees to cover plan reviews, inspections, and other legal and engineering expenses. Some communities have a set fee schedule (often based on size of the development), and others require developers to reimburse the municipality for actual costs incurred. It is likely that the municipalities with set fees are not completely recovering all their costs incurred for many developments.

Continuing maintenance of stormwater management facilities receives little attention in the existing ordinances. Most municipalities require maintenance bonds for improvements that are dedicated to the municipality, but there is little or no language covering facilities that remain in private ownership, which is often the case with stormwater management facilities (e.g., retention basins). Some ordinances provide for homeowners' associations to own and maintain such facilities in planned residential or multi-family developments. Only one community specifically mentions maintenance of stormwater retention facilities in its S/LD ordinance, requiring the developer to establish a maintenance fund and perpetual covenants (if necessary). Another stipulates that the municipality must approve maintenance provsions for site improvements in certain multi-family developments.

Generally, the current practice seems to be that the municipality accepts dedication of storm sewers, culverts, or bridges if part of a public road, while storage basins and other stormwater management controls (e.g., swales and seepage pits) remain in private ownership. The Delaware County Planning Commission (DCPC) has developed a policy on ownership and maintenance of retention ponds and basins in residential development. It recommends that:

1. In apartment and/or condominium complexes, maintenance should be the responsibility of the complex owner or the homeowners' association.

2. In single family developments, basins should be located on lots without other structures, and the municipality should be responsible for their maintenance. Basins should not be located on the same lot as a home.

3. Where the municipality is to accept ownership, it should require the developer to provide the first year of maintenance, establish an escrow account to assure this maintenance, and dredge the basin prior to municipal acceptance. The municipal engineer should inspect the basin before the municipality's acceptance.

Better provisions in the ordinances establishing clear maintenance responsibilities prior to development would prevent many of the problems identified in the Conservation District's survey of existing stormwater storage basins in the watershed.

Existing Agencies/Organizations and Their Stormwater Management Functions

An organized approach to stormwater management, beyond the level of the individual development site and municipality, is still a fairly new phenomenon. Therefore, there are fewer agencies and organizations presently involved in managing stormwater runoff quantities and the institutional system is less complex than those required for managing water quality. Other than flood control activities performed by the U.S. Army Corps of Engineers and technical assistance provided by the U.S. Soil Conservation Service, two other levels of government are involved: the Commonwealth of Pennsylvania and the local municipalities. In between, there are very few stormwater management responsibilities.

This section briefly describes the differing roles and responsibilities of the various levels of government, specifically as they relate to stormwater management activities in the Ridley Creek watershed. Included in the discussion is an evaluation of the compatibility and consistency between the existing plans and programs of these agencies and the Ridley Creek watershed plan.

Federal Agencies and Functions

Environmental Protection Agency (EPA)

Congress, in 1972, passed the Clean Water Act (PL 92-500). This piece of legislation and subsequent amendments deal primarily with the water quality aspects of storm runoff, but because water quality and water quantity are interrelated, PL 92-500 does impact stormwater management activities. The federal agency responsible for implementation of the Clean Water Act is the Environmental Protection Agency, which administers its programs in this area through its Region III office located in Philadelphia. In the stormwater area, a principal function of EPA is to oversee and fund the preparation of the areawide (Section 208) water quality management plans, which include consideration of water quality impacts of stormwater runoff. EPA is also conducting

Property Owner

When all is said and done, it is the property owner who bears the final responsibility to provide safe control of stormwater runoff from his/her property. This situation is true for a private person or organization as well as for a public agency performing its proprietary functions. The property owner must design and construct stormwater management controls required to meet the standards of Act 167 (Section 13), the watershed plan (when adopted), and the municipal ordinances. Unless a stormwater control facility is dedicated to a public entity, private property owners are usually responsible for the ongoing maintenance of these facilities.

CHAPTER VII

MUNICIPAL REGULATORY APPROACHES TO STORMWATER MANAGEMENT

This section outlines some guidelines for incorporating stormwater management provisions consistent with the watershed plan in municipal land use and development ordinances. The regulatory approach presented here involves the creation of a stormwater ordinance package. This approach utilizes the powers provided in local zoning ordinances (including planned residential development regulations), S/LD ordinances (including E/S and grading regulations), and building codes. In this way, the ordinance package ensures a comprehensive stormwater management system that applies to all types of land alteration, whether they be new development, expansion or redevelopment of existing lots and structures, or agricultural activities.

The ordinance package, rather than a separate, single-purpose stormwater ordinance, is recommended for one primary reason. The Municipalities Planning Code (MPC) and the municipal codes provide very clear enabling powers to municipalities to adopt these types of ordinances and to address stormwater drainage issues within these ordinances. Also, as discussed in the legal framework section, the MPC establishes clear procedural requirements for administering these ordinances, which protects both the municipality and the applicant. Therefore, if a land alteration activity falls within the scope of the MPC, then it should be assumed that the Legislature intended it to be reviewed and regulated according to these procedures, whether the activity is being regulated for density, lot layout, street design and construction, slope preservation, floodplain or stormwater management, or any of the areas where municipalities may regulate development.

In addition, most municipalities in the Ridley Creek watershed presently enforce one or more of these three 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 the developers) to add the necessary stormwater provisions and reviews to their existing regulatory system rather than to create a new and separate one.

Constructing Effective Stormwater Ordinance Provisions

Before discussing specifics of the stormwater ordinance package, some general comments on regulatory objectives and approaches may be helpful. From meetings with local officials, developers, and builders, it is clear that all parties are apprehensive about implementing a successful regulatory approach to a complex issue like stormwater. Municipalities are concerned about developing a reasonable set of controls which are within their technical and financial capability to administer. Developers are also concerned about reasonable controls, ones that are applied fairly and uniformly throughout a watershed and that do not discourage creative solutions to stormwater management problems.

These are very legitimate concerns, and a conscious effort should be made to address them during the drafting and implementation of the stormwater regulations. To be most effective, the stormwater ordinance controls must be:

- o clear (understandable) and readily obtainable,
- o flexible, and
- o uniform throughout the watershed.

Clarity is very important for both 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 is essential for sound stormwater management. Municipalities do not want to discourage creative design and engineering in stormwater management. Developers should be encouraged to seek solutions that best fit their sites while meeting the objectives of the watershed plan and Act 167. Whenever possible, ordinances should use incentives to encourage good stormwater management practices rather than using negative regulations. Both the developer and the 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 ordinances. A performance standard states an end result or outcome which is to be achieved, but it does not prescribe specific means for achieving it. In contrast, a specification standard states the exact characteristic or design standard to be used. Usually, a performance standard is easier to interpret and supply to real situations. Therefore, municipal officials are less likely to face repeated requests for changes or modifications in the standard to accommodate a particular development site condition.

In actuality, the best set of stormwater regulations will combine performance and specification standards. Performance standards will establish what the stormwater system as a whole must accomplish (e.g., the release rate percentage), while specification standards will apply to parts of the system, such as rainstorm intensities for which detention basins must be designed.

Finally, uniformity of the regulatory measures is necessary if all the municipal ordinances are to be consistent with the watershed plan. This does not mean that all municipalities have to adopt the exact same ordinances. It does mean, though, that all municipal ordinances will have to apply the same stormwater standards and criteria, as descirbed in the watershed plan, in their ordinances.

A uniform regulatory approach has other advantages. Municipalities could save by jointly administering the stormwater portions of their ordinances (e.g., engineering reviews and site inspections). This more efficient administration could enable the municipalities to afford more professional technical assistance and minimize the potential delays in administrative processes. A uniform system makes it easier for municipalities and developers alike 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.

It would be desirable for the watershed plans to adopt a fairly uniform regulatory approach in all of the designated watersheds in Delaware County. More County-wide cooperation would be possible on stormwater management activities. It would simplify management for some of the larger municipalities whose borders include two or more watersheds. Otherwise, a municipality could find itself with several approaches to stormwater management and a very real administrative nightmare.

The Stormwater Ordinance Package

There are three principal parts to the municipal stormwater ordinance package:

- the subdivision and land development ordinance,
- the zoning ordinance, and
- the building code.

The majority of the stormwater management controls should be placed in one article (or section) of the S/LD ordinance. For easy reference and to promote regulatory coordination, the municipality's E/S and grading (cut/fill) provisions should be included as additional articles in the S/LD ordinance.

Since all land alteration activities do not come under the definition of a "subdivision" or "land development," it is important to link the zoning ordinance into the ordinance package. By appropriate cross-referencing in the zoning district and general regulations (including planned residential or mobile home park standards if permitted by the ordinance), the municipality can ensure that stormwater standards apply to single lot or single structure developments, expansions or reuses of existing sites, and specialized land use activities such as farming and mining.

The inclusion (or appropriate referencing) of stormwater provisions in the building code reinforces the application of stormwater standards to all building construction or alteration in the municipality. The building code also sets standards for the use of such stormwater management techniques as roof-top or parking lot storage. It is not essential that a municipality have a building code in order to implement the stormwater standards and criteria of this plan. However, if the municipality desires to regulate the use and application of many structurally related stormwater control techniques, then it must do so through a building code.

The following sections identify some of the key additions and changes to the municipal ordinances that are needed to incorporate the standards and criteria of the Ridley Creek watershed plan. Although a general format has been given to some of the ordinance provisions to assist local officials, the drafting of the final ordinance language will, of course, remain each municipality's responsibility. Not all of the ordinance provisions discussed here will apply equally to all of the watershed municipalities. The municipalities reflect different levels, types, and patterns of development and different growth objectives. Each municipality can tailor these general ordinance guidelines to its own particular needs and circumstances, but it must be sure that the final ordinances are consistent with the watershed plan and compatible with those of the other watershed municipalities. To a large degree, this coordination can be accomplished through County Planning's review of the municipal ordinances as they are adopted and amended (as required by the MPC).

Subdivision and Land Development Ordinance

There are several reasons for recommending that the majority of the stormwater controls be included in the S/LD ordinance. Many of the land alteration activities with significant stormwater impacts will fall under the purview of this ordinance. Also, most watershed municipalities already apply some type of drainage provisions as part of the S/LD plan review.

Article V of the MPC clearly empowers municipalities to address runoff and drainage issues as part of their S/LD ordinances. Under their S/LD regulatory powers, municipalities may adopt standards for the layout, development, and continuing maintenance of the site and for the installation of public improvements (or common facilities), including stormwater management facilities; make provisions for necessary drainage easements; and require financial guarantees that all proposed improvements are completed in accordance with the approved S/LD plan and the ordinance. These are the major authorities which a local community needs to implement an effective stormwater program.

Some municipalities try to apply site development standards (e.g., site planning, street design, and drainage) through their zoning controls, which is a doubtful use of the municipality's zoning powers. The MPC clearly states that the zoning ordinance regulates the use of land and the location, dimensions, density, and intensity of uses and that the S/LD ordinance provides the standards for the development and improvement of land. There is a clear division of labor between the two types of ordinances.

Table VII-1 outlines the major elements of the stormwater article for the S/LD ordinance. The material follows a sample format for the article with explanatory comments on the various provisions. It provides a guide to the watershed municipalities for reviewing their existing S/LD ordinances and preparing the necessary amendments to implement the watershed plan's standards and criteria. As noted in the comments, the municipalities will have to adapt these guidelines to their existing ordinance format and make sure that they are compatible with related provisions of their ordinances (e.g., site plan review procedures).

TABLE VII-1

SAMPLE FORMAT:
STORMWATER MANAGEMENT ARTICLE, S/LD ORDINANCE

- -

Sec. 101 PURPOSE AND APPLICABILITY

1. Purpose

   - To manage stormwater runoff resulting from land alteration and disturbances in accordance with the Ridley Creek Stormwater Management Plan and the Pennsylvania Stormwater Management Act (Act 167).

   - To utilize and preserve the desirable existing natural drainage systems and to preserve and restore the flood-carrying capacity of streams.

   - To maintain existing flows and quality of streams.

   - To maximize recharge of groundwaters and encourage natural infiltration of rainfall to preserve groundwater supplies and stream flows.

   - To provide for adequate maintenance of all permanent stormwater management structures in the municipality.

2. Applicability

All forms of land alteration and disturbances relating to subdivisions, land developments, and mobile home parks unless specifically exempted or modified by this article.

Sec. 102 DEFINITION OF TERMS

Comment: Specific stormwater terms used in this article, such as release rate percentage, should be included either here or in a separate article for definitions (if this is the form of an existing ordinance).

Sec. 103 STORMWATER PLAN REQUIREMENTS

Comment: This section should outline the requirements for the form and contents of the applicant's stormwater plan and the procedures for reviewing and approving the plan. General suggestions for these requirements are presented here, but they should be adapted to fit the municipality's established S/LD review process.

1. No earthmoving or land disturbance activity shall commence before the S/LD and stormwater plan for the site is approved.

2. Exemptions from the submission of a stormwater management plan for a development site

    a. Subdivisions or land developments that do not create more than 7,500 square feet of impervious land area shall be exempt from the stormwater plan requirements of this section.

    b. For parcels under single ownership, no more than one subdivision or land development creating less than 7,500 square feet of impervious surface shall be permitted before requiring a stormwater management plan for the entire parcel.

    c. Application procedures for exempt developments:

        (1) Persons engaged in land alteration of exempt development sites are exempt <u>only</u> from the <u>full</u> stormwater plan requirements of this

ordinance. They are still responsible for applying sound stormwater management practices in accordance with the standards of this ordinance and the Pennsylvania Stormwater Management Act (Act 167) in the development of the site.

(2) A sketch stormwater plan showing the location and nature of the proposed stormwater techniques for the site shall be submitted to the municipal engineer.

(3) The stormwater plan for the site must be approved by the engineer prior to the issuance of any building (or zoning use) permits.

Comment: The definition of exempt developments should be consistent with the watershed plan. Section 2(b) is necessary to eliminate attempts to use the small development exemption to avoid stormwater requirements.

3. Contents of the stormwater plan submission

Comment: The ordinance should identify the materials which the applicant is required to submit and the specified format he is expected to follow. These may vary in each municipality so they should be consistent with the S/LD plan procedures established in the community's ordinance.

Generally, the stormwater site plans should be prepared at a scale of at least one inch = 100 feet. At a minimum, five-foot contours (existing and proposed) should be shown, although two-foot intervals are desirable. The plans should show all existing and proposed drainage courses, 100-year floodplains, bodies of water (natural or artificial) and similar significant natural features, and sanitary and storm sewers. The information should include soil types and underlying geology on the development site.

All proposed stormwater management control techniques should be located on the plans, along with proposed E/S controls (temporary and permanent). Design information for these facilities should be included.

Existing and proposed drainage easements or rights-of-way should be identified. The plan submission should include all of the calculations required for determining pre- and post-development discharge rates and for designing any proposed stormwater control facilities.

4. Plan review process

a. Preliminary plan review

Comment: Most communities use a two-phase, preliminary and final, review process for S/LD plans. The applicant should submit the stormwater management plan as part of the preliminary subdivision and land development plan. Applicants should be encouraged to meet with the municipal engineer during this phase to discuss proposed stormwater management techniques. Also, applicants should be sure that they understand the stormwater management performance standards and are using the correct base data. The preliminary submission should include documentation of the runoff calculations and other pertinent information.

It is imperative that the proposed stormwater plans be reviewed by an engineer with expertise and experience in stormwater management. Engineers who do not regularly work with hydrology and hydraulics may not fully understand the stormwater computation procedures or they may not be up-to-date on facility design.

b. Final plan review

Comment: The submission of the final stormwater plan should include any modifications requested during the preliminary plan reviews. Final plan approval and/or building permits should not be granted until all necessary obstruction, floodplain, and/or E/S permits have been obtained.

The regulations should require that any modifications to the preliminary stormwater management plan be reviewed and approved by the municipal engineer. These normally would be major changes relating to a change in the control technique or relocation or redesign of a control facility.

Modifications to the stormwater management controls should not be made by either the planning commission or the governing body in their approval of the entire S/LD plan without taking into account the technical comments of the municipal engineer. It must be recognized that the intent of the review and approval process is to ensure that all proposed stormwater management activities are consistent with the watershed plan and the municipal ordinances.

Sec. 104 STORMWATER MANAGEMENT PERFORMANCE STANDARDS

Comment: This section begins with the general performance standard which incorporates the language of Section 13 of the Pennsylvania Stormwater Management Act (Act 167). This provides the overall standard (i.e., test) by which to measure specific stormwater controls. By including the Section 13 language in the local ordinance and not simply making reference to Act 167, the municipality can enforce Section 13's standards under its own regulatory authorities.

Following the general performance standard, the section establishes the procedure for utilizing the release rate percentage, direct discharge, and downstream impact evaluation standards. Eventually, this section of the ordinance would be organized by watershed within the municipality. Initially, the amendments to the local S/LD ordinance would separate the standards for the Ridley Creek watershed from those for the remaining watersheds in the municipality.

1. General performance standard

   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:

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

   b. 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. Release rate percentages - Ridley Creek watershed

For purposes of stormwater management, each subarea of the watershed is assigned a release rate percentage, as defined by this ordinance and shown on the Ridley Creek Watershed Release Rate Map (Plate No. 2) available in the municipal offices. This percentage is applicable to any particular site in that subarea. The post-development peak stormwater runoff rate discharging from the outfalls of a development site cannot exceed the subarea release rate percentage in order to comply with the Ridley Creek watershed plan. The following procedure should be followed in applying the release rate percentage.

a. Compute pre- and post-development runoff hydrographs and peak discharges for the 2-, 10-, 25-, and 100-year storms using the U.S. Soil Conservation Service (SCS) Soil-Cover Complex Method. The 24-hour total runoff depths for these return periods for the Ridley Creek watershed shall be:

Return Period	Depth in Inches
2-year	2.92
10-year	4.68
25-year	5.54
100-year	6.85

The computations should assume actual existing soil and land use conditions on the site, using the existing land use map and the SCS Soil Classification Map for the watershed. The computations for post-development discharges should include all reduction for proposed on-site infiltration techniques.

b. Compare post-development discharges to the pre-development discharges. If greater, on-site storage is required. Off-site storage may be substituted provided that (1) proper legal arrangements (easements, perpetual covenants, etc.) are made, (2) no problems are created between the development site and the off-site storage location, and (3) it is approved by the municipal engineer.

c. If on-site storage is required, the size of the facility(s) shall be determined by applying the release rate percentage to the post-development discharges for the 2-, 10-, and 25- year design storms. Provisions shall also be made for safely passing the post-development 100-year runoff flows without damaging (i.e., impairing the continuing function of) these systems. The storage area shall be designed in conformity with the provisions of this ordinance.

d. The proposed plan and computations must be prepared by a registered professional engineer with expertise in stormwater management.

Comment: Copies of the release rate map and all background data required by the applicant should be readily available in the municipal offices. There should be arrangements for the applicants to purchase copies of these materials through either the municipality or the County.

3. Direct discharge - Ridley Creek watershed

This provision applies only in subareas that are immediately adjacent to Ridley Creek (Subareas ____________). Development sites in these subareas may discharge total stormwater runoff flows through outfalls directly into Ridley Creek. Stormwater outfalls must be constructed so as to prevent erosion and scour of the Ridley Creek channel. Under these conditions, post-development peak runoff rates may exceed pre-development peak runoff rates.

Comment: The rationale for this provision is based on the flow "timing" characteristics of the watershed, as explained earlier in the plan. The stormwater management plans for sites proposing to use direct discharge would have to be approved by the municipal engineer.

4. Downstream impact evaluation - Ridley Creek watershed

If an applicant proposes to exceed the release rate percentage for a subarea, one of the following evaluations must be completed.

a. If the stormwater runoff flow from the development is proposed to be directed into an existing or proposed stormwater conveyance channel (i.e., closed storm sewers and concrete lined or riprap protected channels), the post-development discharge may exceed the prescribed release rate percentage. The applicant must demonstrate sufficient capacity in the proposed conveyance

Sec. 105 CRITERIA AND STANDARDS FOR STORMWATER MANAGEMENT CONTROL TECHNIQUES AND FACILITIES

Comment: This section identifies types and design criteria for stormwater management control measures, including either on- or off-site storage facilities. To promote flexibility and innovative approaches, applicants should be permitted to submit plans for control measures that they believe to be most appropriate to the site and capable of meeting the stormwater performance standards.

1. Applicants may utilize any appropriate stormwater management techniques or a combination of techniques as approved by the municipal engineer. Off-site control measures, including storm sewers and/or storage facilities, may be used in accordance with the watershed stormwater plan and as approved by the municipality.

2. Possible stormwater control measures, including on-site infiltration techniques, detention facilities, and other measures, are described in the Ridley Creek watershed plan. Other measures are acceptable when approved by the municipal engineer. Information and standards for developing stormwater management controls may be found in the following references:

    a. "Urban Hydrology for Small Watersheds," Technical Release No. 55, USDA, Soil Conservation Service, January, 1975.

    b. "Soil Erosion and Sedimentation Control Manual," Pennsylvania Department of Environmental Resources, May, 1976.

    c. "Engineering Field Manual for Conservation Practices," USDA, Soil Conservation Service, 1975.

    d. "Practices in Detention of Urban Storm Water Run-off," Special Report No. 43, American Public Works Association, June, 1974.

3. If special geological hazards or soil conditions are identified on the site, the developer's engineer shall consider the effect of proposed stormwater management measures on these conditions. In such cases, the municipality may require an in-depth report by a competent soils engineer.

4. Storage facilities shall be designed to control the post-development peak stormwater runoff rates for the 2-, 10-, and 25-year design rainfall events to the subarea's release rate percentage or that approved through the downstream impact evaluation. Provisions shall also be made for passing the post-development 100-year runoff flows through a stormwater detention facility without damaging or causing failure of (i.e., impairing the continued function of) the facility. A detailed description of the design and construction of detention basins to accomplish the performance standards of the watershed plan is presented in Appendix D. Storage facilities shared by more than one development site are permitted within a single subarea of the watershed, provided they meet the above criteria.

   Runoff from the development sites involved shall be conveyed to the facility from its source in a manner so as to avoid adverse impacts, such as flooding or erosion and scour of natural channels, to downstream channels and property.

   Comment: The municipality may desire to include other design standards for storage facilities relative to their location, accessibility, and security (e.g., fencing). At a minimum, a community should require that basins be accessible for maintenance based on the type of equipment or procedures required.

5. Storm sewer systems

   Comment: All watershed municipalities now include design specifications for storm sewers in their existing S/LD ordinance or other municipal specifications. These standards should continue to be applied.

   Where storm sewers are proposed, developers must show that there is sufficient channel capacity from the point where the storm sewer outlets into the natural drainage system and further downstream to the base of the watershed.

   Also, municipalities should make sure that the required obstruction permits are obtained, along with floodplain permits if required.

Sec. 106 MAINTENANCE OF STORMWATER FACILITIES

Comment: It is essential that the stormwater regulations provide for the perpetual maintenance of all stormwater management control measures, especially any storm sewer and storage facilities. The maintenance provisions should identify ownership of the control facilities and provide financing sources for future maintenance activities. The provisions should be in accordance with the approved watershed plan. The ordinance guidelines here are consistent with the policies presented in this plan and with those of the Delaware County Planning Commission.

1. Stormwater control facilites located on or serving properties developed for commercial, industrial, or multi-family residential (including condominium uses) shall be owned and maintained by the owner of the property or the complex. If a homeowners' association is formed, then the facilities shall be the responsibility of this association.

2. Stormwater control facilities serving single-family (individual lots) or multi-family developments wherein the streets, sewers, and other public improvements are to be accepted by the municipality shall likewise be accepted and maintained by the municipality.

3. Stormwater control facilities serving public or semi-public uses, such as schools, hospitals, churches, or similar institutional facilities, shall be owned and maintained by the property owner.

4. Stormwater control facilities serving state, county, or municipal facilities such as parks shall be owned and maintained by the respective political entity.

5. Where shared-storage facilities are proposed, the applicant shall submit a plan for their maintenance with the preliminary and final stormwater management plans, identifying the facility owner, easements, covenants providing for access to the facility, and a proposed maintenance funding plan (if the facility is not to be accepted by the municipality).

6. In single family, multi-family, commercial, or industrial developments where the stormwater control facilities (especially basins) are not to be accepted by the municipality, the developer shall submit a proposed maintenance schedule and funding plan as part of the stormwater plan for the development site, which shall

be approved by the municipality. Prior to approval of the final S/LD plan, the developer shall establish an escrow or similar account to set aside funds for the first year's (after completion) maintenance costs.

7. Stormwater control measures located on an individual lot/structure, such as roof-top storage, drainage swales, and seepage pits, shall be the responsibility of the property/structure owner. These responsibilities shall be included in the deed or lease for the property or structure. This provision is applicable although other stormwater control facilities, such as storm sewers or storage basins, are to be owned and maintained by another public or private agency.

Comment: It will be most effective to have individual on-site stormwater techniques maintained by the owner, rather than requiring easements, etc. to provide access by another entity. The important point is to stipulate these responsibilities in advance in the deed or lease for the property.

8. Prior to the acceptance of any stormwater facility, the municipal engineer shall inspect the facility to ensure its proper construction and functioning. All facilities must be free of sediment or debris before acceptance and/or dedication. Any required access easements should be obtained.

9. The municipality shall require that a maintenance guarantee, in accordance with the provsions of the MPC (Sec. 509), be provided.

10. Before acceptance and/or dedication of any facility, the developer shall submit as-built plans and a schedule for required maintenance. As-built plans need not be submitted for facilities located on an individual lot/structure.

Comment: Many municipalities already require that as-built plans be submitted prior to acceptance of streets, sewers, and other improvements in the S/LD. This should be a standard procedure for all municipalities, and this provision could be included in the section of the S/LD ordinance dealing with public acceptance of site improvements.

Sec. 107 INSPECTIONS

Comment: Regular inspections by the municipal engineer or other qualified persons are the only way to ensure that the approved stormwater management plan is implemented properly.

The following section identifies the key intervals when inspections ideally should be made. Generally, these points will coincide with other inspections for site improvements, building construction, and erosion/sedimentation. This schedule will have to be adjusted to fit the particular conditions of the development and the available staff of the municipality. Municipalities should include fees for the necessary inspections as part of their development fee schedules.

1. Key inspection phases

   a. At the completion of preliminary site preparation, including stripping of vegetation, stockpiling of topsoil, and construction of temporary stormwater management and erosion control facilities.

   b. At the completion of rough grading, but prior to placing topsoil, permanent drainage, or other site development improvements and ground covers.

   c. During construction of the permanent stormwater facilities at such times as specified by the municipal engineer.

   d. Completion of permanent stormwater management facilities, including established ground covers and plantings.

   e. Completion of any final grading, vegetative control measures, or other site restoration work done in accordance with the approved plan and permit.

2. It is the responsibility of the developer/builder to notify the municipal engineer well in advance of the completion of each identified phase and to arrange for the required inspection.

3. Work should not commence on a subsequent stage until the preceding stage has been inspected and approved. Any portion of the work which does not comply with the approved stormwater plan must be corrected by the

permittee within a stipulated time. No work shall proceed on any subsequent phase of the stormwater management plan, the subdivision or land development, or building construction until the required corrections have been made.

4. If at any stage of the work the municipal engineer determines that the stormwater management controls or other requirements are not being installed as shown in the approved plans, the municipality may revoke existing permits until a revised plan is submitted and approved.

Sec. 108 PERFORMANCE ASSURANCES, FEES, AND VIOLATION PENALTIES

Comment: These final items should be included in the appropriate articles of the S/LD ordinance. They should be consistent with current practices of the municipality and applicable state law.

The ordinance should identify the types of acceptable financial guarantees (e.g., bonds, escrow accounts, etc.) required for any stormwater management controls. These must be in conformance with Section 509 of the MPC. In most of the municipal ordinances, this can be handled by amending their existing provisions to indicate clearly that stormwater controls are subject to maintenance guarantees if they are to be dedicated to the municipality.

The ordinance should also provide that the governing body may establish reasonable fees to cover the cost of the plan reviews and inspections for the stormwater management systems. The actual fee schedule should be adopted by separate resolution so that it can be changed without having to go through a formal amendment of the S/LD ordinance.

Fee types and amounts are at the discretion of the municipality. It should recognize that adequate administration of the stormwater provisions may require additional staff or consulting time (particularly if its current stormwater controls are fairly minimal), and these costs should be paid by the applicant. Watershed municipalities already using developer's agreements or directly reimbursable fee systems should not have to amend their existing fee provisions.

Failure to implement the approved stormwater plan for the site would be a violation of the S/LD ordinance, and penalties would be as prescribed by the municipal ordinance. (Refer to Section 515 of the MPC.)

The municipality can also take action under Section 15 of the Stormwater Management Act. Any violation of the Act, the watershed stormwater plan, or the ordinances adopted to implement it is a public nuisance. The municipality can seek an injunction, writ of mandamus, or other appropriate action to abate, prevent, or restrain the violation.

Also, if the violation involves an obstruction permit or relates to the E/S measures, the municipality can seek remedies under the Dam Safety and Encroachments Act (Section 19) or the Clean Streams Law (Article VI). Again, violations of these statutes are declared public nuisances. In these cases, the municipality would first seek enforcement action through DER. If DER fails to respond, then the municipality, upon notice to the Commonwealth, may bring suit in the name of the Commonwealth to abate the nuisance or prevent or restrain the violation.

Zoning Ordinance

Municipalities can utilize their zoning ordinances to ensure that stormwater standards are applied to single lot/structure developments and changes or reuses of existing uses. Also, through the zoning ordinance, municipalities can protect sensitive environmental areas (e.g., steep slopes) which may contribute to stormwater problems or are subject to runoff damage (e.g., wetlands).

Incorporating adequate stormwater provisions in accordance with the watershed plan should not require substantial amendments to most of the existing municipal ordinances or maps. The key additions or changes are outlined here; many of these simply involve cross-referencing to appropriate sections of the stormwater management article of the S/LD ordinance. Again, the municipalities should draft the necessary amendments carefully to ensure internal consistency among all sections of the zoning ordinance and with other municipal ordinances.

The recommended additions or changes to the local zoning ordinances are:

1. The watershed release rate percentage map should be adopted as an overlay to the zoning map, and, if possible, designated 100-year floodplains should be shown on the overlay. This recommendation is made to facilitate the review of applications; the overlay map immediately alerts both the developer and the municipality to the fact that a site is subject to stormwater management (and/or floodplain) requirements.

2. Language should be added in the general provisions or supplementary regulations section of the ordinance extending the coverage of stormwater management standards to all uses covered by the zoning ordinance. For example:

   a. All uses covered by the provisions of this zoning ordinance shall comply with the requirements and standards of the stormwater plan for the watershed in which the use is located and to the provisions of Article ____ of the municipal S/LD ordinance and applicable provisions of the municipal building code.

   b. Agricultural activities, where permitted by this ordinance, shall have a conservation plan prepared (or reviewed) by the U.S. Soil Conservation Service. Appropriate administrative procedures of the Delaware County Conservation District must be followed. The standards and criteria of the applicable watershed plan shall be considered in the preparation of the conservation plan.

   In the case of farming activities, municipalities do not attempt to regulate them extensively, especially in relation to stormwater management and E/S controls. However, these activities do appear to constitute land alteration or disturbance activities within the scope of the Stormwater Management Act. This may require municipalities to rethink how they handle farming activities under their zoning ordinances.

3. The municipalities should review the district regulations and planned residential development (PRD) sections of their ordinances to remove any contradictory provisions for stormwater management. The district regulations could make reference to the stormwater requirements in the general provisions. Similar language as in item "2a" above could be included in the PRD provisions.

   This type of cross-referencing would eliminate the potential for contradictory or inconsistent language in the stormwater management standards in the zoning ordinance. This is currently a problem in some of the municipal ordinances.

4. The zoning ordinance should specify that an applicant cannot obtain a zoning use (or building) permit until any required floodplain, obstruction, and E/S permits have been obtained. These provisions assure the municipality that the requirements of these laws have been met by the applicant.

   Municipalities are sometimes prone to overlook these prior permitting procedures under pressure to get a project under-

INSTRUCTIONS

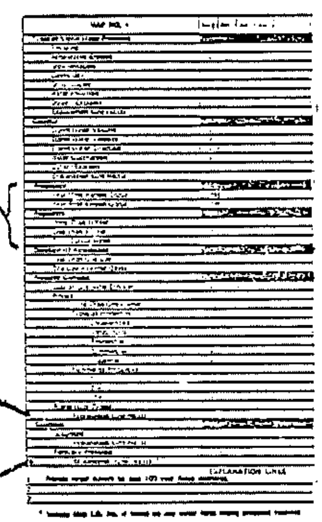
Begin with A-1 as the first map number to identify the first storm water problem area. Illustrate the defined problem on the watershed map provided, and identify it with its map number.

For each storm water problem area within your municipality, enter the map identification number at the head of the column. Describe the problem by placing a check (✓) in the appropriate blocks of the column under this map identification number.

When an additional explanation is required, write the line number(s) used in the column marked "Explanation Line No.(s)". Example 1, 2-3, etc.

If storm water problem occurred during and after Agnes, describe the frequency of the problem after Agnes.

Sample



Use the explanation lines to list the typs of public property damages, e.g. roadways, hospitals, etc.

Enter the line no.(s) used to list the map ID no.(s) for the proposed facilities.

Definitions

Storm Water Problem Area
An area that defines the farthest extent of a storm water problem, including any area that experiences property damage, inundation, accelerated erosion, surface water pollution, groundwater pollution, landslides, or any other problem as a result of storm water runoff.

Groundwater
Water in the ground below the water table.

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

Sedimentation
The process by which soil or other surface materials, transported by surface water, is deposited on stream bottoms.

Water Obstruction
Any dike, bridge, culvert, wall, wingwall, fill, pier, wharf, embankment, abutment, or other structure located in, along, across, or projecting into any watercourse, floodway, or body of water.

EXPLANATION LINES (continued)

4 __________
5 __________
6 __________
7 __________
8 __________
9 __________
10 __________
11 __________
12 __________
13 __________
14 __________
15 __________
16 __________
17 __________
18 __________
19 __________
20 __________
21 __________
22 __________
23 __________
24 __________
25 __________

12/81 SIGNIFICANT OBSTRUCTIONS (MAN-MADE OR NATURAL) FORM B SHEET ______ OF ______

WATERSHED

NAME ____________________
MUNCIPALITY ____________________
COUNTY ____________________

FOR COUNTY USE:

FORM COMPLETED BY

NAME ____________________
TELEPHONE ____________________
DATE ____________________

INSTRUCTIONS

a. Read definition of significant obstruction on reverse side before filling out form

b. See measurement key and sample diagrams on reverse side for interpretation of measurements.

c. Enter the "material" type used for each obstruction

d. Use sketches to show unusual obstructions and provide measurements for culverts with modified inlets and unusual lengths.

Map ID No.	Owner/Landowner Name and Address	Yr. built	Design Data Avail. yes/no	Capacity CFS	Map ID form A	OPENING									MEASUREMENTS							OPEN CHANNEL			SKETCH NO.
						Nos. of	Type		(√) Shape																
							Part of brdg (√)	Culvert Purpose	Culvert □	Culvert ○	Culvert ⌓	Bridge ∩	Bridge ⊓		T	D	HT	W	PW	Skew Angle	Material	TW	Dpth	B	
B–																									
B–																									
B–																									
B–																									
B–																									
B–																									

Definition

Significant Obstruction

Any man-made or natural obstruction, that causes water to back up, creating a storm water drainage problem, as described on Form A.

Use the "Map ID No." to identify the location of the bridge/culvert on the map provided.

List the number of bridge openings located in the channel or number of culverts

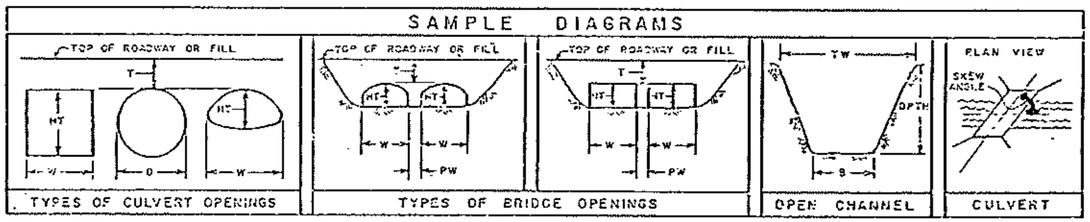
Map ID No.	Owner/Landowner Name and Address	Yr. built	Design Data Avail. yes/no	Capacity CFS	Map ID form A	Opening: Num. of	Opening: Type: Part of bldg (✓)	Opening: Type: Culvert Purpose	Opening: Shape: Culvert ▢	Opening: Shape: Culvert ○	Opening: Shape: Culvert ⬭	Opening: Shape: Bridge ⌒	Opening: Shape: Bridge ⊓	Measurements: T	D	HT	W	PW	Skew Angle	Material	Open Channel: TW	Dpth	B	Sketch No.
8-1	DER Harrisburg, PA 17120	1930	Yes	1000	A1	2		Roadway		✓				4'	60"				75°	Corrugated metal	30'	10'	10'	

Write the storm water problem area's Map ID No. to which this obstruction is involved.

Write the purpose of the culvert. In most cases, the purpose will be the surface use of the land above the culvert.

MEASUREMENT KEY

T = Height of Fill
D = Diameter
HT = Height
W = Width
PW = Pier Width
TW = Top Width
Dpth = Depth
B = Bottom Width



SKETCH (only for unusual obstructions and openings)

#	#	#

12/81

EXISTING FLOOD CONTROL PROJECT FORM C

SHEET______ OF______

WATERSHED
Name______________________
Municipality______________________
County______________________

FORM COMPLETED BY
Name______________________
Telephone______________________
Date______________________

TYPICAL TYPES OF FLOOD CONTROL PROJECTS

Channel Excavation/Widening	Levee	Dams
Channel Realignment	Gabions	Floodwall
Rock Riprap	Pipe Channel	Concrete Lining

For County Use

Map ID No.	Type of Flood Control Project	Year Constr Built	Expected Life Yrs	Design Flood: Frequency Yrs	Design Flood: Discharge C.F.S. (if known)	Owner Name, Address and Phone
C–						
C–						
C–						
C–						
C–						

12/81

SHEET________ OF ________

PROPOSED FLOOD CONTROL PROJECT FORM D

WATERSHED
Name__________
Municipality__________
County__________

FORM COMPLETED BY
Name__________
Telephone__________
Date__________

TYPICAL TYPES OF FLOOD CONTROL PROJECTS

Channel Excavation/Widening	Levee	Dam
Channel Realignment	Gabions	Floodwall
Rock Riprap	Pipe Channel	Concrete Lining

For County Use

Map ID No.	Type of Flood Control Project	Study Phase Begun			Year Constr Planned	Projected Completion Date	Expected Life Yrs	Design Flood		Map ID No Form A *	Owner Name, Address and Telephone
		Yes		No				Frequency Yrs	Discharge C.F.S. (If known)		
		Prelim	Final								
D–											
D–											
D–											
D–											
D–											

* Enter the storm water problem area's map ID No., if the proposed project will solve or reduce any/all of an identified drainage problem.

1/82

EXISTING STORM WATER CONTROL FACILITIES FORM E

SHEET ______ OF ______

WATERSHED

Name ______________________

Municipality ______________________

County ______________________

FORM COMPLETED BY

Name ______________________

Telephone ______________________

Date ______________________

FOR COUNTY USE

DEFINITION

Storm Water Control Facility

A natural/man-made device or structure specifically designed and/or utilized to reduce the rate and/or volume of storm water runoff from a site or sites.

Map ID No.	Type of Storm Water Control Facility	Year Built	Contact Person Name, Address and Phone	Comments
E–				
E–				
E–				
E–				
E–				
E–				
E–				

TYPICAL TYPES OF STORM WATER CONTROL FACILITIES

- Detention/Retention Basin
- Natural Pond or Wetland
- Parking Lot Ponding
- Roof-Top Storage
- Semi-Pervious Paving
- Infiltration Device (Seepage/Recharge Basin or Underground Tank)

1/82 PROPOSED STORM WATER CONTROL FACILITIES FORM F SHEET_____ OF_____

WATERSHED
Name________________
Municipality________________
County________________

FORM COMPLETED BY
Name________________
Telephone________________
Date________________

DEFINITION

Storm Water Control Facility

A natural/man-made device or structure specifically designed and/or utilized to reduce the rate and/or volume of storm water runoff from a site or sites.

FOR COUNTY USE

Map ID No.	Type of Storm Water Control Facility	Proposed Constr. dates		Map No. Form A *	Contact Person Name, Address and Phone	Comments
		Start	End			
F–						
F–						
F–						
F–						
F–						
F–						
F–						

* Enter the storm water problem area's map ID No., if the proposed facility will solve or reduce any/all of an identified drainage problem.

TYPICAL TYPES OF STORM WATER CONTROL FACILITIES

–Detention/Retention Basin
–Natural Pond or Wetland
–Parking Lot Ponding
–Roof-top Storage
–Semi-Pervious Paving
–Infiltration Device (Seepage/Recharge Basin or Underground Tank)

1/82

EXISTING STORM WATER COLLECTION SYSTEM FORM G

SHEET ______ OF ______

WATERSHED

Name ____________________

Municipality ____________________

County ____________________

FORM COMPLETED BY

Name ____________________

Telephone ____________________

Date ____________________

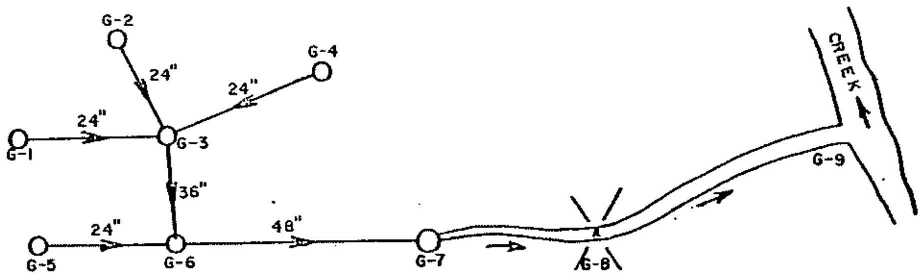
Instructions

Diagram each system on the appropriate map.
Establish map points to show changes in system elements, pipe size or pipe direction. (If unknown, outline the systems extent.)
Complete this form only where specific information on construction is available. Use a separate form for each system.
Identify the points within a system consecutively (ex. G-1, G-2, G-3). Start the first point in each additional system 20 numbers higher. For example, G-3 ends one system so G-23 begins the next. *See Sample Diagrams and Form on Reverse.*

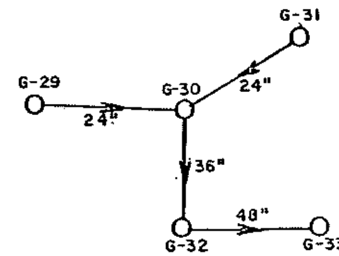
Map I.D. No.		System's Element (✓)			Measurements *				Material	Year Constr.	Design Data Avail.	Contact Person Name and Phone	Name of Final Ownership and Maintenance Responsibility
					Pipe	Channel/Swale							
From	To	Pipe	Open Channel	Swale	D	TW	B	Depth					
G-	G-												
G-	G-												
G-	G-												
G-	G-												
G-	G-												
G-	G-												
G-	G-												
G-	G-												
G-	G-												
G-	G-												
G-	G-												

* See measurement key on reverse side.

Measurement Key
D = Diameter TW = Top Width B = Bottom Width



SAMPLE DIAGRAM FOR SYSTEM ONE



SAMPLE DIAGRAM FOR SYSTEM TWO

SAMPLE FORM (System One Only)

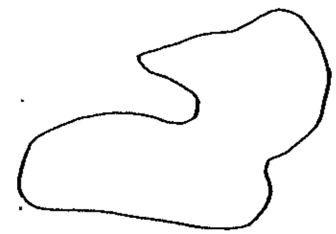
EXISTING STORM WATER COLLECTION SYSTEM FORM 6

WATERSHED
Name ____
Municipality ____
County ____

FORM COMPLETED BY
Name ____
Telephone ____
Date ____

Instructions

Map I.D. No. From	To	Pipe	Open Channel	Swale	Pipe D	TW	B	Depth	Material	Year Constr.	[illegible]	Current Person Name and Phone	Name of Final Owner and Maintenance Responsibility
G-1	G-3	✓			24"				CMP	1978	Yes	John Doe 123-4567	Borough of ABC
G-2	G-3	✓			24"				CMP	1978	Yes	John Doe 123-4567	Borough of ABC
G-4	G-3	✓			24"				CMP	1978	Yes	John Doe 123-4567	Borough of ABC
G-3	G-6	✓			36"				CMP	1978	Yes	John Doe 123-4567	Borough of ABC
G-5	G-6	✓			24"				CMP	1978	Yes	John Doe 123-4567	Borough of ABC
G-6	G-7	✓			48"				CMP	1978	Yes	John Doe 123-4567	Borough of ABC
G-7	G-8		✓			84"	36"	24"	Concrete	1980	Yes	John Doe 123-4567	Borough of ABC
G-8	G-9			✓		84"	36"	24"	Natural grass				Borough of ABC
G-	G-												
G-	G-												
G-	G-												



Outline known areas where construction exists but construction data is unavailable.

1/82

PROPOSED STORM WATER COLLECTION SYSTEMS FORM H

SHEET ______ OF ______

WATERSHED

Name ______________________

Municipality ______________________

County ______________________

FORM COMPLETED BY

Name ______________________

Telephone ______________________

Date ______________________

Instructions

On the map for proposed storm water collection systems, diagram each proposed system.
Indicate a map point to show changes in system elements, pipe size, pipe direction and connections to existing systems.
For proposed additions to existing systems, diagram only the additions and their connection point into the existing system.
Complete a separate form for each proposed new system and one for each existing system having one or more proposed additions.
Identify the points within a system consecutively (ex. H-1, H-2, H-3, etc.). Start the first point in each additional system 20 numbers higher (if H-3 ends one system, begin the next with H-23). Be sure to show the point where proposed additions connect into existing systems, using the map point number from the existing system form and map. *See Sample Diagrams and Form on Reverse.*

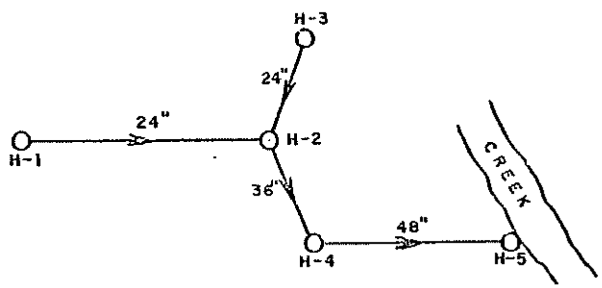
Map I.D. No.		System Elements (√)			Measurements *				Material	Map I.D. Nos. ** Form A	Proposed Constr. Dates		Design Data Avail.	Contact Person Name and Phone	Name of Final Ownership and Maintenance Responsibility
					Pipe	Open Channel/Swale									
From	To	Pipe	Open Channel	Swale	D	TW	B	Depth			Start	End			
H-	H-														
H-	H-														
H-	H-														
H-	H-														
H-	H-														
H-	H-														
H-	H-														
H-	H-														
H-	H-														
H-	H-														

* See measurement key on reverse side.

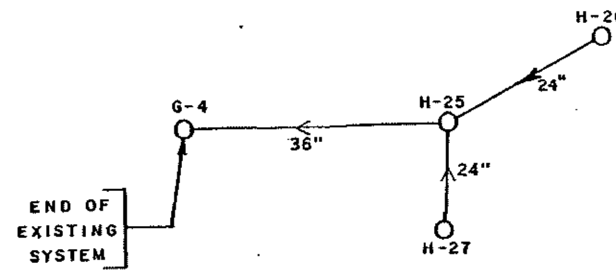
** Enter the storm water problem areas' map I.D. Nos., If proposed project will solve or reduce any/all of the drainage problems.

SAMPLE DIAGRAMS

Measurement Key
D = Diameter TW = Top Width B = Bottom Width



NEW SYSTEM



ADDITION TO EXISTING SYSTEM

SAMPLE FORM (New System Only)

WATERSHED	FORM COMPLETED BY	Instructions
Name ____ Municipality ____ County ____	Name ____ Telephone ____ Date ____	[illegible]

Map I.D. No. From	To	Pipe	Open Channel	Swale	D	TW	B	Depth	Material	[illegible]	Start	End	Design Data Avail.	[illegible]	[illegible]
H1	H2	✓			24"				CMP	A1	[illegible]	[illegible]	Yes	John Doe [illegible]	Borough of ABC
H3	H2	✓			24"				CMP	A1	[illegible]	[illegible]	Yes	John Doe [illegible]	Borough of ABC
H2	H4	✓			36"				CMP	A2	[illegible]	[illegible]	Yes	John Doe [illegible]	Borough of ABC
H4	H5	✓			48"				CMP	A2	[illegible]	[illegible]	Yes	John Doe [illegible]	Borough of ABC
H	H														
H	H														
H	H														
H	H														
H	H														
H	H														

APPENDIX B

EXISTING STORMWATER CONTROL FACILITIES INVENTORY AND EVALUATION

Introduction

A research effort was undertaken by the Delaware County Conservation District to locate existing stormwater control facilities within the Ridley Creek watershed. The Conservation District searched through the erosion and sedimentation control plans submitted to it for review since 1971. The facilities that were indicated as having been installed through the follow-up activities of the Soil Conservation Service (SCS) were listed. This list was then enlarged by the addition of the facilities reported by the local municipalities.

The second step in this study was to field investigate all existing stormwater control facilities. The SCS District Conservationist assisted with these field investigations to comment upon existing conditions. Those facilities which were located from existing erosion and sedimentation control plans were reviewed further to determine if the facilities had been installed as proposed.

The third step in this study was to determine ownership of the facilities. As many owners as possible were then located and interviewed to gain insights about maintenance requirements and various other problems associated with stormwater control facilities.

The following is a summary of the findings of this effort. With very few exceptions, detention basins appear to be the only form of stormwater control currently utilized within the watershed. Further, the majority of the existing detention basins have only recently been installed.

Inventory Summary

A total of eighteen detention basins were located. Their municipal distribution is as follows: Upper Providence Township-seven, Edgmont Township-six, Middletown Township-two, Brookhaven Borough-two, and Nether Providence Township-one. In addition, one site in Edgmont Township utilized seepage pits to control stormwater, and two other sites proposed the utilization of seepage pits.

The Conservation District was able to locate plans in its files for all but four of the reported detention basins. It is important to note that of the eighteen detention basins, eight were located within projects under active construction. There was only one case in which a detention basin was indicated as being in existence in a developer's comments on an erosion and sedimentation control plan and not located in the field.

Evaluation Summary

The majority of the completed detention basins would probably be considered eyesores if they were located in visible areas. Maintenance of the inside slopes of the larger basins appears to be an extremely difficult task. This maintenance problem is complicated by the fact that eight of the ten basins located within completed projects show evidence of standing water. The basins that were seeded with crown vetch have developed a good vegetative cover. However, weeds, trees, and scrub growth have become established within the crown vetch, detracting from their appearance.

One detention basin owned and maintained by Nether Providence Township on Wiltshire Drive stands out from the rest with regard to maintenance. The detention basin does have a small pool of standing water, and the planting of evergreens on the embankment of the basin could present future problems, but on the whole, the basin is very well maintained.

The ability of a basin to function properly is nearly impossible to evaluate under normal conditions. The nature of a detention basin is such that its operation is not evident until rains of a certain frequency storm occur. These storms are usually severe enough to prohibit outdoor field investigations. In fact, the basins in all probability have not even experienced the maximum storm for which they have been designed.

All of the basins were evaluated in detail, and a representative photograph was taken. The evaluation was recorded on the attached forms, and a photograph will be kept on file in the Conservation District Office.

Ownership

The ownership of the existing detention basins and the proposed ownership of the recently completed basins is extremely varied. Municipalities with multiple basins also have multiple forms of ownership for these basins. There does not seem to be a direct relationship between type of ownership and degree or quality of maintenance. A breakdown of the various forms of ownership is as follows: two basins are owned by a municipality, four are proposed to be owned by a homeowners' association, two will be owned by the person who purchases the lot on which the basin is located, and the remainder comprise various corporate and public forms of ownership.

Conclusions

The existence and location of stormwater management facilities have not been adequately documented in the past. No one agency keeps track of the installation of stormwater facilities, and, consequently, municipal officials have a difficult time compiling an inventory of existing facilities. The preparation of a list of existing stormwater control facilities is a time consuming activity, and no guarantee can be made that all facilities will be located.

The maintenance of detention basins is, with few exceptions, limited within the watershed. This limited maintenance may have adverse effects on the proper functioning of the basin, such as clogging of the outlet structure, and, in extreme cases, a reduction in the storage capacity. Ownership of the basins can present problems when the owner is not familiar with the designed function of the detention basin. No regulatory procedures are in effect to ensure that the owner of a facility will be able to maintain the basin properly. A basin will not function properly if the outlet structure is removed, if water is diverted from entering the basin, or if the basin is converted into a permanent pond.

Recommendation

This inventory and evaluation was conducted to provide information to the consultants for the Ridley Creek Stormwater Management Plan. The Conservation District recommends that this information be utilized to assist in the development of a stormwater management plan that addresses the specific conditions within the Ridley Creek watershed.

RIDLEY CREEK WATERSHED- EXISTING STORMWATER CONTROL FACILITIES INVENTORY- AUGUST 1982

PERFORMED BY: ED MAGARGEE, CONSERVATION DISTRICT
& WILLIE WARD, SOIL CONSERVATION SERVICE

MUNICIPALITY: Nether Providence

NAME OF DEVELOPMENT: Wallingford Valley Apts.

TYPE OF STORMWATER FACILITY: "none existing"

LOCATION: near the intersection of Brookhaven and Waterville Roads

LAND USE: residential-garden style and mid-rise apts., condominiums

PRE-DEVELOPMENT PLANS IN FILES: Yes "Wallingford Valley"

OWNERSHIP OF FACILITIES:

MAINTENANCE REQUIRED:

ESTIMATED COST OF MAINTENANCE:

FREQUENCY OF MAINTENANCE:

COMMENTS: Twp. Manager is not aware of a basin in that area

YEAR CONSTRUCTED:

EXISTING CONDITIONS: 1. vegetation too thick to verify existence 2. an additional phase of the development reports it as existing 3. designed storage 512,000 cubic feet

RIDLEY CREEK WATERSHED- EXISTING STORMWATER CONTROL FACILITIES INVENTORY- AUGUST 1982

PERFORMED BY: ED MAGARGEE, CONSERVATION DISTRICT
& WILLIE WARD, SOIL CONSERVATION SERVICE

MUNICIPALITY: Nether Providence

NAME OF DEVELOPMENT: E & W - Wiltshire Drive

TYPE OF STORMWATER FACILITY: detention basin

LOCATION: south on 352, turn left onto Brookhaven Rd., right onto Moore Rd. to Wiltshire Dr.

LAND USE: residential--twin homes

PRE-DEVELOPMENT PLANS IN FILES: yes "Wallingford Shopping Center, Inc."

OWNERSHIP OF FACILITIES: Nether Providence

MAINTENANCE REQUIRED: cutting of grass, cleaning out debris after storms

ESTIMATED COST OF MAINTENANCE: none

FREQUENCY OF MAINTENANCE: whenever grass needs cutting and after storms

COMMENTS: Twp. Manager says it has not been much of of a problem

YEAR CONSTRUCTED: 1979

EXISTING CONDITIONS: 1. basin has been well maintained 2. fenced in 3. riser pipe outlet structure 4. embankment type of basin 5. design project area 9.074 + acres 6. design storage 23,960 cubic feet

RIDLEY CREEK WATERSHED- EXISTING STORMWATER CONTROL FACILITIES INVENTORY- AUGUST 1982

PERFORMED BY: ED MAGARGEE, CONSERVATION DISTRICT
& WILLIE WARD, SOIL CONSERVATION SERVICE

MUNICIPALITY	NAME OF DEVELOPMENT
Brookhaven	Plaza 352

TYPE OF STORMWATER FACILITY: detention basin

LOCATION: behind K-Mart off of Route 352

LAND USE: commercial-shopping center

PRE-DEVELOPMENT PLANS IN FILES: no

OWNERSHIP OF FACILITIES: Plaza 352 Corporation

MAINTENANCE REQUIRED: Brookhaven Borough is currently attempting to have needed maintenance performed

ESTIMATED COST OF MAINTENANCE:

FREQUENCY OF MAINTENANCE:

COMMENTS:

YEAR CONSTRUCTED:

EXISTING CONDITIONS: 1. vegetation too thick and unmaintained for site inspection 2. ponded water 3. fenced in

RIDLEY CREEK WATERSHED- EXISTING STORMWATER CONTROL FACILITIES INVENTORY- AUGUST 1982

PERFORMED BY: ED MAGARGEE, CONSERVATION DISTRICT
& WILLIE WARD, SOIL CONSERVATION SERVICE

MUNICIPALITY: Upper Providence

NAME OF DEVELOPMENT: Highland Avenue

TYPE OF STORMWATER FACILITY: detention basin

LOCATION: on the left side, near the bend on Highland Ave. towards Orange St.

LAND USE: residential-single family homes

PRE-DEVELOPMENT PLANS IN FILES: no

OWNERSHIP OF FACILITIES: lot owner

MAINTENANCE REQUIRED:

ESTIMATED COST OF MAINTENANCE:

FREQUENCY OF MAINTENANCE:

COMMENTS: project under construction

YEAR CONSTRUCTED:

EXISTING CONDITIONS: 1. outlet structure riser pipe (holes are quite large) 2. unlined emergency spillway 3. basin has good vegetative cover 4. some evidence of downstream erosion 5. protected rip-rap outlet 6. evidence of water over emergency spillway

RIDLEY CREEK WATERSHED- EXISTING STORMWATER CONTROL FACILITIES INVENTORY- AUGUST 1982

PERFORMED BY: ED MAGARGEE, CONSERVATION DISTRICT
& WILLIE WARD, SOIL CONSERVATION SERVICE

MUNICIPALITY: Upper Providence

NAME OF DEVELOPMENT: Kelly Lane II

TYPE OF STORMWATER FACILITY: detention basin

LOCATION: ½ mile from the intersection of Rose Tree Rd. on Sycamore Mill Rd. on the left

LAND USE: residential-single family homes

PRE-DEVELOPMENT PLANS IN FILES: yes "R.C.H. Inc."

OWNERSHIP OF FACILITIES: lot owner

MAINTENANCE REQUIRED: no maintenance required to to this point, owner will be responsible for basin

ESTIMATED COST OF MAINTENANCE: not available

FREQUENCY OF MAINTENANCE:

COMMENTS: project under construction

YEAR CONSTRUCTED: 1980

EXISTING CONDITIONS: 1. outlet structure 12" pipe 2. rip-rap emergency spillway 3. inside slopes show some erosion 4. original plans called for on-lot control measures, Township required basin

RIDLEY CREEK WATERSHED- EXISTING STORMWATER CONTROL FACILITIES INVENTORY- AUGUST 1982

PERFORMED BY: ED MAGARGEE, CONSERVATION DISTRICT
& WILLIE WARD, SOIL CONSERVATION SERVICE

MUNICIPALITY: Middletown

NAME OF DEVELOPMENT: Lima Estates

TYPE OF STORMWATER FACILITY: detention basin #2 (South)

LOCATION: across from Fair Acres on 352

LAND USE: residential-apartments

PRE-DEVELOPMENT PLANS IN FILES: no

OWNERSHIP OF FACILITIES: Lima Estates

MAINTENANCE REQUIRED: grass cutting, had to clean out with a backhoe in 1981, scheduled maintenance project for 1982

ESTIMATED COST OF MAINTENANCE: not available

FREQUENCY OF MAINTENANCE: mainly after large storms

COMMENTS:

YEAR CONSTRUCTED: 1979

EXISTING CONDITIONS: 1. riser pipe principal spillway 2. emergency spillway-gabion basket 3. embankment type 4. is frequently mowed 5. has a gabion lined inlet channel with severe erosion 6. small pool of standing water approximately 2 feet deep 7. storage appears to be inadequate 8. evidence of recent overflow through spillway

RIDLEY CREEK WATERSHED- EXISTING STORMWATER CONTROL FACILITIES INVENTORY- AUGUST 1982

PERFORMED BY: ED MAGARGEE, CONSERVATION DISTRICT & WILLIE WARD, SOIL CONSERVATION SERVICE

Upper Providence — Toft Woods

MUNICIPALITY — **NAME OF DEVELOPMENT**

detention basin #1

TYPE OF STORMWATER FACILITY

LOCATION: north on Providence Rd., turn left onto Bishop Hollow, signed entrance on left

LAND USE: residential-townhouses

PRE-DEVELOPMENT PLANS IN FILES: yes

OWNERSHIP OF FACILITIES: homeowners' association

MAINTENANCE REQUIRED: to be established

ESTIMATED COST OF MAINTENANCE:

FREQUENCY OF MAINTENANCE:

COMMENTS: project under construction

YEAR CONSTRUCTED: 1980

EXISTING CONDITIONS: 1. basin berm is being mowed 2. inside basin is grown up with weeds 3. inside basin slopes show some sign of erosion 4. basin has a rock lined emergency spillway 5. outlet structure is an ordinary pipe 6. dug out type of basin 7. designed storage 13,780 cubic feet

RIDLEY CREEK WATERSHED- EXISTING STORMWATER CONTROL FACILITIES INVENTORY- AUGUST 1982

PERFORMED BY: ED MAGARGEE, CONSERVATION DISTRICT
& WILLIE WARD, SOIL CONSERVATION SERVICE

MUNICIPALITY: Upper Providence

NAME OF DEVELOPMENT: Toft Woods

TYPE OF STORMWATER FACILITY: detention basin #2

LOCATION: north on Providence Rd., left onto Bishop Hollow, signed entrance on left

LAND USE: residential-townhouses

PRE-DEVELOPMENT PLANS IN FILES: yes

OWNERSHIP OF FACILITIES: homeowners' association

MAINTENANCE REQUIRED: to be established

ESTIMATED COST OF MAINTENANCE:

FREQUENCY OF MAINTENANCE:

COMMENTS: project under construction

YEAR CONSTRUCTED: 1980

EXISTING CONDITIONS: 1. has a very good vegetative cover 2. drainage swale into basin shows signs of erosion 3. outlet structure riser pipe 4. rip-rapped emergency spillway 5. designed storage 1,313 acre-feet 6. very little existing maintenance

RIDLEY CREEK WATERSHED- EXISTING STORMWATER CONTROL FACILITIES INVENTORY- AUGUST 1982

PERFORMED BY: ED MAGARGEE, CONSERVATION DISTRICT & WILLIE WARD, SOIL CONSERVATION SERVICE

MUNICIPALITY: Edgmont

NAME OF DEVELOPMENT: Cold Spring Farms

TYPE OF STORMWATER FACILITY: detention basin

LOCATION: north on Route 352, then turn right onto Valley Rd, ¼ mile on the right

LAND USE: residential-single family homes

PRE-DEVELOPMENT PLANS IN FILES: yes "B & B Company"

OWNERSHIP OF FACILITIES: homeowners' association

MAINTENANCE REQUIRED: to be established

ESTIMATED COST OF MAINTENANCE:

FREQUENCY OF MAINTENANCE:

COMMENTS: project under construction

YEAR CONSTRUCTED: 1981

EXISTING CONDITIONS: 1. riser pipe outlet structure 2. emergency spillway (unlined) 3. embankment type 4. designed storage 21,312 cubic feet 5. basin has severe erosion all along berm 6. drainage ways into the basin are severely eroded 7. very sparse vegetative cover 8. heavy silt deposits in basin

RIDLEY CREEK WATERSHED- EXISTING STORMWATER CONTROL FACILITIES INVENTORY- AUGUST 1982

PERFORMED BY: ED MAGARGEE, CONSERVATION DISTRICT & WILLIE WARD, SOIL CONSERVATION SERVICE

MUNICIPALITY: Edgmont	**NAME OF DEVELOPMENT:** Okehocking Hills
TYPE OF STORMWATER FACILITY: detention basin	
LOCATION: north on 352, turn right onto Valley Road, then right onto Stackhouse Rd. approx. 3/4 mile	**LAND USE:** residential-single homes
PRE-DEVELOPMENT PLANS IN FILES: yes "Eastern Pennsylvania Land Company"	

OWNERSHIP OF FACILITIES: homeowners' association

MAINTENANCE REQUIRED: to be established

ESTIMATED COST OF MAINTENANCE:

FREQUENCY OF MAINTENANCE:

COMMENTS: project under construction

YEAR CONSTRUCTED: 1981

EXISTING CONDITIONS: 1. embankment style 2. riser pipe outlet structure 3. basin shows no signs of basic mowing 4. weeds need cutting 5. heavy silt deposits in basin 6. approximately 2 feet of standing water 7. surface water entrance area from road is heavily eroded, some rip-rap placed to correct this condition

RIDLEY CREEK WATERSHED- EXISTING STORMWATER CONTROL FACILITIES INVENTORY- AUGUST 1982

PERFORMED BY: ED MAGARGEE, CONSERVATION DISTRICT
& WILLIE WARD, SOIL CONSERVATION SERVICE

MUNICIPALITY: Edgmont

NAME OF DEVELOPMENT: Pier-Angeli Company

TYPE OF STORMWATER FACILITY: (A) small basin, (B) seepage pit

LOCATION: south of the intersection of Providence Rd. & West Chester Pike, on left side

LAND USE: light industry- office building & ware-house

PRE-DEVELOPMENT PLANS IN FILES: yes "Hough/Loew Associates"

OWNERSHIP OF FACILITIES: did not follow up

MAINTENANCE REQUIRED:

ESTIMATED COST OF MAINTENANCE:

FREQUENCY OF MAINTENANCE:

COMMENTS:

YEAR CONSTRUCTED:

EXISTING CONDITIONS: (A) 1. small basin has an elbow pipe to control flow 2. some silt has collected at bottom 3. vegetation has been maintained (B) 1. one seepage pit looks to be installed as designed 2. in rear of building is a 4" pipe which goes down to running water 3. could not locate 2 seepage pits proposed in plan, site not installed to existing plan

RIDLEY CREEK WATERSHED- EXISTING STORMWATER CONTROL FACILITIES INVENTORY- AUGUST 1982

PERFORMED BY: ED MAGARGEE, CONSERVATION DISTRICT
& WILLIE WARD, SOIL CONSERVATION SERVICE

MUNICIPALITY: Edgmont

NAME OF DEVELOPMENT: Henderson-Condominium

TYPE OF STORMWATER FACILITY: detention basin #1

LOCATION: ¼ mile west of Providence Rd. on West Chester Pike

LAND USE: light industry-warehouse, office, large beer distributor

PRE-DEVELOPMENT PLANS IN FILES: yes "Edgmont Racquet Club"

OWNERSHIP OF FACILITIES: Henderson-Lawrence Corp., 777 Henderson Blvd., Folcroft, PA

MAINTENANCE REQUIRED: functioning and has not required any maintenance

ESTIMATED COST OF MAINTENANCE: not available

FREQUENCY OF MAINTENANCE: no scheduled maintenance procedures

COMMENTS: rental building

YEAR CONSTRUCTED: 1980

EXISTING CONDITIONS: 1. plans are not implemented as designed 2. riser pipe outlet 3. embankment type 4. basin banks are seeded with crown vetch and have a very good cover 5. bottom of basin has grown up weeds 6. small pool of standing water 7. no signs of maintenance

RIDLEY CREEK WATERSHED- EXISTING STORMWATER CONTROL FACILITIES INVENTORY- AUGUST 1982

PERFORMED BY: ED MAGARGEE, CONSERVATION DISTRICT
& WILLIE WARD, SOIL CONSERVATION SERVICE

MUNICIPALITY: Edgmont

NAME OF DEVELOPMENT: Henderson-Condominium

TYPE OF STORMWATER FACILITY: detention basin #2

LOCATION: ¼ mile west of Providence Rd. on West Chester Pike

LAND USE: light industry-warehouse, office

PRE-DEVELOPMENT PLANS IN FILES: yes "Edgmont Racquet Club"

OWNERSHIP OF FACILITIES: Henderson-Lawrence Corp., 777 Henderson Blvd., Folcroft, PA

MAINTENANCE REQUIRED: functioning and has not required any maintenance

ESTIMATED COST OF MAINTENANCE: not available

FREQUENCY OF MAINTENANCE: no scheduled maintenance procedures

COMMENTS: tenant manager not aware of its existence

YEAR CONSTRUCTED: 1980

EXISTING CONDITIONS: 1. riser pipe outlet 2. concrete emergency spillway 3. embankment type 4. unable to check erosion condition of basin because of high weeds 5. basin shows no signs of maintenance 6. small pool of standing water

RIDLEY CREEK WATERSHED- EXISTING STORMWATER CONTROL FACILITIES INVENTORY- AUGUST 1982

PERFORMED BY: ED MAGARGEE, CONSERVATION DISTRICT
& WILLIE WARD, SOIL CONSERVATION SERVICE

MUNICIPALITY: Edgmont

NAME OF DEVELOPMENT: Edgmont Plaza

TYPE OF STORMWATER FACILITY: detention basin

LOCATION: 5081 West Chester Pike, ½ mile west of Providence Rd.

LAND USE: light industry-office, warehouse

PRE-DEVELOPMENT PLANS IN FILES: yes "McGinn Property"

OWNERSHIP OF FACILITIES: Providence Associates, P. O. Box 267, Edgmont, PA

MAINTENANCE REQUIRED: seeded to crown vetch, thus only need to cut grass around the top

ESTIMATED COST OF MAINTENANCE: not available

FREQUENCY OF MAINTENANCE: no major problems as of yet

COMMENTS: project under construction

YEAR CONSTRUCTED: 1979

EXISTING CONDITIONS: 1. 24" riser feeds to 18" outlet 2. embankment type 3. designed storage 38,225 cubic feet 4. side slopes in good condition with grass cover 5. bottom of basin has grown up with weeds 6. some maintenance evident 7. basin has a small pool of water because of springs

APPENDIX C

LINE DIGITIZATION METHOD

The development of many of the data parameters that are needed as input to PSRM requires that the physical characteristics of the land area in the watershed be determined. Examples of these parameters include subbasin area, percent imperviousness in each subbasin, and the average slope in each subbasin. The first step in developing input data for PSRM is to determine the areal pattern of each of the following attributes over the watershed:

- subarea indicator or identification number
- slope range (e.g., 0-2 percent)
- land use type (e.g., residential)
- hydrologic soil type (e.g., soil in Soil Conservation Service (SCS) hydrologic group B)

Conventionally this is done by preparing a set of transparent overlays for an appropriate base map of the watershed. The second step involves determining the areas associated with composite attribute sets; for example, the amount of land area in Subarea 1 that is of a residential land use type. The simplest of these sets are subarea-slope and subarea-land use. Using manual methods, this step is accomplished by combining the appropriate overlay maps and planimetering the regions associated with the appropriate composite attribute. For example, the total area in Subarea 1 that is occupied by land use Type A (.66 to .99 residential units per acre) may be determined. This area would then be recorded for the composite attribute--subarea (1) - land use (A), or just "1A." The most complicated attribute set used in the development of PSRM input is subarea-land use-soil type. The information that is furnished by this set is used to compute average runoff curve numbers (CN). In this case, three overlays must be combined and planimetered. For large watersheds, the labor required for overlay drafting, hand planimetering, record keeping, and computation quickly becomes unmanageable. In addition to being very slow and tedious, manual methods are prone to human error. The larger the study area, the more error that is unavoidably accumulated.

Some less apparent, but equally troublesome shortcomings of the manual method are the:

- Need to compile all attribute maps at the same scale.
- Difficulty in accommodating a change in one of the attribute maps. Each change involves recombination of the overlays and replanimetering of the affected regions.

- The overlays, once prepared, will generally not be compatible with map information developed independently by workers in adjoining study areas. Consequently, a considerable quantity of work effort must be duplicated when study areas are enlarged or merged in subsequent investigations.

Digitization and digital map processing provide an alternative method for preparing PSRM input parameters which avoids the aforementioned problems. With this computer assisted approach, the details of each attribute map are translated by the computer into a numerical list which is referred to as a "digital map file." Computer data files contain all of the necessary information to reconstruct the attribute map at any desired scale and level of precision. Very importantly, checks can be built into the digitization process to protect against the introduction of damaging errors. Once the pertinent digital map files are generated, "overlaying" of the individual attribute map files, measurement of single attribute and composite attribute areas, and manipulation of the area data to produce the required PSRM input (e.g., average runoff curve number, percent imperviousness, average slope, etc.) are handled by the computer. Due to the flexibility that is inherent in digital processing, digitization offers many advantages, including:

- Digital map files, created from original work maps that have been compiled at widely varying scales, can be easily and effectively combined.

- Changes made to one or more digital map files do not necessitate the need for new human labor to reanalyze. The computer quickly handles the recomputation of composite attribute areas and input parameters.

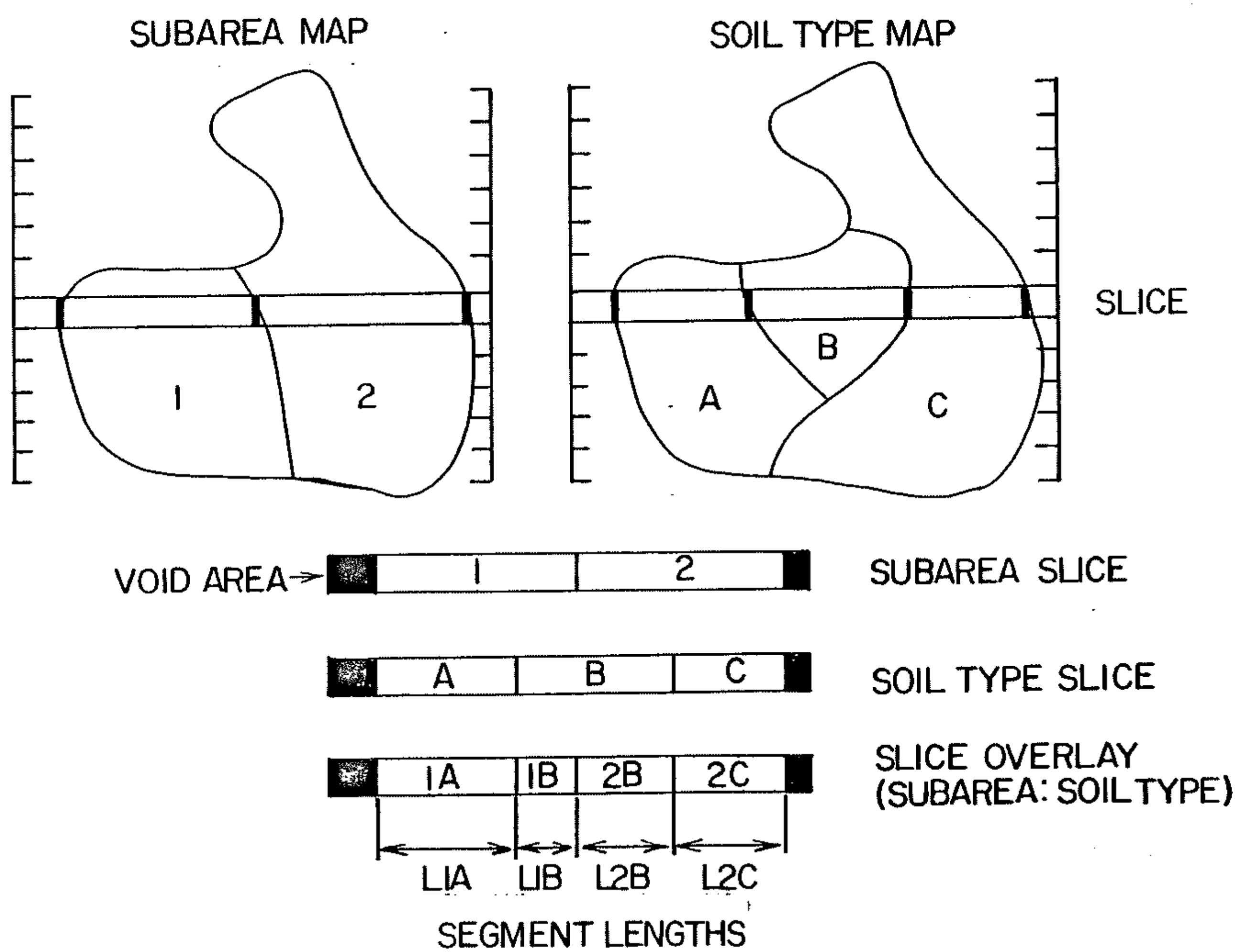
- Digital map files created by different workers in unrelated study areas can, in most cases, be merged at some later occasion. This is true even when different digitization techniques are used.

- Since no physical overlays are involved, all of the map information and the results of computations are conveniently stored on durable magnetic tapes or cassettes.

There are two general classes of digitization methods, cell digitization and line digitization. In cell digitization, the map is divided into a grid of identical squares. A value or attribute is assigned to each square on the basis of an average for the square (in the case of a value) or majority contribution (in the case of an attribute). Total areas are computed by summing squares which have a fixed unit area. The resolution of cell digitized maps depends upon the dimensions of the squares chosen.

In line digitization, a map is divided into a set of stacked "slices" of identical width (see Figure C-1). Each slice is, in turn, broken

FIGURE C-1
LINE DIGITIZATION METHOD



into two attribute boundaries. Areas are computed by summing line lengths and multiplying by the fixed slice width. The resolution of line digitized maps depends upon the slice width.

Cell and line digitized map files can be interconverted, but not, in general, without some loss of information. Ideally, digital maps which are to be combined should be digitized on the same cell grid or slice pattern to prevent any loss of resolution and to minimize computer time and expense. The absolute scale of the digitization grid or pattern, however, does not matter. A cell grid or slice pattern should be selected which ensures a level of precision that is at least as good as that of the original work maps.

The line digitization method was employed to develop input parameters for PSRM in this pilot study. Original work maps were compiled on two different scales, 1:24,000 and 1:4,800. The digitizing program that was developed by Satterthwaite Associates, Inc., contains an internal subroutine which automatically sets the scale and orientation of each digital map to conform to a common standard coordinate system. For the pilot study, the Universal Transverse Mercater (UTM) coordinate system was selected. A slice pattern with 100 meter wide east-west slices was selected and laid out on each of the base maps. The digitization technique involves moving a recording device across the center line of each slice in sequence. The device is connected directly to the computer that is handling the construction of the digital map file. Attribute boundaries encountered by the device together with the attribute designation are coded into the digital map file. The coded information describing the set of segments in each slice are referred to as a digital record. Each record has a unique place in the computer's "digital map" which is created. The records in maps of different attributes must agree exactly in number and sequence. Digital maps of composite attributes are created by "overlaying" records from different maps (see Figure C-1). Only those records corresponding to identical slices are overlayed. The process of temporarily overlaying the individual files creates a new "digital map file" in which the records describe the lengths of slice segments with composite attributes. To find the land area occupied by a specific attribute or composite attribute, the computer simply sums the lengths of all similar segments in the new temporary file and multiplies each sum by the predetermined slice width. These areas are then automatically carried through the appropriate computations which are necessary to generate the required PSRM parameters.

APPENDIX D

A PROCEDURE FOR THE DESIGN OF DETENTION BASINS

A general detention basin design procedure is presented in Chapter V. This appendix presents a more detailed discussion of techniques that can be used to accomplish each step in the general detention basin design procedure.

- Define the Site Conditions (pre- and post-development)

  Refer to SCS Technical Release 55 (TR-55) Chapter 2, ("Urban Runoff Curve Numbers") for the procedure to develop a weighted curve number (CN) reflecting both pre- and post-development conditions.

- Determine the Total Quantity of Stormwater Runoff that Arrives at the Entrance of the Detention Facility

  After determining the weighted CN value for both pre- and post-development site conditions, use (Eq. 2-7, TR-55):

$$S = \frac{1,000}{CN} - 10$$

  to determine the potential abstraction(s) for pre- and post-development conditions. Then substitute the value determined for the potential abstraction into (Eq. 2-5, TR-55):

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

  to determine the total runoff in inches (Q). P is the total precipitation for the 2-, 10-, 25-, or 100-year rainfall events. For this pilot study, the precipitation quantities for these events are given in Table D-1.

TABLE D-1

24-HOUR RAINFALL DEPTHS FOR SELECTED RETURN PERIODS IN THE RIDLEY CREEK WATERSHED

Return Periods	Depth in Inches
2-year	2.92
10-year	4.68
25-year	5.54
100-year	6.85

The total runoff volume should be calculated for all rainfall events over both pre- and post-development conditions. The total runoff volume that will be infiltrated through on-site infiltration facilities can be subtracted from the total runoff (Q) when the total runoff for post-development conditions is calculated.

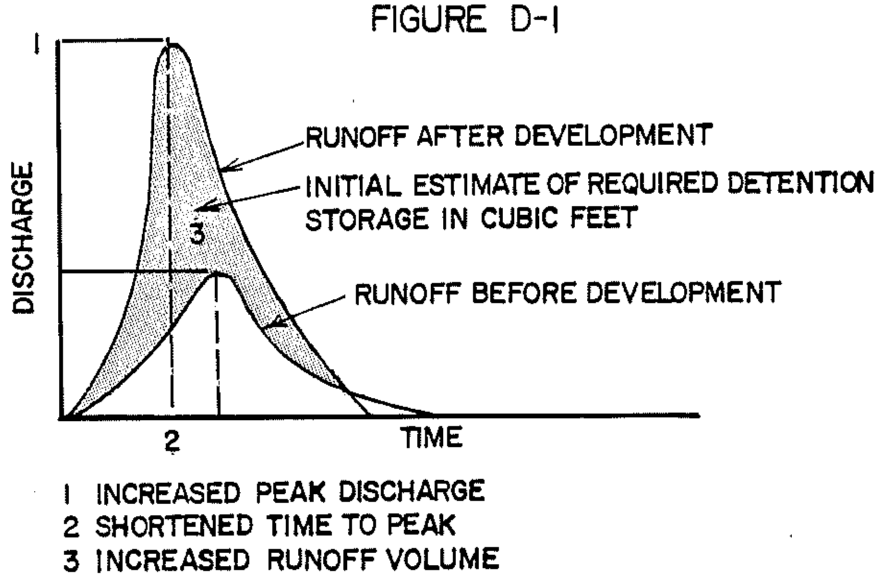
o Develop Runoff Hydrographs for All Rainfall Events

Determine the time of concentration (T_c) for the site in both pre- and post-development conditions. Using the appropriate chart in Table 5-3 of TR-55 relating to the T_c that has been determined for pre- and post-development, construct the hydrographs for all four rainfall events. A total of eight hydrographs should, therefore, be developed. A convenient computation sheet is provided on the following page for constructing the hydrographs.

o Determine a Preliminary Basin Design

A first attempt at determining an initial size for the proposed detention basin should be made by plotting the pre- and post-development hydrographs for all rainfall events. The area on this graph between the pre- and post-development hydrographs will provide an estimate of the volume of runoff that may be needed to control the peak runoff rate after development to the pre-development peak runoff rate. (If the development site is in a subarea with a release rate percentage, however, the appropriate peak discharge rate should be defined and the estimated volume increased in relation to the release rate percentage. Refer to Chapter V for a discussion of the release rate percentage.) Figure D-1 shows example pre- and post-development hydrographs. In Figure D-1, the shaded area between the hydrographs would provide an estimate of the required detention storage volume for this hypothetical condition.

FIGURE D-1



- The unknown impact of the operation of the stormwater management system within the development site on downstream areas

  When the stormwater management system is a last-minute add-on, the only criterion used for it is a specific performance control (post-development peak runoff rate no greater than the pre-development peak runoff rate) at the development site boundary. The impact of redirected or increased stormwater runoff on-site and in downstream areas may create future claims for damage by affected landowners. Minor revisions of the development site design and review procedure may provide for better coordination of the stormwater management system design with other site development design phases.

An alternative procedure for developing a stormwater management system for a land development site may include the use of a "stormwater management feasibility study." The feasibility study could be used to preliminarily define an "optimum" stormwater management system for a site which can be more effectively designed and reviewed. The use of a feasibility approach can also help cut the overall costs for stormwater management on a development site. The contents of a stormwater management feasibility study for a land development site may include the items listed in Table E-1.

The existing site development plan review process that was presented earlier (Figure E-1) was reviewed to determine whether or not a feasibility study alternative could be incorporated into the existing system. Figure E-2 illustrates one alternative for incorporating a stormwater management feasibility study approach into the existing review process for Delaware County municipalities.

The benefits of the recommended procedure for incorporating the feasibility study approach into the site development review process include:

- A potential reduction of wasted engineering fees resulting from detailed work which is determined to be inadequate by the reviewing municipality at advanced stages of the review process.
- A potential reduction in the overall time required for the review procedure because of early coordination between the applicant and the municipality.
- The definition of potential areas of environmental concern during the initial planning phases when cost-effective methods for eliminating this potential for adverse impact can best be determined.
- Better overall coordination of the efforts of developers, technical consultants, municipal engineers, and local municipal officials.

TABLE E-1

TYPICAL CONTENTS OF A
STORMWATER MANAGEMENT FEASIBILITY STUDY
AND PRELIMINARY SITE SKETCH PLAN

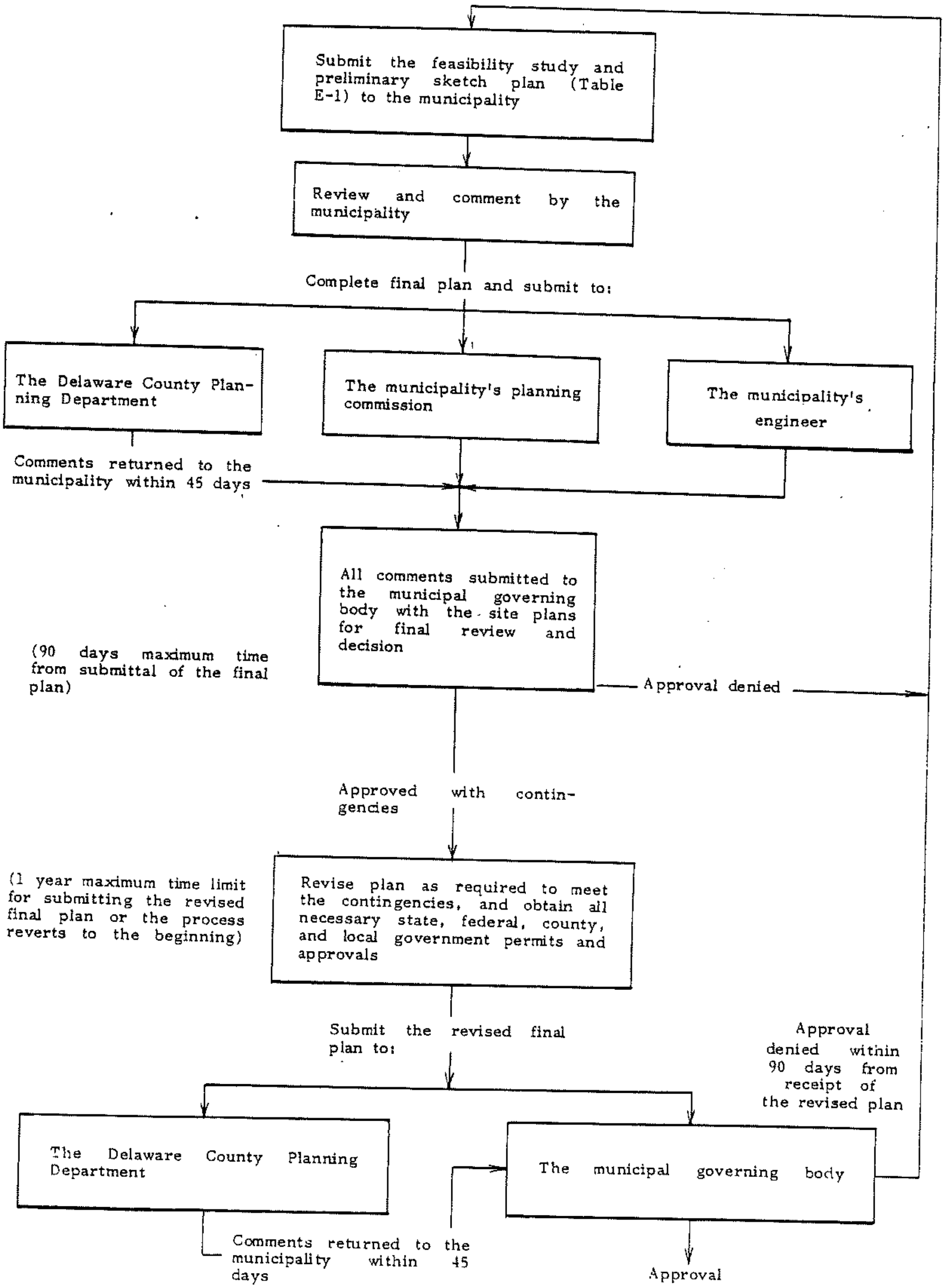
A. Feasibility Study

- Existing ground cover conditions
- Soil descriptions, boundaries, seasonal high groundwater levels (SCS Soil Surveys can be used as a reference)
- Underlying geologic conditions
- Definition of the existing natural drainage paths and drainage area boundaries
- Designation of any wetland areas
- 100-year floodplain boundaries
- Definition of existing on- or off-site drainage problems
- Appropriate stormwater management criteria as defined by the standards and criteria of the pilot stormwater management plan
  - Release rate percentage
  - Direct discharge
  - Downstream impact evaluation

B. Preliminary Site Sketch Plan

- Architectural layout of streets, buildings, approximate building dimensions, parking areas, walkways, and other impervious areas
- Configuration of the storm and sanitary sewer system layout
- Approximate location and layout of the stormwater management system with a description of its proposed operation
- No detailed calculations are required at this time

FIGURE E-2


Submit the feasibility study and preliminary sketch plan (Table E-1) to the municipality
Review and comment by the municipality
Complete final plan and submit to:
The Delaware County Planning Department
The municipality's planning commission
The municipality's engineer
Comments returned to the municipality within 45 days
All comments submitted to the municipal governing body with the site plans for final review and decision
(90 days maximum time from submittal of the final plan)
Approval denied
Approved with contingencies
(1 year maximum time limit for submitting the revised final plan or the process reverts to the beginning)
Revise plan as required to meet the contingencies, and obtain all necessary state, federal, county, and local government permits and approvals
Submit the revised final plan to:
Approval denied within 90 days from receipt of the revised plan
The Delaware County Planning Department
The municipal governing body
Comments returned to the municipality within 45 days
Approval

APPENDIX F

STORMWATER MANAGEMENT PROBLEM IDENTIFICATION AND COST ACCOUNTING SYSTEMS

A concern commonly considered when the subject of stormwater management planning is discussed involves the actual cost of repair and maintenance resulting from stormwater related damages. A question that is frequently asked is: "Is there adequate justification for the stormwater management planning effort in our community?" In most areas, a detailed inventory of repair work resulting from storm runoff damages is not kept up-to-date by municipal maintenance crews. As a result, only limited information is typically available describing the cause of storm runoff damages. Therefore, it is difficult to evaluate the costs of actual repair and maintenance that result from stormwater related damages. Documentation of a frequently occurring problem can provide justification for decisions regarding the correction of the problem and can also help to identify where revisions to an existing stormwater management plan are most necessary.

The problem identification and cost accounting system that has been developed for this pilot stormwater management plan is, in a sense, an effective management practice that can be used to develop one of the critical aspects of any long-term stormwater management plan, i.e., the necessary justification for the preventative approach to the problem of stormwater runoff control. In addition, the system can also help provide the basis for educational programs aimed at pointing out the consequences and/or impacts of inefficient and/or ineffective stormwater management programs. The problem identification and cost accounting system includes three forms that may be utilized in the following fashion:

Form No.1:

This form is a log sheet for repair or maintenance that is required as a result of stormwater runoff. This form or log sheet is intended to be a one-page sheet that is carried in the municipal maintenance trucks and completed whenever a maintenance crew is called out to repair any damages resulting from stormwater runoff or to repair and provide routine maintenance of a stormwater management facility. The proper use and importance of the log sheet should be described to municipal management and maintenance personnel in order for it to be readily accepted and, therefore, easily used. It would need to be pointed out to the maintenance crews, probably by the municipal engineer or manager, that the form is a critical part of a long-term stormwater management planning program and that it needs to be filled out for all stormwater runoff related repair and/or maintenance activities. The form should be signed by the job foreman, and each job should be assigned a job number (see Form No. 1). The important items on this form include:

- Location of activities

- Reason why the repair or maintenance is required

  This description involves the mere checking of a particular item on the form, so it can be easily used by maintenance personnel.

- The work required

  This section is split between repair or replacement of structures and general maintenance (see Sections C and D of Form No. 1). This item is important because total annual stormwater costs should be identified in terms of costs spent on needed repair or replacement activities and costs spent on general maintenance.

- General information that can be used to develop costs for the job

  Sections E through J are intended to provide information on the time required and the materials used in order that a total cost for the job can be developed at a later date.

Completed Form No. 1 sheets should ideally be collected and reviewed by the municipal engineer or manager on a quarterly basis (or more frequently as appropriate). In addition, any repair or replacement work (see Section C) should signal the need to fill out Form No. 2 for that particular problem.

<u>Form No.2</u>:

This form is intended to be used by the municipal engineer for problems directly related to stormwater runoff. That is, any critical problems (particularly recurring problems) that are repaired or fixed should be documented for use in an annual summary of these type of repairs. An example of a problem that would be written up in this manner is an undersized road culvert that is removed and replaced by a larger sized culvert so that immediate upstream flooding can be eliminated or reduced. These types of activities on a municipal- or watershed-wide basis are those for which you would like to have documentation as you initiate or update a watershed-level stormwater management plan.

This documentation will allow the municipality to see if it is constantly "putting band-aids on the wounds" as opposed to addressing (healing) the source of the problem. For example, if a particular municipality in the downstream portion of the watershed is consistently having to increase the size of its drainage facilities (e.g. road culverts), and the Delaware County Planning Department can see that

FORM NO. 1
LOG SHEET FOR STORMWATER RELATED
REPAIR OR MAINTENANCE

Municipality: ______________________________

A. Job no. ____________ and location ______________________________

____

B. Why repair or maintenance is required: (check appropriate item/s)

- _____ flooding of structures
- _____ nuisance flooding affecting roadways, parking areas, public open areas, etc.
- _____ overflow of man-made drainage systems; i.e., storm sewers, combined sewers, concrete open channels, etc.
- _____ erosion of stream channels
- _____ erosion of slopes, open areas, etc.
- _____ damage to bridge or culvert
- _____ surface water or wetland contamination
- _____ mosquito control
- _____ other: ____

____

C. Work required - repair or replacement of:

- _____ bridge or culvert
- _____ storm or combined sewer
- _____ inlet structure
- _____ outflow structure
- _____ pumps
- _____ man-made channel
- _____ other: ____

____

D. Work required - general maintenance such as:

- _____ sediment (sand & silt) removal
- _____ obstruction removal; i.e., logs, tires, etc.
- _____ sewer flushing
- _____ grass mowing

FORM NO. 3
ANNUAL SUMMARY OF STORMWATER RELATED COSTS FOR 19__

Municipality: ______________________________

A. Brief summary description of general watershed runoff problems or problem types: ______________________________

____

____

(attach additional sheet or report if required)

B. Brief summary description of the potential causes of the key watershed problems: ______________________________

____

____

(attach additional sheet or report if required)

C. Number of stormwater runoff related problems that have been reported to and/or addressed by the municipality:

_____ substantial flooding affecting structures

_____ nuisance flooding affecting roadways, parking areas, public open areas, etc.

_____ overflow of man-made drainage systems; i.e., storm sewers, combined sewers, concrete open channels, etc.

_____ erosion of stream channels

_____ erosion of slopes, open areas, etc.

_____ damage to bridge or culvert

_____ surface water or wetland contamination

_____ mosquito control

_____ other: ______________________________

____

D. Number of stormwater runoff related problems for which log sheets have been prepared, with total costs:

FORM NO. 3
ANNUAL SUMMARY OF STORMWATER RELATED
COSTS FOR 19__
(CONTINUED)

Number of Instances	Description of Activity	Total Costs
1. Repair or replacement of:		
____	bridge or culvert	____
____	inlet structure	____
____	channel or drainage swale	____
____	outflow structure	____
____	other: ____________	____
	____________	
2. General maintenance		
____	sediment removal	____
____	sewer flushing	____
____	weed control	____
____	placing of rip-rap or similar materials	____
____	obstruction removal; i.e., logs, tires, etc.	____
____	grass mowing	____
____	regrading	____
____	other: ____________	____
	____________	

E. Annual summary of stormwater related costs:

1. Number of jobs requiring only maintenance ____________

Total cost ____________

Number of jobs requiring repair and/or construction ____________

Total cost ____________

Total annual stormwater related costs ____________

ACT 167

STORMWATER MANAGEMENT PLAN

FOR THE

RIDLEY CREEK WATERSHED

VOLUME II ADDENDUM

RIDLEY CREEK STORMWATER MANAGEMENT STUDY

DELAWARE COUNTY PLANNING DEPARTMENT
Toal Building
2nd & Orange Streets
Media, PA 19063

WALTER B. SATTERTHWAITE ASSOCIATES, INC.
720 N. Five Points Road
West Chester, PA 19380

GREEN INTERNATIONAL, INC.
504 Beaver Street
Sewickley, PA 15143

June, 1988

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INTRODUCTION

This document serves as an addendum to Volume II of the Act 167 Stormwater Management Plan for the Ridley Creek Watershed. The text reflects changes in the watershed's land use and municipal ordinance structures between 1982, when the plan was originally prepared, and 1988, the time of County adoption.

TECHNICAL ANALYSIS UPDATE

Technical Update Approach

The original "pilot" watershed plan was developed based on land use data and information gathered in the spring and summer of 1982 and, therefore, reflected the current development conditions in the watershed at that time. Between the time of the original plan preparation and this update, some development activity has occurred within the watershed, changing the present land use conditions. As part of this update, land use information was gathered in the fall of 1986 by the Delaware County Planning Department and placed onto appropriate mapping so that the digitized data base for the watershed could be updated to reflect the current conditions at that time.

The reason for the update of the technical aspects of the plan is to determine whether the existing plan provisions are adequate or whether new or stricter requirements are appropriate. The update is intended to examine the impacts of the changes in land use resulting from actual development activity in the watershed as well as any other important stormwater or flood control facilities that may have been constructed since the original plan preparation. In the case of the Ridley Creek watershed in 1986, it was deemed appropriate to modify the Penn State Runoff Model (PSRM) simulation modeling of the watershed to reflect the actual development which had occurred since the original plan preparation in 1982.

Along with the update of the original 1982 data base, the entire digitized watershed data base was converted to a new digitization program format for use on a personal computer. The original 1982 data base was developed using a main frame computer program at West Chester University which is no longer available. Its conversion to the personal computer digitization program format now provides greater flexibility for use by the County and other users.

Digitization of the mapping provided by the Planning Department, which shows the actual development that has occurred in the Ridley Creek watershed since 1982, was performed. In this way, the new digitized data base was modified to reflect the changes in the actual land use in the existing and future conditions models. The new digitized data base was reaggregated to calculate new SCS runoff curve numbers and impervious percentages for those subareas in which land use changes have occurred. These parameters were also recomputed for the future conditions model, presuming that the actual development which has occurred is not exactly that which was anticipated in 1982.

The PSRM input sequences for the existing and future conditions models were updated using the recalculated curve numbers and impervious percentages. The new models were run to compute new subarea and watershed peak flow rates for the 10-, 25-, 50-, and 100-year design storms.

The changes in existing and future conditions subarea characteristics resulting from the digitization of updated land use information is reflected in Table A-1, which corresponds to Table IV-4 of Volume II of the pilot watershed plan (page 76). The peak flow rates at selected points of interest resulting from the changes in the existing and future conditions watershed models are illustrated in Tables A-2 and A-3. For the sake of comparison, these tables correspond with Tables IV-3 and IV-5 of Volume II of the plan (found on pages 72 and 77, respectively). As can be observed in these two tables, there has been relatively little increase in peak flow rates at the selected points of interest as a result of the development which has occurred from 1982 to 1986. An increase is noted in the peak flow rates of the 2-year storm near the mouth of the watershed, possibly as a result of significant increases in impervious cover percentages in the middle and lower portions of the watershed (i.e, subareas 37 through 43 and 47 through 59). The peak flow rate changes are evident in both existing and future conditions modeling results.

Tables A-4 and A-5 present the subarea peak runoff flow rates and the total watershed peak flow rates at subarea outlets throughout the watershed. These results correspond with Tables IV-6 and IV-7 of Volume II (found on pages 79 and 80 therein). The individual subarea peak runoff flow rates reflect increases that can be anticipated in those subareas where development has occurred, which has raised both runoff curve numbers and impervious percentages. The total watershed peak flow rates at subarea outlets further reflect the trends and the results described above.

Summary of Modeling Results

The modeling results of the 1986 update show little change in the results obtained in 1982. This reflects the rather minor amount of development which has occurred relative to the watershed as a whole. There were no new flood control or major stormwater management structures constructed in the watershed which would cause a significant change in modeling results. Therefore, the provisions for stormwater management developed in the 1982 plan are still believed to be appropriate for implementation in 1988. The most significant changes in peak flow rates noted are for the smaller, more frequent design storm events, so the focus for stormwater management in the Ridley Creek watershed continues to be on addressing those events (i.e., the 2-through 25-year storms). The standards and criteria presented in Volume I of the watershed plan remain the recommended provisions for implementing stormwater management control in accordance with the requirements of Section 13 of Act 167.

Update of Release Rate Percentages

A primary performance standard for stormwater management control and facility design in the Ridley Creek watershed is the release rate percentage which has been assigned to each subarea of the watershed. Along with the updated watershed modeling, new release rates were calculated using the new PSRM model output. The new release rates presented on Plates 1 and 2 of the watershed plan reflect the updated hydrologic modeling results. The release rates presented in the tables on Plates 1 and 2 have been checked to ensure that the desired control of peak flow rates is achieved at downstream points of interest while also ensuring that the computed release rates are not overly conservative and a burden to land development. A description of the basis for computing the release rates and for their use in stormwater management design according to the standards and criteria is presented in Volume II, pages 86 through 100.

TABLE A-1

EXISTING AND FUTURE SUBAREA CHARACTERISTICS
(1986 UPDATE)

		Existing Land Cover		Future Land Cover	
Subarea No.	Area (Acs.)	Percentage Impervious	Curve No.	Percentage Impervious	Curve No.
3	312	4	65	8	64
4	108	1	65	7	62
5	150	4	71	9	66
6	217	4	65	8	63
7	105	0	61	8	63
8	46	4	64	9	64
9	242	4	65	8	67
11	219	1	68	7	64
12	233	3	72	7	65
14	56	33	67	33	67
16	193	24	63	58	64
17	63	10	62	10	62
18	50	32	67	35	63
19	77	4	63	10	65
20	397	0	61	0	61
21	594	0	65	8	65
22	235	0	61	0	61
23	184	5	62	8	62
24	125	3	60	3	60
25	105	1	60	3	60
26	541	0	58	0	58
27	393	3	60	3	61
28	59	8	59	9	60
29	284	0	57	0	57
30	97	13	62	17	63
31	262	9	61	13	62
32	227	0	59	1	59
33	79	0	59	0	59
34	238	11	68	11	68
35	204	4	64	4	64
36	226	17	62	17	63
37	96	13	62	14	63
38	208	12	63	15	64
39	221	10	69	14	68
40	312	12	63	12	64
41	190	13	62	19	63
42	403	10	62	13	63
43	352	34	65	35	66
44	80	33	62	33	62
45	308	12	63	12	63
46	0	0	62	0	62
47	332	25	65	25	65
48	145	44	66	44	66
49	151	32	63	32	63

TABLE A-1

EXISTING AND FUTURE SUBAREA CHARACTERISTICS
(1986 UPDATE)

CONTINUED

		Existing Land Cover		Future Land Cover	
Subarea No.	Area (Acs.)	Percentage Impervious	Curve No.	Percentage Impervious	Curve No.
50	207	16	66	16	66
51	226	13	61	13	62
52	131	29	62	31	60
53	340	18	62	19	62
54	446	17	61	17	61
55	140	35	68	43	68
56	475	20	68	22	68
57	189	29	69	30	69
58	191	44	66	44	66
59	188	19	73	20	73
60	387	30	71	30	71
61	0	0	62	0	62
62	497	19	67	19	67
63	165	23	71	24	71
64	416	34	67	35	67
65	401	59	62	62	62

TABLE A-2

PEAK FLOW RATES AT SELECTED POINTS OF INTEREST
(1986 UPDATE)

Point of Interest[1]	EXISTING CONDITIONS Peak Flow in Cubic Feet Per Second Q2	Q10	Q25	Q100	Comment/Capacity
9	210	620	930	1,460	Mouth of Stackhouse Mill Run
12	730	2,670	3,510	5,040	Main stem flows below Stackhouse Mill Run
14	880	3,200	4,190	6,030	Flow rate at County line
20	910	3,390	4,400	6,330	State park boundary
21	930	3,460	4,490	6,480	Gradyville Rd. bridge/ 4,856 cfs
26	140	180	270	500	Mouth of unnamed tributary
27	960	3,590	4,670	6,760	State park boundary - bridge at Sycamore Mills/unknown
33	190	290	410	670	Mouth of Dismal Run
40	150	280	400	630	Mouth of Spring Run
41	1,030	3,850	5,030	7,280	Rose Tree Rd. bridge/ unknown
46	1,060	3,950	5,180	7,490	Media Water Filtration Plant - Baltimore Pike bridge/ 14,860 cfs
50	1,090	4,020	5,270	7,610	USGS stream gage at Moylan - Manchester Rd. bridge/10,271 cfs
53	240	400	510	740	Mouth of Vernon Run
56	1,130	4,140	5,450	7,830	Brookhaven Road bridge/8,763 cfs
62	1,330	4,260	5,610	8,040	Route 320 bridge/not applicable
65	1,520	4,330	5,720	8,170	Mouth of Ridley Creek

1 Number of subarea outlet where flow was computed

TABLE A-3

PEAK FLOW RATES AT SELECTED POINTS OF INTEREST
(1986 UPDATE)

Point of Interest[1]	FUTURE CONDITIONS Peak Flow in Cubic Feet Per Second Q2	Q10	Q25	Q100	Comment/Capacity
9	250	630	930	1,440	Mouth of Stackhouse Mill Run
12	730	2,640	3,480	5,000	Main stem flows below Stackhouse Mill Run
14	870	3,180	4,160	5,980	Flow rate at County line
20	910	3,360	4,360	6,280	State park boundary
21	930	3,430	4,460	6,420	Gradyville Rd. bridge/ 4,856 cfs
26	150	210	300	530	Mouth of unnamed tributary
27	960	3,570	4,640	6,700	State park boundary - bridge at Sycamore Mills/unknown
33	210	330	470	750	Mouth of Dismal Run
40	160	300	430	680	Mouth of Spring Run
41	1,040	3,840	5,000	7,220	Rose Tree Rd. bridge/ unknown
46	1,070	3,940	5,150	7,430	Media Water Filtration Plant - Baltimore Pike bridge/ 14,860 cfs
50	1,100	4,010	5,240	7,560	USGS stream gage at Moylan - Manchester Rd. bridge/10,271 cfs
53	260	420	530	760	Mouth of Vernon Run
56	1,140	4,130	5,420	7,780	Brookhaven Road bridge/8,763 cfs
62	1,390	4,250	5,580	7,980	Route 320 bridge/not applicable
65	1,590	4,320	5,690	8,110	Mouth of Ridley Creek

1 Number of subarea outlet where flow was computed

TABLE A-4

SUBAREA PEAK RUNOFF FLOW RATES (1986 UPDATE)

Subarea No.	Existing Conditions Q100[1]	Q25	Q10	Q2	Future Conditions Q100	Q25	Q10	Q2
1	390	270	200	70	390	270	200	70
2	300	210	160	50	300	210	160	50
3	210	120	80	40	260	160	120	60
4	140	70	40	30	140	80	60	50
5	190	110	70	20	170	110	70	40
6	220	120	80	40	230	140	100	60
7	60	30	20	20	100	60	50	30
8	40	20	10	10	50	30	20	10
9	180	110	70	30	250	150	110	50
10	4,400	3,090	2,280	650	4,400	3,090	2,280	650
11	310	160	90	40	290	160	110	70
12	200	120	70	20	180	110	80	40
13	1,050	730	540	170	1,050	730	540	170
14	140	100	80	40	140	100	80	40
15	400	280	210	70	400	280	210	70
16	380	260	200	120	670	510	420	250
17	90	50	40	30	90	50	40	30
18	120	80	70	40	120	80	70	40
19	110	60	40	40	150	90	60	40
20	150	80	50	40	150	80	50	40
21	510	250	150	90	710	420	300	150
22	140	80	50	50	140	80	50	50
23	190	110	70	60	210	130	90	70
24	100	50	40	40	100	50	40	40
25	40	20	10	10	50	30	20	10
26	180	100	70	70	180	100	70	70
27	300	170	120	120	320	180	120	110
28	50	30	30	20	60	40	30	20
29	140	90	90	90	140	90	90	90
30	140	90	60	40	160	100	80	40
31	280	180	130	100	350	220	170	110
32	110	60	50	50	120	70	50	50
33	40	20	10	10	40	20	10	10
34	350	220	150	70	350	220	150	70
35	180	100	70	40	180	100	70	40
36	390	250	190	140	410	260	190	130
37	130	80	60	40	140	90	70	40
38	320	200	140	100	360	230	170	100
39	270	170	120	50	300	190	140	70
40	420	270	200	120	440	280	200	110
41	170	120	90	50	220	160	120	70
42	350	230	180	100	410	280	220	120
43	880	620	490	280	910	650	500	280
44	200	140	110	80	200	140	110	80
45	380	240	180	100	380	240	180	100
46	--	--	--	--	--	--	--	--
47	640	450	350	190	640	450	350	190
48	350	260	210	120	350	260	210	120

TABLE A-4

SUBAREA PEAK RUNOFF FLOW RATES (1986 UPDATE)
CONTINUED

Subarea No.	Existing Conditions Q100[1]	Q25	Q10	Q2	Future Conditions Q100	Q25	Q10	Q2
49	410	280	210	150	410	280	210	150
50	400	250	180	90	400	250	180	90
51	280	190	140	90	290	190	150	90
52	270	190	150	90	270	200	160	100
53	530	350	270	160	540	360	280	160
54	540	380	300	170	540	380	300	170
55	340	240	190	100	390	280	220	120
56	860	570	420	210	900	600	450	230
57	440	310	240	130	450	320	240	130
58	420	310	250	140	420	310	250	140
59	460	300	220	90	470	310	220	100
60	830	590	450	230	830	590	450	230
61	--	--	--	--	--	--	--	--
62	910	600	450	230	910	600	450	230
63	340	230	170	80	350	240	180	90
64	870	630	490	270	890	640	500	270
65	1,170	900	730	420	1,220	940	760	440

1 All flows in cubic feet per second

TABLE A-5

TOTAL PEAK FLOW RATES AT SUBAREA OUTLETS (1986 UPDATE)

Subarea	Existing Conditions				Future Conditions			
No.	Q100[1]	Q25	Q10	Q2	Q100	Q25	Q10	Q2
1	390	270	200	70	390	270	200	70
2	300	210	160	50	300	210	160	50
3	840	560	400	140	840	570	410	150
4	140	70	40	30	140	80	60	50
5	1,070	710	490	170	1,040	690	490	180
6	220	120	80	40	230	140	100	60
7	60	30	20	20	100	60	50	30
8	310	170	110	60	380	230	170	100
9	1,460	930	620	210	1,440	930	630	250
10	4,400	3,090	2,280	650	4,400	3,090	2,280	650
11	310	160	90	40	290	160	110	70
12	5,040	3,510	2,670	730	5,000	3,480	2,640	730
13	1,050	730	540	170	1,050	730	540	170
14	6,030	4,190	3,200	880	5,980	4,160	3,180	870
15	400	280	210	70	400	280	210	70
16	550	380	260	140	790	590	430	270
17	6,200	4,310	3,330	900	6,150	4,280	3,310	900
18	120	80	70	40	120	80	70	40
19	190	120	90	50	200	130	100	50
20	6,330	4,400	3,390	910	6,280	4,360	3,360	910
21	6,480	4,490	3,460	930	6,420	4,460	3,430	930
22	6,490	4,500	3,470	930	6,450	4,460	3,450	930
23	190	110	70	60	210	130	90	70
24	100	50	40	40	100	50	40	40
25	320	180	120	100	350	200	150	120
26	500	270	180	140	530	300	210	150
27	6,760	4,670	3,590	960	6,700	4,640	3,570	960
28	50	30	30	20	60	40	30	20
29	190	110	90	90	190	110	90	90
30	140	90	60	40	160	100	80	40
31	340	220	160	100	420	280	200	110
32	450	280	200	120	530	340	250	140
33	670	410	290	190	750	470	330	210
34	7,000	4,830	3,710	990	6,940	4,800	3,690	1,000
35	7,040	4,860	3,730	990	6,980	4,820	3,710	1,000
36	390	250	190	140	410	260	190	130
37	480	310	230	170	500	320	230	160
38	7,130	4,930	3,780	1,010	7,070	4,890	3,760	1,010
39	270	170	120	50	300	190	140	70
40	630	400	280	150	680	430	300	160
41	7,280	5,030	3,850	1,030	7,220	5,000	3,840	1,040
42	7,360	5,080	3,890	1,040	7,300	5,050	3,880	1,050
43	690	500	400	240	710	520	410	240
44	790	570	450	270	820	590	460	270
45	380	240	180	100	380	240	180	100
46	7,490	5,180	3,950	1,060	7,430	5,150	3,940	1,070
47	7,540	5,220	3,980	1,070	7,480	5,190	3,970	1,080
48	350	260	210	120	350	260	210	120

TABLE A-5

TOTAL PEAK FLOW RATES AT SUBAREA OUTLETS (1986 UPDATE)

Subarea	Existing Conditions				Future Conditions			
No.	Q100[1]	Q25	Q10	Q2	Q100	Q25	Q10	Q2
49	670	470	360	190	670	470	360	190
50	7,610	5,270	4,020	1,090	7,560	5,240	4,010	1,100
51	7,620	5,290	4,020	1,090	7,560	5,260	4,010	1,100
52	270	190	150	90	270	200	160	100
53	740	510	400	240	760	530	420	260
54	7,740	5,380	4,090	1,110	7,690	5,350	4,080	1,120
55	340	240	190	100	390	280	220	120
56	7,830	5,450	4,140	1,130	7,780	5,420	4,130	1,140
57	7,860	5,470	4,150	1,140	7,800	5,440	4,140	1,150
58	420	310	250	140	420	310	250	140
59	460	300	220	90	470	310	220	100
60	830	590	450	230	830	590	450	230
61	1,300	890	660	320	1,300	900	670	330
62	8,040	5,610	4,260	1,330	7,980	5,580	4,250	1,390
63	8,060	5,630	4,270	1,360	8,010	5,600	4,260	1,430
64	8,120	5,680	4,300	1,440	8,060	5,650	4,290	1,510
65	8,170	5,720	4,330	1,520	8,110	5,690	4,320	1,590

1 All flows in cubic feet per second

MUNICIPAL ORDINANCE UPDATE

Since 1982, when the original pilot watershed plan was prepared, municipalities have made numerous changes in their general regulatory controls and provisions which address stormwater-related issues. Tables A-6 and A-7, which correspond to Tables VI-1 and VI-2 of Volume II, (found on pages 148 and 153, respectively) represent updated versions of these original tables, and reflect 1987 municipal regulations.

TABLE A-6
INVENTORY OF EXISTING REGULATORY CONTROLS
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Zoning	Subdivision Land Development	Grading	Erosion Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Brookhaven Borough	Planning & Zoning Code Title 4 Zoning 1974 Chapt. 1270 Flood-plain District	DELCO Subdiv. Ord. #78-5 1978 Sec. 307.3 Stream Easements Sec. 308 Erosion & Sedimentation Sec. 309 Storm Drainage Sec. 310 Natural Features Preservation	B & H Code Chapt 1432 1972 All DELCO Subdiv. Ord. #78-5 1978 Sec. 308.3 Grading for Drainage	B & H Code Chapt. 1432 1972 All DELCO Subdiv. Ord. #78-5 1978 Sec. 308 Erosion & Sedimentation	P & Z Code Title 4 Zoning Chapt. 1270 B & H Code Chapt. 1470 Flood Hazard	B & H Code Chapt. 1432 1972 Grading Drainage & Erosion Control	B & H Code Chapt. 1432 1972 All DELCO Subdiv. Ord. #78-5 1978 Sec. 309 Storm Drainage Systems		P & Z Code Title 2 Land Plan-ning 1962 Chapt. 1222 Develop. Plans DELCO Subdiv. Ord. #78-5 1978 Sec. 310 Natural Features Preser-vation

1 All sections of ordinance relevant to stormwater/drainage management
P = Planning Z = Zoning B & H = Building and Housing

TABLE A-6
INVENTORY OF EXISTING REGULATORY CONTROLS
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Zoning	Subdivision Land Development	Grading	Erosion Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Chester City	P & Z Titles 1948, as amended Art. 1367 1980 Flood-plain	P & Z Code Title 1 1965 Art. 1307.03 (Plan info.) Art. 1309.02 Construction of Facilities Art. 1309.045 Manholes Art. 1309.08C Stormwater			P & Z Code Title 5 Art. 1367 1980 Floodplain	BOCA 1979			Various Coverage Require-ments

TABLE A-6
INVENTORY OF EXISTING REGULATORY CONTROLS
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Zoning	Subdivision Land Development	Grading	Erosion Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Eddystone Borough	Ord. #402 1967 Chapt. 128 Imper- vious Coverage	DELCO. Subdiv. Ord. #78-5 1978 Sec. 307.3 Stream Easements Sec. 308 Erosion & Sedimentation Sec. 309 Storm Drainage Sec. 310 Natural Features Preservation	DELCO Subdiv. Ord. #78-5 1978 Sec. 308.3 Grading for Drain- age	DELCO. Subdiv. Ord. #78-5 1978 Sec. 308 Erosion & Sedimentation	Ord. #444 Chapt. 41 Art. II 1976 Flood-Prone Areas	Ord. #444 Chapt. 41 Art. II 1976 Flood- Prone Areas	DELCO. Subdiv. Ord. #78-5 1978 Sec. 309 Storm Drainage	Ord. #402 1967 Sec. 2.4 PUD	DELCO Subdiv. Ord. #78-5 1978 Sec. 310 Natural Features Preser- vation Ord. #444 Chapt. 112 Art. IV Sec. 112.18 Road Con- struc- tion Drainage

TABLE A-6
INVENTORY OF EXISTING REGULATORY CONTROLS
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Zoning	Subdivision Land Development	Grading	Erosion Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Edgmont Township	Ord. #79 1984 Art. 9 PRD Art. 15 Flood Hazard District Sec. 2004 Open Space Sec. 1915.C.4 Enviro-mental	Ord # 70 1980 Sec. 706 Grading-see Ord. #82 Sec. 708 Steep Slopes Sec. 709 Easements Sec. 811 Storm Sewer System Sec. 818 Grading-see Ord. #82 Ord. #81 1984 Erosion & Sedimentation All Replacement for Sec. 707 of the DELCO Subdiv. Ord. Ord. #82 1986 Grading - All	Ord. #82 1986 All Ord. #70 1980 Sec. 706 Grading- see Ord. #82	Ord. #81 1984 Erosion & Sedimentation/ Stormwater All	Ord. # 79 1984 Art. 15 Flood Hazard District All Ord. #59 1977 Structures in the Flood-plain Ord. #60 1977 Floodplain District Ord. #61 1977 Floodplain District	BOCA 1978 Ord. #59 1977 Struct. in the Flood-plain	Ord. # 81 1984 Erosion & Sedimentation/ Stormwater All	Ord. #48 1975 Sec. 323.d.2 Sec. 323.d.6 Ord. #79 1984 Sec. 900.E Purpose Sec. 906.C. 1.d Cover. Sec. 907.B Storm-water All Sec. 907.C Erosion & Sedi-menta-tion Sec. 910.A.6 Drain-age Drawing Sec. 910.A.7 Soils Map	Ord. #79 1984 Art. 16 Steep Slopes All Sec. 1915 Enviro. Impact Sec. 2004 Open Space Sec. 910.A.14 Erosion & Sedi-mentation Sec. 910.A.18 Ease-ments

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INVENTORY OF EXISTING REGULATORY CONTROLS
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Zoning	Subdivision Land Development	Grading	Erosion Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Media Borough	Ord. #726 1982 Clusters (to be amended) Ord. #625 Amended 1983 Art. XXI Flood-plain All	Ord. #495 1965 Sec. 8 Storm Sewers Sec. 10.2 Storm Sewers Sec. 10.3 Stream Encroachment			Ord. #625 1983 Art. XXI Floodplain All				Ord. #625 Art. XIV Sec. 4 Land-scaping

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INVENTORY OF EXISTING REGULATORY CONTROLS
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Zoning	Subdivision Land Development	Grading	Erosion Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Middletown Township	Chap.IX Zoning 1986 Sec. 1106 PRD District Sec. 2600 Flood-plain District Art. 30 General Provi-sions Art. 27 Steep Slope	Ord. #296 1981 Sec. 305, 307 Conditions on Approval Sec. 402.b.15, 402.d Preliminary Plan Sec. 403.a.9.(d) Sec. 403.a.11 Sec. 403.a.12 Sec. 403.a.14 Sec. 403.a.15 Final Plans Sec. 502.b, 502.d General Standards Sec. 512 Stormwater Sec. 513 Erosion & Sedimentation Sec. 515 Easements Sec. 517 Topography & Grading Sec. 518 Natural Features Sec. 521 Inspection	Ord. #296 1981 Sec. 517 Grading 1982 Rev. Chapt. 3 Sec. 211 Erosion & Sedimen-tation	Ord. #296 1981 Sec. 513 Erosion & Sedimentation 1982 Rev. Chapter 3 Sec. 211 Erosion & Sedimentation	Chap. IX Zoning 1986 Sec. 2600 Floodplain	BOCA 1978 Chap. VII 101	Ord. # 296 1981 Sec. 512 Sec. 515	Chap IX Zoning 1986 Sec. 1100 PRD	Ord. #296 1981 Sec. 518 Natural Features

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INVENTORY OF EXISTING REGULATORY CONTROLS
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Zoning	Subdivision Land Development	Grading	Erosion Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Nether Providence Township	Ord.#434 1970 Apt. Dist. Sec. 704.A.2 Drainage Sec. 705.b.1.(d)(2) Plan Info. Ord. #454 1973 Profess. Office Dist. Sec. 802.a.A.1(c) Storm Drainage Ord.#463 1974 Multiple Dwelling Sec. 703.c. (j) thru (l) j Flood k Nat. F l Drain	Ord. # 270 1979 Sec. 3.A Subdiv. of a Lot Sec. B.8. Open Space Sec. B.9. Suitability of Land Sec. B.12. Storm Sewers Sec. B.13. Culverts Sec. B.14. Bridges Sec. C.2.d.(5) Preliminary Plan Sec. C.3.c(2)(d) Profile of Storm Sewers Sec. C.3.c(1)(e) Location of Storm Sewers Sec. C.4. Record Plan Sec. C.6. Consolidated Plans	Ord. #478 1976 Grading, Erosion Stormwater	Ord. # 478 1976 Grading, Erosion, Stormwater Ord. # 487 1978 Floodplain Section 8 Ord. # 544 1986 Environmental Impact Section 4	Ord. # 487 1978 Floodplain Ord. # 496 1980 Floodplain Amendment Ord. #544 1986 Environmental Impact Section 4	BOCA 1978	Ord. # 478 1976 All Ord. # 544 1986 Environmental Impact Section 4	Ord. # 543 1986 Amend to PRD	Ord. #544 1986 Enviro. Impact All

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INVENTORY OF EXISTING REGULATORY CONTROLS
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Zoning	Subdivision Land Development	Grading	Erosion Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Nether Providence Township (Cont'd)	Sec. 705.C.2 Drainage Sec.712. C.1 Physical Features Sec.712. C.1.e. Provisions Sec.712. C.1.f. Changes in Water Course	Sec. C.3.C(2)(d) Profile of Storm Sewers Sec. D.4.d Construction Guarantee Record Plan Sec. E.1 Required Improvements Sec. E.4.a Inspection Prior to Construction Sec. F.2 Conditions of Acceptance Ord. #509 1981 Fees Sec. 1.E							

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INVENTORY OF EXISTING REGULATORY CONTROLS
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Zoning	Subdivision Land Development	Grading	Erosion Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Parkside Borough	Ord.#335 1986 None	DELCO Subdiv. Ord. #78-5 1978 Sec. 307.3 Stream Ease-ments Sec. 308 Erosion & Sedimentation Sec. 309 Storm Drainage Sec. 310 Natural Features Preservation	DELCO Subdiv. Ord. #78-5 1978 Sec. 308.3 Grading for Drainage	DELCO Subdiv. Ord. #78-5 1978 Sec. 308 Erosion & Sedimentation	Ord. # 278 1977 - All	BOCA 1981	DELCO Subdiv. Ord. #78-5 1978 Sec. 309 Storm Drainage	Ord. #250 1969 Sec. 7(13) Sec. 12(c)	DELCO Subdiv. Ord. #78-5 1978 Sec. 310 Natural Features Preser-vation

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INVENTORY OF EXISTING REGULATORY CONTROLS
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Zoning	Subdivision Land Development	Grading	Erosion Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Ridley Township	Ord. #1441 1977 Sec. 10.200 Flood-plain District Sec. 16.1001 Powers & Duties of Engi-neer	Ord. #1443 1982 All	Ord.#1443 1982 Sec. 3.701.2.9.1 Final Plan Require-ments Sec. 7.302 Excava-tion & Grading in Flood-plain Areas Ord.#1362 1973 Sec. II	Ord. # 1443 1982 Sec. 3.100 Plan Require-ments Sec. 3.201.1 Pre-applica-tion Data Sec. 3.502.5 Preliminary Erosion & Sedimentation Sec. 3.801.18.4 Final Erosion & Sedimentation Sec. 3.801.18.6 Assurance of Future Erosion & Sedimenta-tion Sec. 4.800 Erosion & Sedimentation General Standards	Ord. # 1441 1977 Sec. 10.200 Floodplain Ord. #1443 1982 Sec. 3.204 Inform if Flood Hazard Sec. 4.300 Easements Sec. 4.1002 Waterways Art. VII Floodplain Areas All	Ord. #497 1949 None	Ord. # 1443 1982 Sec. 3.301.6 For 50+ Lots Sec. 3.502.9 Preliminary Stormwater Adequacy Sec. 3.601.2 Master Plan Surface Water Drainage Sec. 3.701.2.9.1 Final Plan Requirements Sec. 3.801.18.3 Storm Sewer Profiles Sec. 4.205 Storm Drainage Provisions	Ord. #114 Art. XIV All	Ord. #1443 1982 Sec. 3.1100 Earth Moving Activi-ties

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INVENTORY OF EXISTING REGULATORY CONTROLS
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Zoning	Subdivision Land Development	Grading	Erosion Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Ridley Township (Cont'd)							Sec. 4.300 Show Easements Sec. 4.700 Storm Drainage Sec. 4.1000 Stormwater Right-of-way Sec. 5.400 Storm Drainage Sec. 7.303 Drainage Facilities		

TABLE A-6
INVENTORY OF EXISTING REGULATORY CONTROLS
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Zoning	Subdivision Land Development	Grading	Erosion Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Rose Valley Borough	Ord #156 1954 Sec. 1004 Stream Distance	Ord. # 191 1964 Sec. 506.6 Bonds Sec. 609 Drainage			Ord. # 234 1977 All	Ord. #182 1961 None	Ord. # 191 1964 Sec. 609 Drainage		

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INVENTORY OF EXISTING REGULATORY CONTROLS
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Zoning	Subdivision Land Development	Grading	Erosion Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Thornbury Township	Chapt. XXVII Zoning Part M. Flood-plain Conser-vation Part 1 PRD Sec. 501.4 Purpose Sec. 504.G. Storm Drainage Ord. #5 1982 Mobile Home Parks	Chapt. XXII Subdiv. Land Dev. 1977 Part 3 Sec. 21.B Purpose & Bond Part 4 Sec. 31.B Inspection Part 5 Sec. 46 Performance & Maintenance Guarantees Part 5 Sec. 47.B Must conform with all re-cent regula-tions Sec. 51.A.(2) Preliminary Plans Sec. 51.B Final Plan Requirements Sec. 72 Stormwater Sec. 76.E Easements Part 4 Sec. 33.A Restrictions Part 5 Sec. 51.C Conservation Plans	Chapt. IX Grading & Excavating All	Chapt. IX Grading & Excavating All	Chapt. XXVII Zoning Part M Floodplain Conservation	Chapt. V Buildings All BOCA 1981	Chapt. IX Grading & Excavating Part 4 Special Re-quirements Stormwater Calculations Chapt. XXII Stormwater Sec. 72	Chapt. XXVII Part 1 PRD All	Resolu-tion #1 1975 Fees

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INVENTORY OF EXISTING REGULATORY CONTROLS
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Zoning	Subdivision Land Development	Grading	Erosion Sedimentation	Floodplain	Building Code	Stormwater	PRD	Other
Upper Providence Township	Chapt. 80 Rev. 1984 Art. X Apart. Dist. Sec. 80-56 Art. XA Town-house Dist. Sec. 80-58.7 Sec. 80.58.10 Art. XIV Flood-plain Art. XVIII 1979 Cluster	Ord. # 118 1979 Art. III Sec. 64-8D(8) Sec. 64-9 Sec. 64-11B(10)a,b Sec. 64-11B(12) g,k,l. Sec. 64-11B(13)f Art. IV Sec. 64-22 Easements Art. V Sec. 64-27C Bonds Sec. 64-32 Storm Sewers Sec. 64-38-40 Natural Con-ditions, Bonds Art. VI Grading Art. VII Sec. 64-65A,C Sec. 64-65D(5)c Mobile Homes Art. IX Bonds	Ord. #118 1979 Art. VI Grading & Erosion Control	Ord. # 118 1979 Art. VI Grading & Erosion Control Ord. # 129 1982 Stormwater & Erosion/Sedi-mentation Control All	Chapt. 80 Rev. 1984 Art. XIV Floodplain	BOCA	Ord. # 118 1979 Sec. 64-32 Storm Sewers Sec. 64-56 Drainage Chapt. #34 1982 All Ord. #129 1982 Stormwater & Erosion/Sedi-mentation Control All		Ord. #118 1979 Sec. 64-38 Existing Natural Condi-tions

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REVIEW OF EXISTING MUNICIPAL ORDINANCES
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

	Municipality		
	Brookhaven Borough	Chester City	Eddystone Borough
Stormwater Control Documents	1. Grading, Drainage, Erosion Control Ord. (Chap. 1432) applies to nonresid. & resid. if other permit req. 2. Co. S/LD[1]	1. S/D Regulations	1. Co. S/LD 2. Road Construction Ord.
Design Standards for Storm Sewers	No (see Co. S/LD)	Minimal - City Engineer sets standards	No (see Co. S/LD) Road Const. Ord. - carry SW from a str. in accord. with Nat'l Plumbing Code
Specify Design Storm	No	No	No
Specify Calculation Method	No (see Co. S/LD)	No	No (see Co. S/LD)
Uses Rate of Runoff Standard	No	No	No
Emphasizes Groundwater Recharge; On-site Infiltration	No	No	No
Design Standard Detention Facility Other SW Management Techniques	No (see Co. S/LD)	S.1309.8- gen'l. refr. to "SW drainage facil." in accord. with Boro Engineer's specif.	No
Uses Co. Conserv. Dist. or refers to SCS Stnd.	Refr. SCS standards	No	No (see Co. S/LD)
Plan Review SW Management, E/S Controls	Bldg. insp. issues permits; Boro Eng. reviews & approves	Rev. storm sewer plans during S/D rev.; no E/S rev.	No (see Co. S/LD)

1 See review of County regulations at end of table

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REVIEW OF EXISTING MUNICIPAL ORDINANCES
RIDLEY CREEK WATERSHED, DELAWARE COUNTY
CONTINUED

	Municipality		
	Brookhaven Borough	Chester City	Eddystone Borough
Fees	1. Permit: $/acre 2. Security deposit for cost of work 3. Cost of insp.	Set fee schedule	Set fee schedule
Regular Inspection Schedule	Set sched. for dvm. <10 sf. homes & for all other dvm. insp. by bldg. insp. and/or Boro Eng.	No-insp. by Eng. during progress	
Maintenance Provisions	Owner respns. for str., graded surf., anti-eros. measures (S. 1432.08)	No-2-yr. mntn. bond for pub. improv.	No
Land Use Planning Controls			
- Permits PRD, Cluster, etc.	No	No	PRD (resid. only)
- Steep Slope, Soils Stnd.	No	No	No
- Impervious Cover Limits	No	No	No
Misc. Comments, Observations on Ordinances	None	None	None

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REVIEW OF EXISTING MUNICIPAL ORDINANCES
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

	Municipality		
	Edgmont Township	Media Borough	Middletown Township
Stormwater Control Documents	1. S/LD Ord. (#70) as amended by Ord. (#81) 2. Zoning Ord. (#79) Article 9 PRD	1. S/LD Ord. (#495) 2. Cluster Zng. (#625) Article VII-A	1. S/LD Ord. (#296) 2. Freestanding Ord. (#327) 3. Zoning Ord. (#400) S.1107.B - PRD
Design Standards for Storm Sewers	Minimum size (15"); follow PennDOT Manual; size to accommodate maximum potential flow	Mentions stnd. & spec. of Boro but none in ord.	S/LD Ord. (#296) S.512.d. - minimum pipe size of 15"
Specify Design Storm	All storms up to 100-yr.	No	100-yr. frequency, 24 hour duration storm
Specify Calculation Method	1. S/LD Ord. (#70) as amended by Ord. (#81) A) Rational method-storm-sewer systems B) TR-55-detention facilities 2. Post development runoff=pre-development	No	S/LD Ord. (#296) S.512.O.1.(a) Soil Cover Complex Method
Uses Rate of Runoff Standard	Yes-post development runoff rate must equal predevelopment rate. S.707.5.B.4.a	No	No
Emphasizes Groundwater Recharge; On-site Infiltration	S/LD Ord. (#70) as amended by Ord. (#81) S.707.5.B.4.d	No	No
Design Standard Detention Facility Other SW Management Techniques	S/LD Ord. (#70) as amended by Ord. (#81) S.707.5.B.4.f detention/retention basin criteria	No	S/LD Ord. (#296) S.512.0.1. detention facility design standards

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REVIEW OF EXISTING MUNICIPAL ORDINANCES
RIDLEY CREEK WATERSHED, DELAWARE COUNTY
CONTINUED

	Municipality		
	Edgmont Township	Media Borough	Middletown Township
Uses Co. Conserv. Dist. or refers to SCS Stnd.	S/LD Ord. (#70) as amended by Ord (#81) S.707.5.B.4.f.1	No	S/LD Ord. (#296) S.512.O.1(a)
Plan Review SW Management, E/S Controls	S/LD Ord. (#70) as amended by Ord. (#81) S.707.7.A part of S/LD review process	Zoning Ord. (#625) SW and E/S plans for cluster Article VI-A, Sec. 9(a)	Part of S/LD and zoning review process Twp. S/LD Ord. (#296) S.512.b stormwater review S.513 erosion sedimentation review
Fees	Developers agreement to cover plan review and inspection	Set fee schedule	Set fee schedule
Regular Inspection Schedule	S/LD Ord. (#70) as amended by Ord. (#81) S.707.8 inspections on a random basis	Notify 24 hrs. before each constr. opera.	S/LD Ord. (#296) S.521 Inspections shall be conducted by the Twp. for E/S and stormwater facilities
Maintenance Provisions	S/LD Ord. (#70) as amended by Ord. (#81) S.707.9.B.1 owner responsible	No	No

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REVIEW OF EXISTING MUNICIPAL ORDINANCES
RIDLEY CREEK WATERSHED, DELAWARE COUNTY
CONTINUED

	Municipality		
	Edgmont Township	Media Borough	Middletown Township
Land Use Planning Controls			
- Permits PRD, Cluster, etc.	Yes-Zoning Ord. (#79) Article 9	Zoning Ord. (#625) req. SWM & E/S Plans for cluster zng. applic. Art. VI-A-9(a)	Yes - Zoning Ord. (#400) Article 11 PRD
- Steep Slope, Soils Stnd.	Yes-Zoning Ord. (#79) Article 16	No	Yes - Zoning Ord. (#400) Article 27 steep slope
- Impervious Cover Limits	Yes-Zoning Ord. (#79)	No	Yes - Zoning Ord. (#400)
Misc. Comments, Observations on Ordinances	None	1. Ord. provide minimal stnd.; no specific req. or perfm. measures 2. Mentions permit from Water & Power Res. Bd. - out of date	None

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REVIEW OF EXISTING MUNICIPAL ORDINANCES
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

	Municipality		
	Nether Providence Township	Parkside Borough	Ridley Township
Stormwater Control Documents	1. E/S Control Ord. (#478) 2. S/LD Ord. (#270) covers storm sewers, (#544) requires env. impact assessment 3. Zoning (#434) R-5A, multip. dw. & prof. off. dist.	1. Co. S/LD 2. PRD Ord. (#250) incl. drng. plan in PRD application	1. S/LD Ord. (#1443) 2. Zoning Ord. (#1441) 3. Grading (#1362)
Design Standards for Storm Sewers	1. S/LD - S.8.3B-12 min. size 15", loc., etc.	(See Co. S/LD)	1. S/LD-S.4.205 min. size 12"
Specify Design Storm	E/S Ord.-100-yr., 24-hr. design criteria for storm drng. (only if detailed drng. study req. - S.6)	(See Co. S/LD), No	1. S/LD-S.4.702.1 10-yr. 20 min.
Specify Calculation Method	E/S Ord.-100-yr. calcul. "based on guidelines from SCS" (only if detailed drng. study req. - S.6)	(See Co. S/LD), No	No
Uses Rate of Runoff Standard	No-E/S Ord.-perm. & temp. SW management fac. designed so that velocity & volume of runoff into any stream not incl'd. S.6b3	(See Co. S/LD), No	No
Emphasizes Groundwater Recharge; On-site Infiltration	No-Zng. - multip. dw. dist. - retain nat. features do not pipe streams except for culverts & roads	(See Co. S/LD), No	No
Design Standard Detention Facility Other SW Management Techniques	S/D - adeq. cap. stnd. for bridges & culverts (gen'l. lang. S.3B-13,14); no stnd. for detnt. fac.	1. PRD Ord. (S.8-5)- Estm. amt. of rnf. & show SWM system (sewers, drng. basin, swales, etc.) (See Co. S/LD)	No (S/LD)-designed to handle existing post-dev't. increase (S.5.402)
Uses Co. Conserv. Dist. or refers to SCS Stnd.	E/S Ord.-Co. Conserv. Dist. (S-5-a4)	(See Co. S/LD), No	No

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REVIEW OF EXISTING MUNICIPAL ORDINANCES
RIDLEY CREEK WATERSHED, DELAWARE COUNTY
CONTINUED

	Municipality		
	Nether Providence Township	Parkside Borough	Ridley Township
Plan Review SW Management, E/S Controls	1. E/S Ord.-submit applic. for E/S permit with prelim. S/LD plan; req. E/S permit if >½ ac. or bldg.a dw. or "will cause sediment"; detail drng. study if site has stream with base flow or "where nec." by Twp. Eng.; E/S plan rev. by Twp. Eng. & approv. by Bd. of Comm. opt. rev. of plan by Co. Conserv. Dist. & N.Prov. Env. Adv. Council. 2. Zng.-R-5A, off., multip.dw. dist. submit SW plans & E/S plan in mltip. dw. dist. - must be rev. by Co. Conserv. Dist.	(See Co. S/LD) 1. PRD - rev. drng. plan	No
Fees	1. S/LD-set applic. fee; insp. fee ($10/day); mat'l. testing 2. E/S Ord. - permit ($ /ac.); if site >1 ac., $5,000 min. bond or escrow before permit	No	1. Grading - $5.00 permit fee
Regular Inspection Schedule	1. S/LD Notify 24 hrs. before each constr. phase; insp. by Twp. Eng. 2. E/S Ord.-random basis & submit as-built plans certified by P.E.; insp. by Twp. Eng.	No	No
Maintenance Provisions	1. S/LD Ord. - none 2. E/S Ord. - (S.8d & e)-owner respn. for cont. mntn. & opera.	1. PRD Ord. - submit mntn. plan for nonpub. op.sp. & fac. with PRD applic.	1. S/LD- 2-yr. mntn. bond for dedic. fac.

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REVIEW OF EXISTING MUNICIPAL ORDINANCES
RIDLEY CREEK WATERSHED, DELAWARE COUNTY
CONTINUED

	Municipality		
	Nether Providence Township	Parkside Borough	Ridley Township
Land Use Planning Controls			
- Permits PRD, Cluster, etc.	No	PRD (#250)	PRD (#1441)
- Steep Slope, Soils Stnd.	No	PRD-no bldg. on slopes 25% or more	No
- Impervious Cover Limits	Multip. Dw. Dist. - no more than 15% area covered by bldg. & 40% covered by paved areas (ex. bldg.) (Zng. S.703c)	No	No
Misc. Comments, Observations on Ordinances	Drng. prov. in zng. should be consistent with E/S ord.; clearer stnd. of when detailed drng. plan required; E/S Ord.-permittee respns. for preventing harm or damage from any activ. (S.8); E/S Ord. no inc. in rnf. volume (S.6b3), not consistent with Act 167 that controls rate of runoff	None	None

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REVIEW OF EXISTING MUNICIPAL ORDINANCES
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

	Municipality		
	Rose Valley Borough	Thornbury Township	Upper Providence Twp.
Stormwater Control Documents	1. S/D Reg. (#191) 2. Zng. (#156)	1. Grading and Excavating (Chp. 9) 2. S/LD (Chp. 22) 3. Zng. (Chp. 27) PRD & mobile homes	1. SWM, E/S Control Ord. (Chp. 34) 2. S/D reg. (#118, Chp. 81) 3. Zng. (Chp. 80 - apt., twh. resid. dist.)
Design Standards for Storm Sewers	S/D-min. 18", grade etc.	1. S/LD- req. storm sewer where rnf. can't be handled in str. cartway; design drng. facil. to handle anticip. inc. in runf. from upstream areas.	1. S/D- connect to storm sewer if within 1,000 ft.; grade, 18" min.; approve by Twp. Eng.
Specify Design Storm	No	1. Grading & Excavating - 2-, 10-, 25-, 50-, and 100-yr. storms	1. SWM - facil. accom. storm intensity of 7.3 in., 24-hr. (100-yr. storm)
Specify Calculation Method	No	1. Grading & excavating - SCC Method	1. SWM - use SCC Meth.
Uses Rate of Runoff Standard	No	Post-dvm. rate of rnf. = pre. dvm. rate for 2-, 10-, 25-, 50-, and 100-yr.	1. SWM- No inc. in peak discharge after earth disturb. activ. (S.34-4A) 2. S/D - no inc. in pre-dvm. discharge from site (S.81-32)
Emphasizes Groundwater Recharge; On-site Infiltration	No	No	1. SWM- mntn. streams, channels, drng. sys., & surf. waters in existing condit. unless Twp. approves alteration

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REVIEW OF EXISTING MUNICIPAL ORDINANCES
RIDLEY CREEK WATERSHED, DELAWARE COUNTY
CONTINUED

	Municipality		
	Rose Valley Borough	Thornbury Township	Upper Providence Twp.
Emphasizes Groundwater Recharge; On-site Infiltration (Continued)			2. S/D-preserve trees & nat. condit. (S.81-38) 3. Zng.- preserve nat. features incl. drng. (twh. res. dist.)
Design Standard Detention Facility Other SW Management Techniques	No (S/D)- adeq. cap. for bridges and culverts (S.609K)	1. Grading & Excavating gen. standard for all drainage facilities 2. S/LD det. facilities in easement or right-of-way	1. SWM (see design storm) 2. S/D if use open watercourse, provide safety, assure capacity & appearance (S.81-32)
Uses Co. Conserv. Dist. or refers to SCS Stnd.	No	Ref. in all ordinances	1. SWM (refers to PA E/S Req.-Chp. 25) 2. S/D- follow E/S Handbook for Del. Co. for excav. (S.81-52) & for E/S (S.81-53)
Plan Review SW Management, E/S Controls	Rev. drng. in S/D plan; Boro Eng. reviews	1. S/LD- drng. plan in conformance with Grading & Excavating Ord. 2. Grading & Excavating req. detailed drng. study where nec. by Eng., P.C. or supervisors, Twp. Eng. rev. plans	1. SWM- req. plan & permit for: (1) if 70% of site already imperv. & disturbed area 400 sf. or more. (2) <70% of site imperv. & disturb. area = 20% of site or 7500 sf., (3) trees removed from >10% of site, (4) in floodplain,

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REVIEW OF EXISTING MUNICIPAL ORDINANCES
RIDLEY CREEK WATERSHED, DELAWARE COUNTY
CONTINUED

	Municipality		
	Rose Valley Borough	Thornbury Township	Upper Providence Twp.
Plan Review SW Management, E/S Controls (Continued)			(5) create steep slope, (6) disturb, modify overland or subsurf. flow of SW; submit E/S plan; Twp. approve 2. S/D- incl. grading plan 3. Zng.- twh. dist.- drng. plan approved by Twp. Eng.
Fees	1. Dev. pay expenses incurred for eng., insp., & legal	Yes- S/LD & E/S & G	1. SWM - $25.00 2. S/LD - set fee by # of units
Regular Inspection Schedule	Notify 24 hr. before each constr. phase	Grading & Excavating, & S/LD- random insp. & as-built plans	1. SWM- random insp. 2. S/D- grading subj. to random insp.
Maintenance Provisions	No-2-yr. mntn. bond for dedic. fac.	1. S/LD (S.46 I & H)- 18 mo. mntn. bond for pub. dedic. improve.; if priv. ownership of sw retnt. fac.-estb. mntn. fund or perpetual covenants	1. SWM- owner respns., Twp. may approve homeowners' assoc. 2. S/D 2-yr. mntn. bond on fac.; owner respns. for cut/fill meas. (S.81-56) 3. Zng. (twh. & cluster dev.) - owner respn. or Twp. may req. homeowners' assoc. or other entity

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REVIEW OF EXISTING MUNICIPAL ORDINANCES
RIDLEY CREEK WATERSHED, DELAWARE COUNTY
CONTINUED

	Municipality		
	Rose Valley Borough	Thornbury Township	Upper Providence Twp.
Land Use Planning Controls			
- Permits PRD, Cluster, etc.	No	PRD	Cluster dvm. by spec. except.
- Steep Slope, Soils Stnd.	No	Zng. (Sec. 365)	Ord. #157
- Impervious Cover Limits	No	No	No
Misc. Comments, Observations on Ordinances	None	None	1. SWM- Twp. can attach any conditions to prevent danger, etc. 2. S/D- incl. grading regul. (S.81-41) 3. Zng.- does not refer to SWM & S/D Ord. Apt. Dist. (S.80-56)- assure that excessive SW does not drain onto adjac. properties- stnd too broad.

TABLE A-7

REVIEW OF EXISTING MUNICIPAL ORDINANCES
RIDLEY CREEK WATERSHED, DELAWARE COUNTY

Municipality	Delaware County
Stormwater Control Documents	1. S/LD Ord. (#78-5) contains min. E/S, grading, & storm drain. stnds.
Design Standards for Storm Sewers	Min 15", grade, placement, depth, manholes, inlets
Specify Design Storm	No
Specify Calculation Method	Rat'l. Meth. (S.309.3)
Uses Rate of Runoff Standard	No
Emphasizes Groundwater Recharge; On-site Infiltration	1. Preserv. nat. drng. patterns wherever possible (308.3); S.310- nat. features preserv.- mntn. watercourses, bodies of water & wetlands
Design Standard Detention Facility Other SW Management Techniques	Swales sodded or planted & conform to Co.Conserv.Dist.(S.308.3) Gen'l.stnd.for drng.sys. (S.309.4);- do not alter existing pts; -do not overload existing drng.system, create flooding or need for add't.drng. str. Bridges & culverts- use PennDOT Stnd. (S.311.2)
Uses Co. Conserv. Dist. or refers to SCS Stnd.	Drng.sys. comply with stnd. of munic.ord. & Co. Conserv.Dist. (S.309.2); E/S meas. comply with Conserv.Dist. (S.308.1)
Plan Review SW Management, E/S Controls	Conserv.Plan (E/S) incl. with final S/LD plan (may not be necessary for minor s/d); if devm. staged submit drng. plan for entire dvm. with first stage

TABLE A-7

REVIEW OF EXISTING MUNICIPAL ORDINANCES
RIDLEY CREEK WATERSHED, DELAWARE COUNTY
CONTINUED

Municipality	Delaware County
Fees	
Regular Inspection Schedule	Municipality respns. for insp.
Maintenance Provisions	No
Land Use Planning Controls	
- Permits PRD, Cluster, etc.	N/A
- Steep Slope, Soils Stnd.	Nat. Features Preserv.- retain nat. terrain & minimize cut/fill
- Impervious Cover Limits	No
Misc. Comments, Observations on Ordinances	Co. Floodplain Ord. (#77-5) may req. retnt. basins in floodplain to prevent inc. in downstream flood elevation

NOTES:

alt. - alteration
cont. - continuous
Co. S/LD - County Subdivision & Land Develop.
ded. - dedicated
drng. - drainage
dvm. - development
dw. - dwelling
E/S - erosion & sedimentation
fac. - facility(s)
imperv. - impervious
inc. - increase
< - less than
MF - multi-family
mntn. - maintenance
> - more than
mltp. - multiple
nec. - necessary
op.sp. - open space
P.C. - planning commission
P.E. - Professional Engineer
PRD - planned residential
Rat'l. - Rational Method
req. - require(d)
rev. - review
rnf. - runoff
S. - section (of an ordinance)
SCC - Soil Cover Complex Method
S/D - subdivision
sf. - square feet
SF - single family
strg. - storage
str. - structure(s)
SW - stormwater
SWM - stormwater management
twh. - townhouse
Zng. - zoning

SOURCE: Review of ordinances, Satterthwaite/Green International, Inc., September 1981 (Revised by DCPD, June 1987)

MISCELLANEOUS CHANGES

As part of the 1988 plan update, the entire report was reviewed for inconsistencies and need for revision. The following is a list of changes which should be made.

Page

vii — Add Plate 2 Delaware County Stormwater Management Plan Ridley Creek Watershed Subarea Map.... Envelope on back cover to the List of Figures.

16 — Delete PA from the parentheses in the first full paragraph.

49 — Add the following paragraph before the last paragraph:

Several of the factors forming the basis for the selection of the 2-, 10-, and 25-year design storm events for stormwater management in the Ridley Creek watershed are as follows:

1. The greatest impacts projected from future development activity in terms of increased runoff peak flow rates are observed in the higher frequency storm events, e.g. the 2- through 25-year return period storms.

2. There is an emerging trend in the stormwater management programs in other states to focus on more frequent storm events.

3. Current drainage design in the watershed utilizes, at most, the 25-year event for carrying stormwater runoff in and around development sites in storm sewer systems, diversion swales, etc.

4. The watershed modeling performed as part of the preparation of this plan reflects no projected increase in the peak 100-year flow rates along the

main stem of Ridley Creek in Delaware County resulting from anticipated future development.

5. The plan requires safe passage of the 100-year storm event through all stormwater management control facilities.

111 Change the word "greater" to "less" in the title of the horizontal axis.

178 Section 103-4-b should read: Final plan approval should be contingent upon obtaining all necessary obstruction, floodplain, and/or E/S permits. Building permits should not be granted until the developer has complied with the same.

185 Section 106
2. Excluded from this requirement are those facilities designed to be situated on and to serve individual lots.

190 Remove the words "zoning use" from #4.