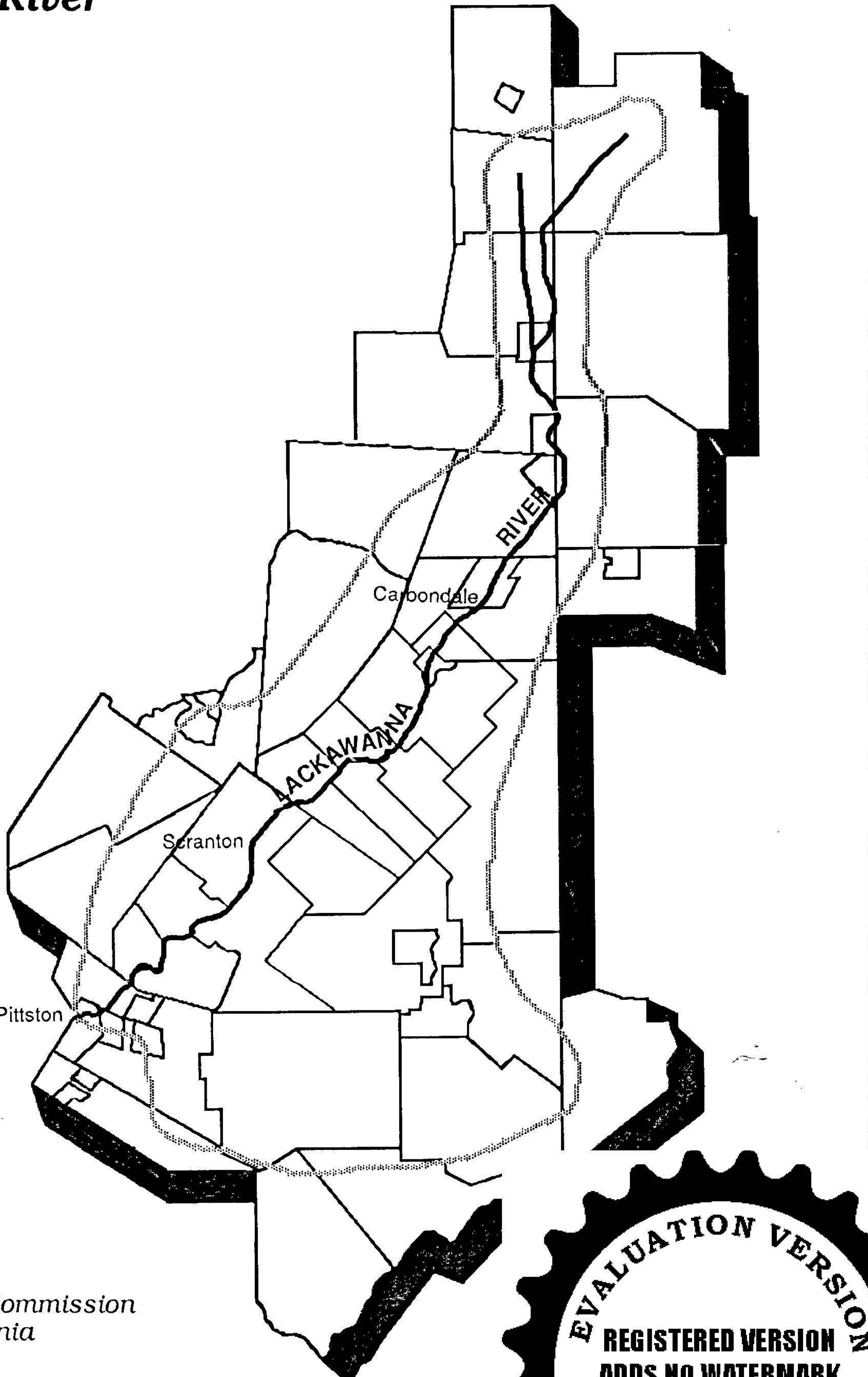
Pressure Flow	The portion of flow that passes through a stream crossing structure.
Transpiration	The process by which vegetation returns water to the air.
Watercourse	Stream channel.
Weir Flow	The portion of flow that passes over a stream crossing structure.

Lackawanna River Watershed

Act 167

Stormwater Management Plan



Prepared by:

Lackawanna County
Regional Planning Commission
Scranton, Pennsylvania

in cooperation with

Walter B. Satterthwaite & Associates, Inc.
West Chester, Pennsylvania

LACKAWANNA RIVER WATERSHED
PENNSYLVANIA ACT 167
STORMWATER MANAGEMENT PLAN

PREPARED BY:

LACKAWANNA COUNTY REGIONAL PLANNING COMMISSION
200 ADAMS AVENUE, ROOM 610
SCRANTON, PENNSYLVANIA 18503
(717) 963-6826

IN CONJUNCTION WITH:

WALTER B. SATTERTHWAITE ASSOCIATES, INC.
720 NORTH FIVE POINTS ROAD
WEST CHESTER, PENNSYLVANIA 19380
(215) 692-5770

SEPTEMBER 1991

LACKAWANNA RIVER WATERSHED
PENNSYLVANIA ACT 167
STORMWATER MANAGEMENT PLAN

PREPARED BY:

LACKAWANNA COUNTY REGIONAL PLANNING COMMISSION
200 ADAMS AVENUE, ROOM 610
SCRANTON, PENNSYLVANIA 18503
(717) 963-6826

IN CONJUNCTION WITH:

WALTER B. SATTERTHWAITE ASSOCIATES, INC.
720 NORTH FIVE POINTS ROAD
WEST CHESTER, PENNSYLVANIA 19380
(215) 692-5770

SEPTEMBER 1991

WALTER B. SATTERTHWAITE ASSOCIATES, INC.

LACKAWANNA RIVER WATERSHED
PENNSYLVANIA ACT 167
STORMWATER MANAGEMENT PLAN

This plan has been prepared under the direction of Harry D. Lindsay, Executive Director and Steve Pitoniak, Senior Planner, Lackawanna County Regional Planning Commission and by Walter B. Satterthwaite Associates, Inc. Its content reflects the input and comments received from the fifty-one affected municipalities as received through meetings of the Watershed Plan Advisory Committee during the planning process as well as the County Soil Conservation Districts and the general public. This plan was financed in part through a grant from the Pennsylvania Stormwater Management Program under provisions of the Pennsylvania Stormwater Management Act of 1978, as amended, administered by the Bureau of Dams and Waterway Management, Pennsylvania Department of Environmental Resources.

Lackawanna River Watershed Advisory Committee Members

Reed H. Burman	Ararat Township
Anthony J. Giordano*	Archbald Borough
James Pickard	Archbald Borough
Martin Boone	Avoca Borough
Harold J. McCusker, Jr.	Blakely Borough
Robert Cramer	Canaan Township
Paul Browne	Carbondale City
Mayor John E. Moran	Carbondale City
Orlando Costa	Carbondale Township
Lawrence Catanzaro	Carbondale Township
John Shumacher	Clarks Green Borough
Robert A. Thorne	Clarks Summit Borough
Shirley Larkin	Clifford Township
Kathryn Stocoski	Clifton Township
Lois Terrel	Clinton Township
Kate Tierney	Covington Township
Anthony Romeo*	Dickson City Borough
Ken Novak	Dickson City Borough
Arthur Moran*	Dunmore Borough
Richard Carr	Dunmore Borough
David Opiela	Dupont Borough
Lois Morreale	Duryea Borough
David Finn*	Elmhurst Township
Eleanor Kish	Elmhurst Township
Bernard F. Mozda	Fell Township
Paul Dovin	Forest City Borough
Paul Slick	Forest City Borough
Joseph Slebodnick	Greenfield Township
Nancy Harzatine	Herrick Township
Rosann Swegel	Herrick Township
Paul Battisti	Hughestown Borough
E. Kenneth Acker	Jefferson Township
Leona Gallagher	Jefferson Township
Russell Arnone	Jenkins Township
Janet Young	Jermyn Borough
James Brunozzi	Jessup Borough
Delores Nichols	Lehigh Township
Patricia Ceccacci*	Madison Township
Debbie Gromlich	Madison Township
Leo Gowat	Mayfield Boro
Christine Ryczak	Mayfield Boro
Clare Conaboy	Moosic Boroug
John Thiel	Moosic Boroug
Marilyn Winkler	Moscow Borou
Eleanor McGraw	Mount Pleasan
William Heen*	Newton Towns
Elmer Swartz	Newton Towns
Leonard Zupon	Old Forge Boro
Anthony J. Giordano	Old Forge Boro
Michael Ferke	Olyphant Boro

Paul McGarry	Pittston City
Coreen Milazzo	Pittston Township
Kuni Holbert	Preston Township
Mary Ann Llewellyn	Preston Township
Albert Zeiss	Ransom Township
Margaret Varzaly*	Roaring Brook Township
Joan Mikelatis	Scott Township
Donald King	Scranton City
John J. Luciani	Scranton City
James Mayfield	South Abington Township
Maryann Rosselli	Springbrook Township
Janet Mullen	Sterling Township
Ann Traeger	Sterling Township
Daniel Zeleniak*	Taylor Borough
Mayor David Noakes	Taylor Borough
Beverly Sheldon	Thompson Township
Frank Eshmont*	Throop Borough
Mary Anne Paulic	Throop Borough
Ronald Foster	Union Dale Borough
Mayor Walter Sample	Vandling Borough
Harry D. Lindsay	Lackawanna County Planning Commission
Ernest Keller	Lackawanna County Conservation District
Adrian Merolli	Luzerne County Planning Commission
Paula Valunis*	Luzerne County Conservation District
Robert Yonker	Luzerne County Conservation District
Carl Pease	Susquehanna County Planning Commission
Lillian Theophanis	Susquehanna County Conservation District
William Douglass*	Wayne County Planning Commission
Robert Davis*	Wayne County Planning Commission
Edward Coar	Wayne County Planning Commission
Robert Muller	Wayne County Conservation District
Edward Kakareka	Ducks Unlimited- North Pocono Chapter
Leonard Carlin	Economic Development Council of N. E. Pa.
Len Altier	Lackawanna F Corrid
Dave Lange	National Park
Roger Neher	Northeastern Enviro
Kim Barnes	Northern Tier Planni

(*)--indicates former W.A.C. members, who no longer re respective municipality or organization.

OVERVIEW

This plan has been developed for the Lackawanna River Watershed in Lackawanna County, Pennsylvania under the requirements of the Pennsylvania Stormwater Management Act, Act 167, of 1978. The designated watershed, No. 138:35, encompasses approximately 348 square miles and all or portions of fifty-one municipalities within Lackawanna, Luzerne, Susquehanna and Wayne Counties. With little and inconsistent existing controls for stormwater management within this watershed, this plan has been developed to focus on a watershed wide consistent set of standards and criteria to control stormwater runoff. The controls established reflect the flooding and quality concerns within priority growth areas as well as the entire drainage area of the River as related to potential future development impacts within the study area. Through the Watershed Plan Advisory Committee these concerns have helped form the basis for final determination of control standards.

This plan is developed with the intent to present all information which may be required in order to implement the plan. Background and detailed information as well as applied examples are included as related to both technical/engineering applications as well as institutional and legal framework discussions. The comprehensiveness of the plan covers legal, engineering and municipal government topics, which combined, form the basis for implementation and enforcement of a final ordinance which will be developed and adopted by each affected municipality. A sample stormwater management ordinance for reference use has been developed as part of the plan and is a separate document. Each municipality has six months to adopt the plan from the date of adoption on the resoluti
the Table of Contents.

SAMPLE RESOLUTION

WHEREAS, Lackawanna County is desirous of promoting the public health safety and welfare of its citizens who live within the Lackawanna River Watershed;and

WHEREAS, the Board of Commissioners of Lackawanna County did submit cooperative agreements to Wayne, Susquehanna and Luzerne counties authorizing Lackawanna County to act on their behalf for the purpose of preparing the Lackawanna River Stormwater Management Plan.

WHEREAS, these actions were undertaken in accordance with Act 167-Stormwater Management Act with the intent to adopt the completed Lackawanna River Stormwater Management Plan and support it for the final goal of municipal implementation;

THEREFORE, BE IT RESOLVED, that the Board of Commissioners of Lackawanna County do hereby adopt the Lackawanna River Stormwater Management Plan as it pertains to Lackawanna County.

ADOPTED, at a regular meeting of the Board of Commissioners of Lackawanna County held on month day, year.

COUNTY OF LACKAWANNA

____

RAY A. ALBERIGI

____

JOSEPH J. CORCORAN

____

JOHN SENIO

ATTEST:

____

GERALD L. STANVITCH
ADMINISTRATIVE DIRECTOR

Approved as to form and legality:

____

JOSEPH A. O'BRIEN, ESQUIRE
COUNTY SOLICITOR

TABLE OF CONTENTS

(409-rep)

TABLE OF CONTENTS
(continued)

TABLE OF CONTENTS
(continued)

WALTER B. SATTERTHWAITE ASSOCIATES, INC.

TABLE OF CONTENTS
(continued)

Page

LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS
(continued)

WALTER B. SATTERTHWAITE ASSOCIATES, INC.

TABLE OF CONTENTS

APPENDICES
(Under Separate Cover)

APPENDICES
(Under Separate Cover)

TABLE OF CONTENTS
(continued)

1.0 INTRODUCTION

1.1 Basics of Hydrology

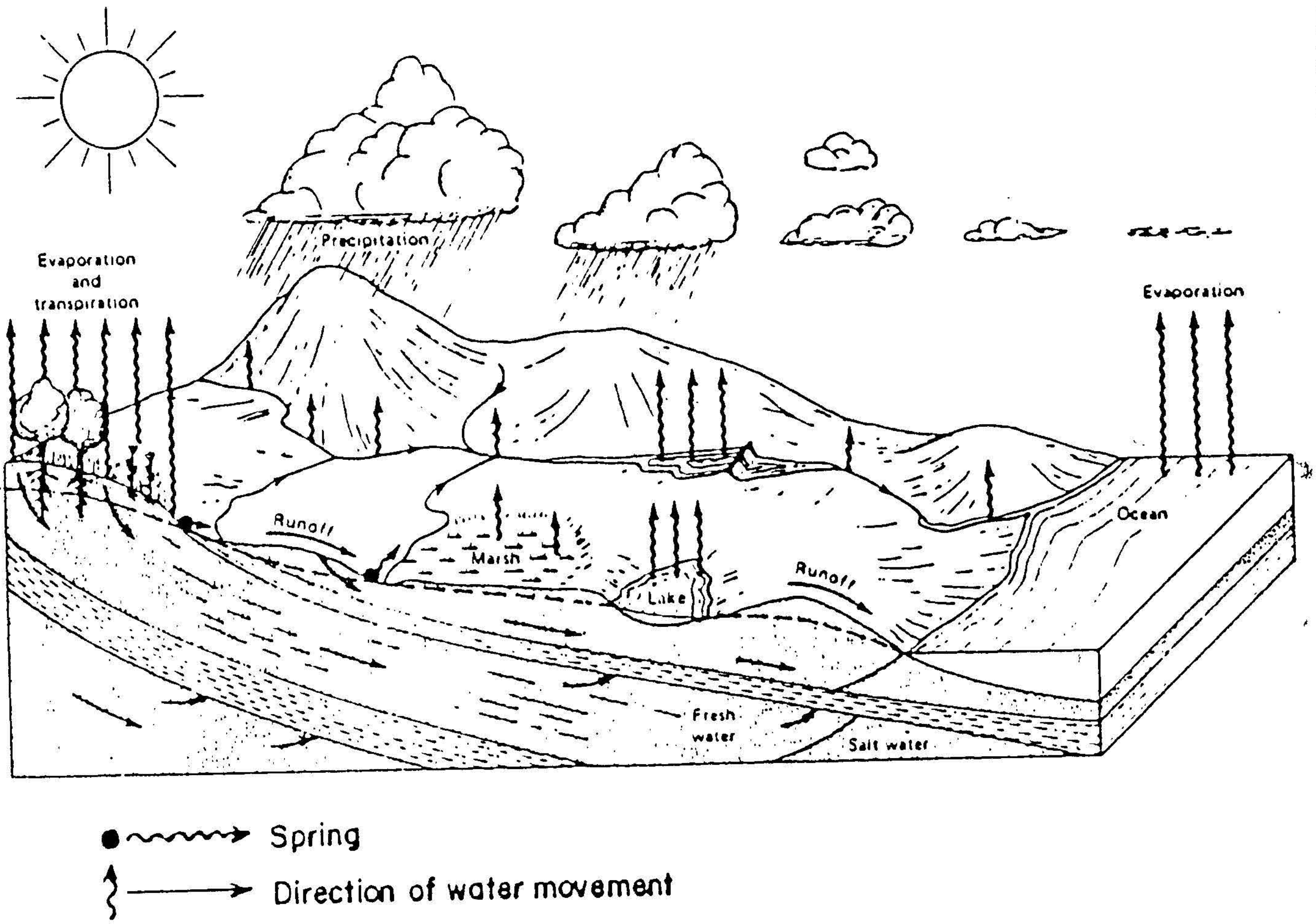
Water is located in all regions of the earth. However, its distribution, quality, quantity, and mode of occurrence are highly variable from one location to another. Hydrology is the science of dealing with the properties, distribution, and circulation of water on the surface of the land, in the soil,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

The hydrologic cycle, illustrated on Figure 1-1, 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.

1.2 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 <u>not covered</u> by pavement, concrete, or buildings). Although many factors interact to affect this segment of they 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 that is stored in depressions, either natur to human activities, on the surface of a spe and,
- Infiltration - The volume of precipitation into the ground over a specific land area.



THE HYDROLOGIC CYCLE

1.2.1 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 percent or more in the catch of rain gages less than twenty feet apart.

For example, Figure 1-2 displays two rainfall hyetographs which illustrate the significant time variation of rainfall occurring during two thirty-minute rainfall events of equal volume. Even though rainfall volumes are equivalent, stormwater runoff flow rates generated for identical time intervals over a specific land area 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 1-3.

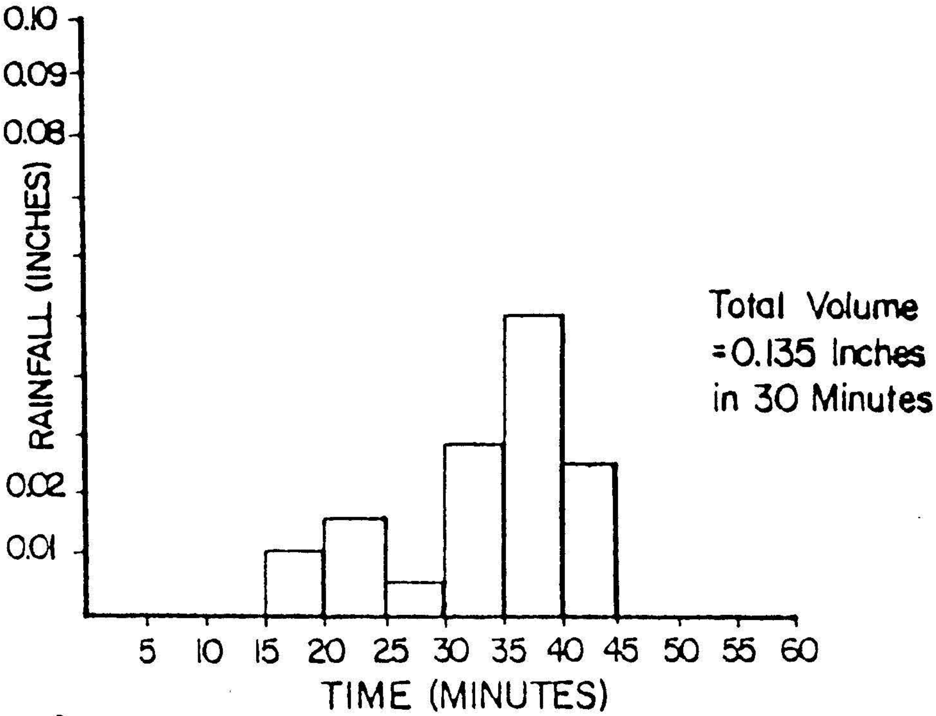
Even with these variations, the statistical analysis of precipitation data has resulted in the ability to establish the probability of storm events of specific volumes and durations occurring. These probabilities are often expressed (for example) as 1-, 2-,..., 10-,..., 25-, and 100-year storm events. That is, the probability of a 25-year storm event occurring in any year is four percent. Figure 1-4 shows an example of rainfall-intensity-duration curves. From an analysis of these curves, the following generalizations can be observed:

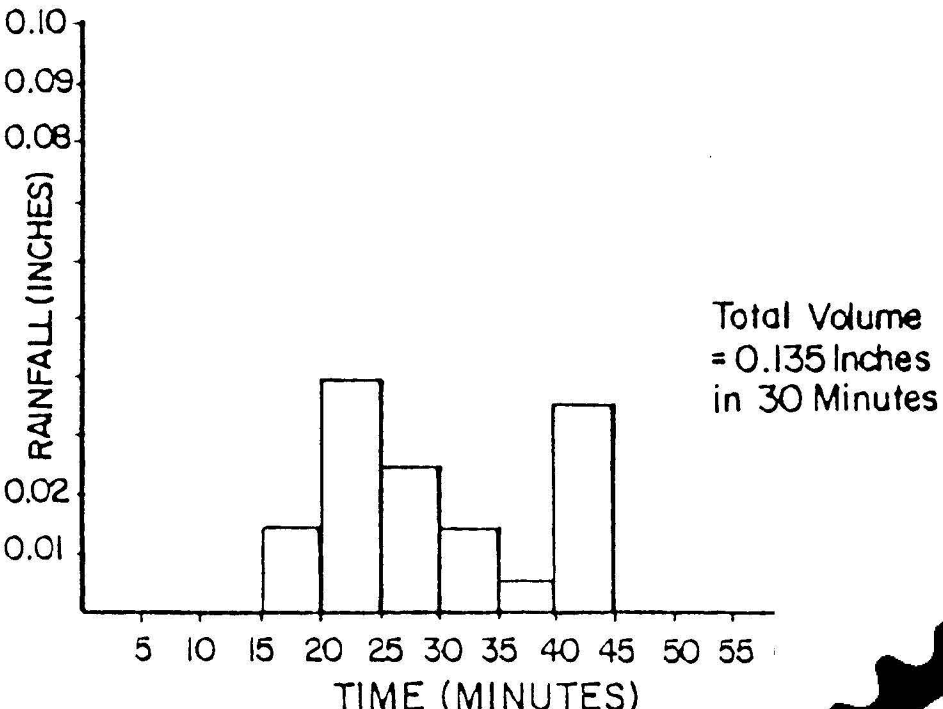
- The more intense the rainfall, the less likely the event is to occur; and,

- Higher intensity rainfalls occur over shorter periods of time than lower intensity events.

1.2.2 Surface Depression Storage

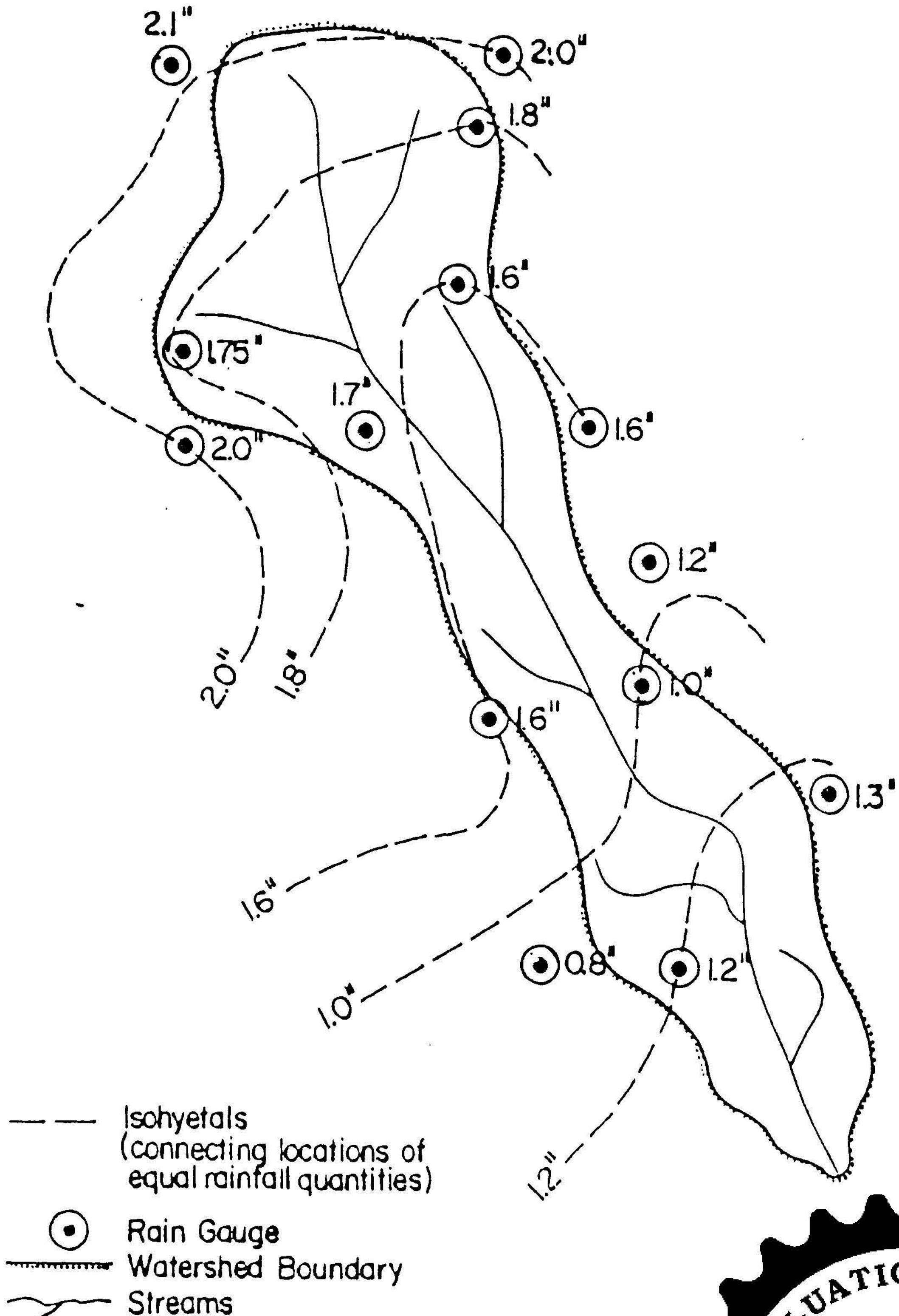
The initial volume of rainfall during any event becomes trapped in numerous small, natural or man-made depressions. The only escape of this stored water is through evaporation or infiltration. Development activities often alte
make acreage available for building/paving anc
mobility of equipment during construction act
practices usually reduce the amount of surface
increasing both the volume and rate of st
Specially designed stormwater management fa
detention basins, terraced slopes, and l
incorporated in site designs may artificially pr
storage lost during development.





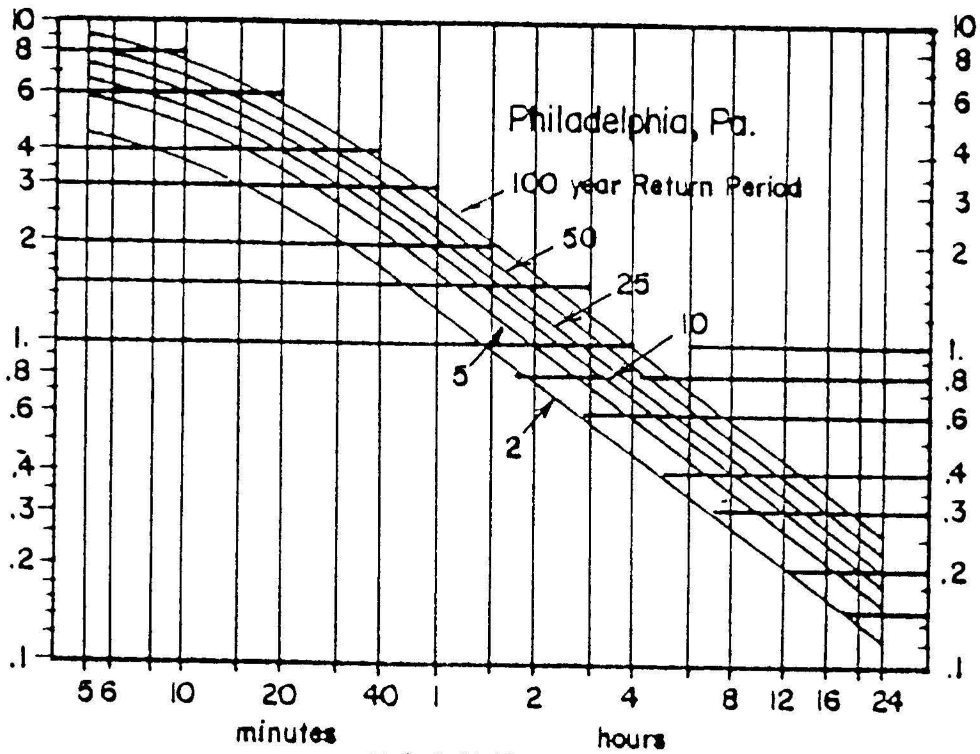
TIME VARIATION OF RAINF

WALTER B. SATTERTHWAITE ASSOC., INC
720 NORTH FIVE POINTS ROAD · WEST CHESTER, PA. 19380 · (215)692-5770
BRANCH OFFICE: 9418 ANNAPOLIS ROAD · LANHAM, MD. 20706 · (301)731-056



STORM PATTERN OVER A WA

WALTER B. SATTERTHWAITE ASSOC., INC
720 NORTH FIVE POINTS ROAD · WEST CHESTER, PA. 19380 · (215)692-5770
BRANCH OFFICE: 9418 ANNAPOLIS ROAD · LANHAM, MD. 20706 · (301)731-056



Rainfall Duration

Source: Pennsylvania Department of Transportation

RAINFALL INTENSITY - DURATION - FREQUENCY CURVES
FOR PHILADELPHIA, PENNSY

1.2.3 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. Development usually results in decreases in available pervious area for infiltration through paving and building construction. However, urban areas are seldom completely covered by associated impervious surfaces. Development on soils having a high infiltration rate (sands or silts) increases the potential for increasing runoff volumes and peak runoff discharges. Accordingly, site designers should give strong consideration to building and road layouts which minimize coverage of areas having soils with a high infiltration rate.

1.3 Estimating the Rate and Volume of Stormwater Runoff

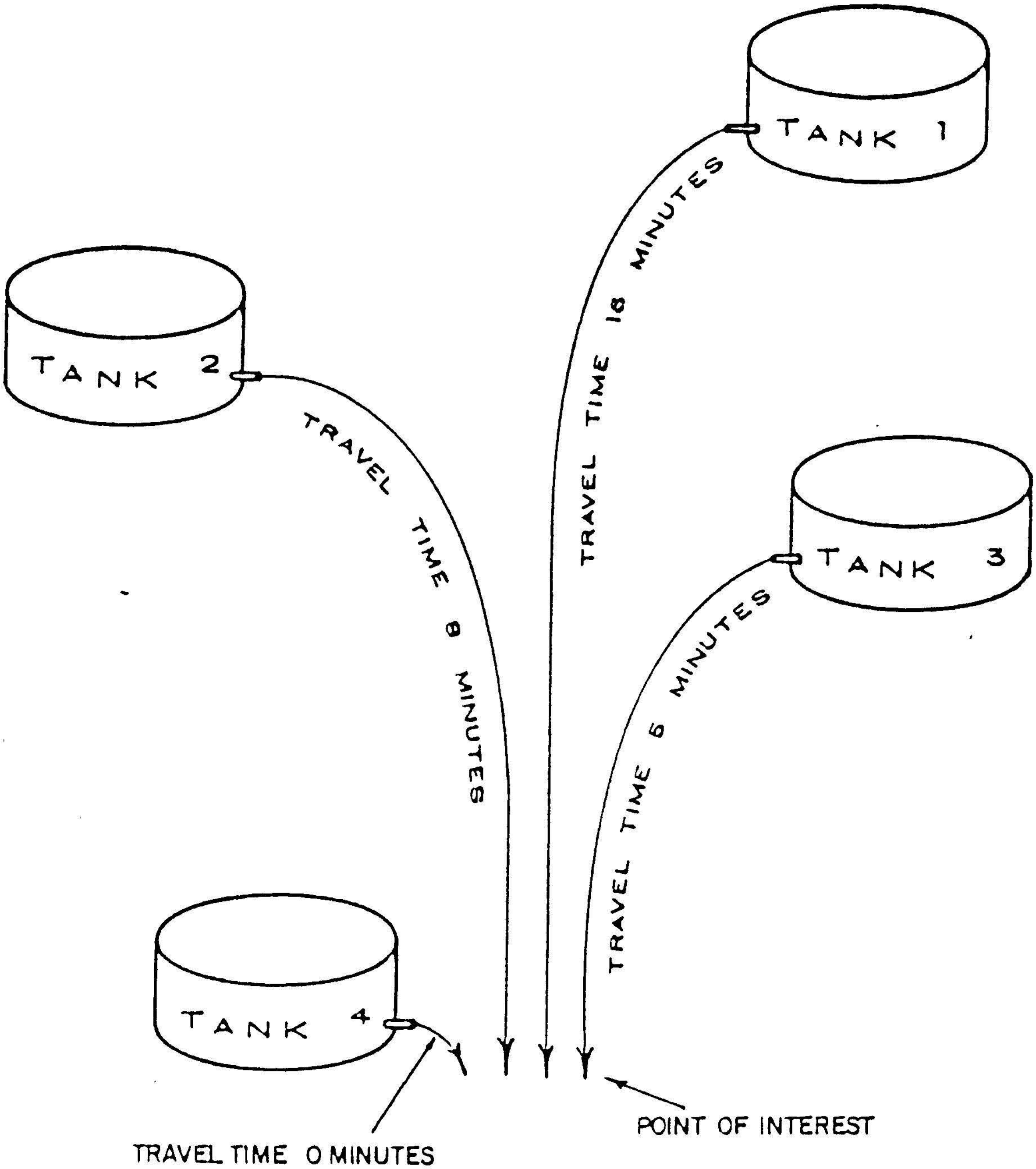
At any point of interest along a waterway, the rate of stormwater runoff can be calculated by evaluating the hydrologic characteristics of the watershed (or land area) draining to that point. The hydrologic characteristics include precipitation, surface storage, and infiltration as described in the previous 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 concentrating in a defined "channel" (e.g., paved roadside gutter, 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 (e.g., a bridge or a chronic flooding location along a stream) can be combined to form what is referred to as a "hydrograph" at that point.

1.4 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 rai
flows at a stream flow recording station or "ga
ideal approach but is rarely possible due to th
gages at points of interest. Lacking this
practice to develop hydrographs involves
information concerning the rate of runoff by
for individual elements of the hydrologic cycle.

To illustrate how a stream flow hydrograph
following example using equal sized water ta
watershed subbasins will be used (Figure 1-5



TANK TRAVEL TIMES

presented here simulates ideal field conditions, which differ from those encountered in a watershed as follows:

- The total flow volume from each tank is the same. Within 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).

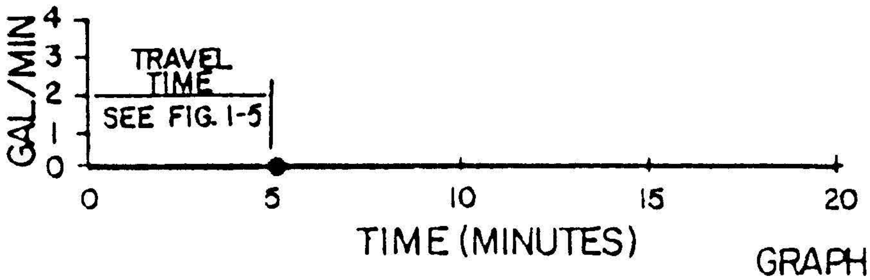
- The rate of flow from each tank is uniform. In nature, however, the rainfall intensity values vary over time in a nonlinear fashion.

- The travel time for the water from each tank to pass the point of interest has been assumed. In an actual watershed, these travel time values are determined from flow velocities that reflect the variable physical characteristics of the flow channels.

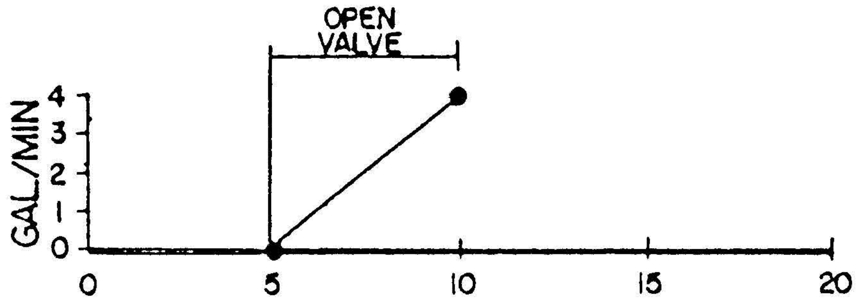
The key to understanding the formation of a watershed hydrograph is to realize that it is generated by runoff contributions from subbasins within the watershed. In the case of the water tank example, (Figure 1-5), the total rate of flow passing the point of interest is a result of the contributions from the individual tanks. Figure 1-6 is the hydrograph associated with Tank 3. In Figure 1-6, 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 1-6 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 the other tanks (see Figure 1-7). 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 1-7 represents that point flow from the associated tank begins to pa interest.

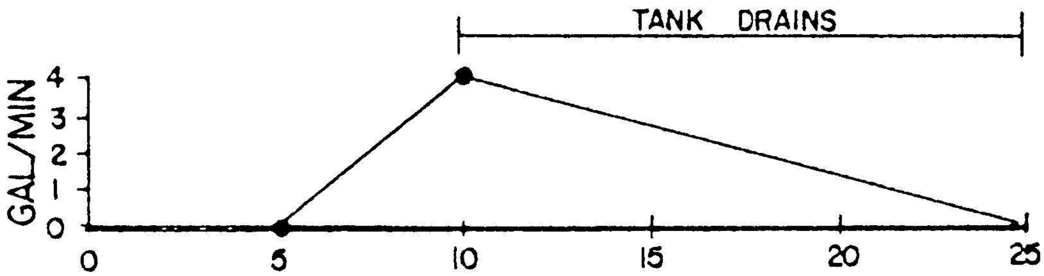
As each tank drains, the decreasing volum tank reduces the gallons per minute discharging zero. As shown in the hydrograph in Figure 1- leaving Tank 3 passes the point of interest tw after the first drop leaves the tank. The figur the flow at the point of interest from Tank 3 r rate ten minutes into the overall storm runoff e



GRAPH A



GRAPH B

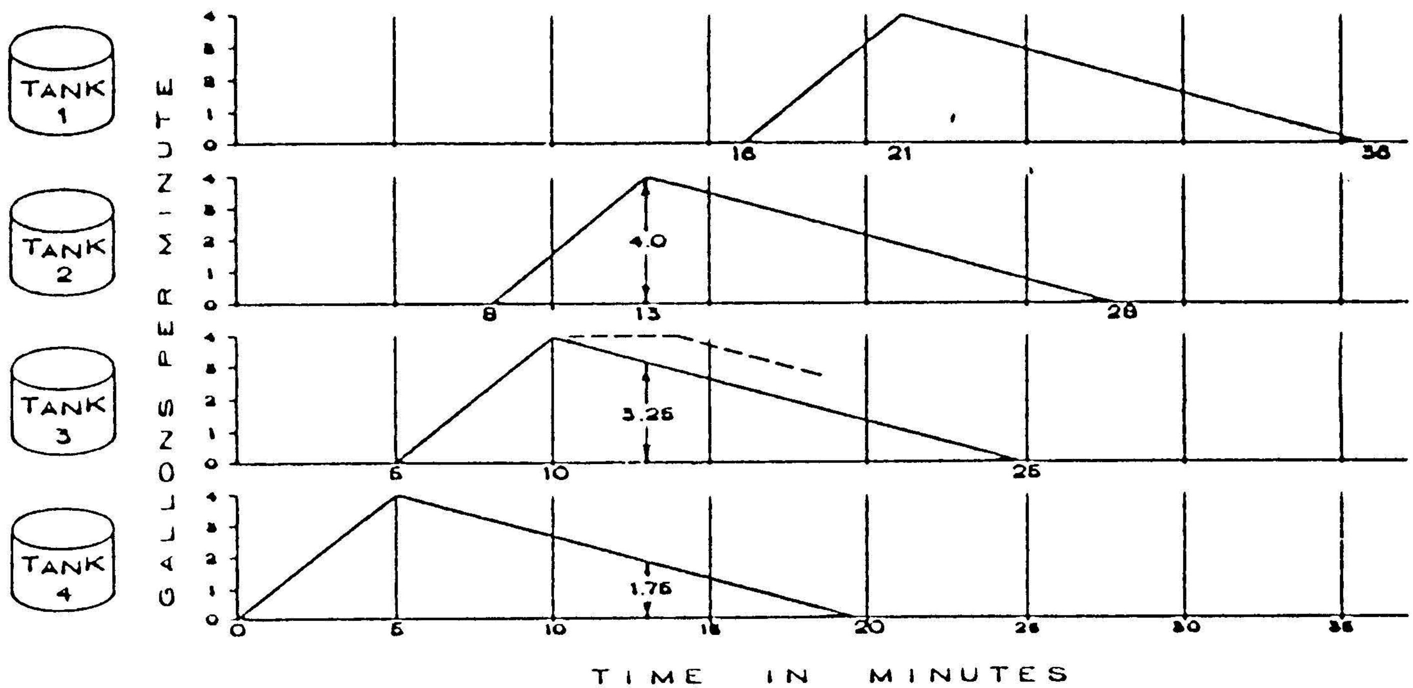


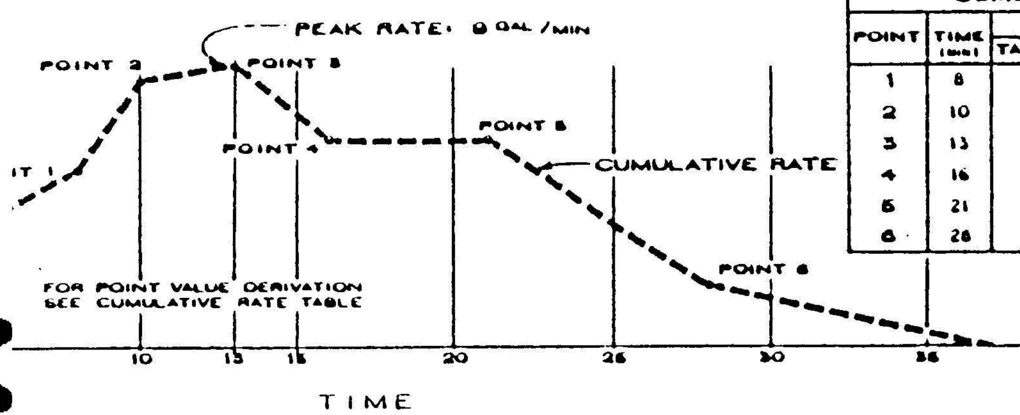
GRAPH C

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 GRA

WALTER B. SATTERTHWAITE ASSOC., INC.
720 NORTH FIVE POINTS ROAD · WEST CHESTER, PA. 19380 · (215)692-5770
BRANCH OFFICE: 9418 ANNAPOLIS ROAD · LANHAM, MD. 20706 · (301)731-056





CUMULATIVE RATE TABLE						
POINT	TIME (min)	CONTRIBUTING GAL/MIN				
		TANK 1	TANK 2	TANK 3	TANK 4	TOTAL
1	8	0	0	2.4	3.25	5.66
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

WALTER B. SATTERTHWAITE ASSOC., INC
720 NORTH FIVE POINTS ROAD · WEST CHESTER, PA. 19380 · (215)692-577
BRANCH OFFICE: 9418 ANNAPOLIS ROAD · LANHAM, MD. 20706 · (301)731-0

Figure 1-7 also shows the rates of flow for the other tanks, which were developed in a similar fashion. All of these hydrographs are then 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 1-7 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 (or hydrograph) 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.

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 is what actually occurs in a watershed. The concept used to develop the cumulative flow rate explained above, however, would be the same.

2.0 RATIONALE AND LEGAL FRAMEWORK FOR STORMWATER MANAGEMENT

2.1 The Need for a Comprehensive Approach to Stormwater Management

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 vent increases because of the reduction in pervious land area (natural land being covered by pavement, concrete, or buildings). That is, the alteration of native land cover and land contours to residential, commercial, industrial, and even crop land-uses results in decreased infiltration of rainfall and an increased rate and volume of runoff.

As development has increased, so has the problem of dealing with the increased quantity of stormwater runoff. Failure to properly manage this runoff has resulted in greater flooding, stream channel erosion and siltation, as well as reduced groundwater recharge. This process occurs every time the land development process causes changes in land surface conditions.

History has shown that individual land development projects are often viewed as separate incidents, and not necessarily as part of a "bigger picture." This has also been the case when the individual land development projects are scattered throughout a watershed (and in many different municipalities). However, it is now being observed and verified that this cumulative nature of individual land surface changes dramatically effects flooding conditions. This cumulative effect of development in some areas 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. Therefore, given the distributed and cumulative nature of the land alteration process, a comprehensive (watershed level) approach must be taken if a reasonable and practical management and implementation approach and/or strategy is to be successful.

2.2 Legal Framework for Stormwater Management

A review of stormwater management woul
without some discussion of the law that crea
management program.

In addition to the Stormwater Manageme
research for the Lackawanna River Watershe
included four other laws, which together
framework for the implementation of a compre
management plan. These additional laws are:

- Flood Plain Management Act (Act 166 of 19
- Dams Safety and Encroachments Act (Act 32

- Clean Steams Law (specifically the erosion and sedimentation regulations)

- Municipalities Planning Code (Act 247 of 1968 as amended by Act 170 of 1988)

The following sections contain brief reviews of each of these laws, point out key provisions that are pertinent to the watershed stormwater management programs. [An abstract overview on governmental immunities has also been prepared to help municipalities understand their potential liabilities.]

It should be noted, though, that the following comments are not intended to be official legal opinions or to constitute advice on any specific issue or case.

2.2.1 Stormwater Management Act (Act 167 of 1978)

Recognizing the need to deal with this serious and growing problem, the Pennsylvania General Assembly enacted Act 167. A primary goal of the Act is to prevent future problems resulting from uncontrolled runoff, including flooding, erosion and sedimentation, landslides, and pollution and debris often carried by stormwater runoff.

Until the enactment of Act 167, stormwater management had been oriented primarily towards addressing the increase in peak runoff rates discharging from individual land development sites to protect property immediately downstream. Minimal attention was 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 also was typically regulated on a municipal level, with little or no designed consistency between adjoining municipalities in the same watershed concerning the types, or degree, of storm runoff control to be practiced.

Act 167 changed this approach by instituting a comprehensive program of stormwater planning and management--on a watershed level. The Act requires Pennsylvania counties to prepare and adopt stormwater management plans for each water
the county, as designated by the Pennsylvania
Environmental Resources (PADER). Most important
are to be prepared in consultation with municipali
the watershed, working through a Watershed Adv
(WAC). The plans are to provide for uniform tech
and criteria throughout a watershed for the
stormwater runoff from new developing sites.

The final product of the Act 167 watershed
is to be a comprehensive and practical imple
developed with a firm sensitivity to the

(financial, legal, political, technical, etc.) of the municipalities within the watershed, so that a common goal of area-wide flood impacts management can be achieved.

2.2.1.1 Watershed Stormwater Plans

Under the Act, each county in the Commonwealth is required to prepare and adopt a watershed stormwater plan for each watershed located in the county as designated by and within the guidelines of the Pennsylvania Department of Environmental Resources (PADER), in consultation with the municipalities located within each watershed.

The counties must organize a Watershed Advisory Committee (WAC) composed of representatives from each municipality in the watershed. The WAC is to advise the county during the planning process, and the plans are to be adopted by the county commissioners and approved by PADER after public review and comment. The completed plan must be consistent with local land-use plans and state plans, such as water quality and floodplain programs.

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

In addition, within six months of the approval of the watershed stormwater management plan, each municipality in the watershed must adopt the stormwater management ordinance provisions in order to implement the plan. These regulations must be consistent with the plan, as well as standards of the Act. Failure to adopt and implement the ordinan in the state withholding funds from the General the municipality might be eligible.

2.2.1.2 Basic Standard for Stormwater M

The basic ground rule of the Act is th activities will generate additional runoff, velocity, or change the direction of its fl responsible for controlling and managing it so the not cause harm to other persons or properties future. The policy is that the legal system w excuse those who negligently disregard the impact their activities. It will not allow them to shift the burden of runoff management to the public or to those property owners downstream.

Section 13 of the Act defines the legal duties of developers and others engaged in the alteration of land by setting performance standards for runoff management. This section provides:

> 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.

The Act defines persons as individuals, private corporations, municipalities, counties, school districts, public utilities, sewer and water authorities, and state agencies. With this coverage, Section 13 becomes a truly comprehensive standard for stormwater control.

The goal of Section 13 (1) is the assurance that future development will not increase the maximum rate of runoff, at any point, from the boundary of the development site to the bottom of the watershed; and that the development will not cause an increase in maximum rate of flow in any other watershed to which its watershed is a tributary.

The purpose of Section 13 (2) is to make the statutory drainage standard more flexible. This section permits changes in runoff characteristics, including increase
provided they do not cause harm.

Implementation of a watershed plan may al
to which the Section 13 (2) standards can
adoption of ordinances which regulate ru
Watershed will limit the maximum possible fut
in turn, will limit the range of future pea
developers and municipal officials to identif
where increasing the peak rate will not cause

2.2.1.3 Violations, Penalties, Remedies

Section 15 of the Act makes any violation of the provision of the Act or of the watershed stormwater plan a public nuisance. A public nuisance is a nuisance per se. This means it is a nuisance by its very existence; therefore, it is not necessary to await damage results. Any aggrieved person, municipality, or county, and/or PADER can institute suits in equity to restrain or terminate a violation of law for damages caused by violations of this Act.

[The state is not subject to penalty provisions and the municipalities, county, and state agencies are not 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.

2.2.2 Other Acts Relating to Stormwater Management

2.2.2.1 Flood Plain Management Act (Act 166)

This Act requires municipalities with floodplain areas to participate in the National Flood Insurance Program, and to adopt floodplain management regulations that control new development in accordance with the minimum standards established by the Federal Insurance Administration in order to preserve natural flood-prone areas. Municipalities participating in the National Flood Insurance Program must require building permits for all construction and development occurring within identified floodplain areas. Such permits are not to be issued until all other required federal and state permits have been received by the applicant (i.e., obstruction and erosion/sedimentation permits).

2.2.2.2 Dam Safety and Encroachments Act (Act 325)

The main source of regulation for dams, existing and new obstructions, encroachments, fill in floodplains, culverts, bridges, retaining walls, and outfalls in a stream or 100-year floodplain. The Act requires permits for the construction of, alteration to, or abandonment of dams, (encroachments. The owners of existing encroachments are also required to obtain pe issued by PADER, the prime agency responsibl administration.

2.2.2.3 Clean Streams Law

Enacted in 1937, with its original inten regulation of discharge of sewage and industri then, its scope and duties have sizably expanded determined that sediment constitutes a water pollutant under the provisions of the law and created regulations for the control of erosion and sedimentation caused by earth-moving activities.

2.2.2.4 Municipalities Planning Code (Act 247 as Amended by Act 170)

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

3.0 EXISTING AND PROJECTED WATERSHED CHARACTERISTICS

3.1 General Description of the Lackawanna River Watershed

3.1.1 Existing Land-Use and Population Characteristics

The Lackawanna River Watershed covers an area of approximately 348 square miles, encompassing 51 municipalities with a combined population of 250,000. It is the largest watershed in Pennsylvania chosen to date for the purposes of the Act 167 program. Thirty-three (33) of the municipalities lie within Lackawanna County; seven (7) are in Luzerne County; six (6) in Susquehanna County; and five (5) in Wayne County. The list of municipalities located, completely or partially, within the Lackawanna River Watershed, is shown in Table 3-1. A breakdown of governmental subdivisions within the watershed indicates that there are 3 cities, 22 boroughs, and 26 second-class townships, ranging in population from 82,000 in the City of Scranton to less than 500 in remote areas such as Lehigh Township at the southern tip of Lackawanna County and Union Dale Borough in eastern Susquehanna County. Population densities per square mile are as diverse as the population ranges. In the Scranton/Carbondale/Clarks Summit areas, densities are highest with an average of 3,400 persons per square mile, while in the most rural areas, densities are less than 100 persons per square mile. (Lowest density being in Lehigh Township -- 21.7 persons per square mile.)

The watershed is characterized by urban/suburban development in what is referred to as the "Valley" area. This concentration of development, sprawling outward from the Lackawanna River banks to the hillside slopes, generally runs southwest to northeast from Pittston to Forest City with the most densely-populated area centered around the City of Scranton.

The southeastern portion of the watershed -- that area generally drained by the Roaring Brook and locally-referred to as the North Pocono region -- is characterized by steep slopes of forest cover with spotted residential and agricultural land-use areas. The headwater area of the watershed -- that area north of Forest City -- is also characterized by steep, forested slopes with small, scattered agricultural areas.

3.1.2 Topography

The topographic features that stand out t
Lackawanna River Watershed are the two nearly-p
ranges that traverse the watershed in a southwe
direction, thereby forming the area known as
Valley. Each of these ranges reach an average
feet above sea level with 20 percent or greater s
valley floor ranges in elevation from 600
southwestern section to 1,500 feet in the northea
width of the valley area is greatest at the s

TABLE 3-1
LACKAWANNA RIVER WATERSHED COMMUNITIES

LACKAWANNA COUNTY

Archbald Borough	Madison Township
Blakely Borough	Mayfield Borough
Carbondale City	Moosic Borough
Carbondale Township	Moscow Borough
Clarks Green Borough	Newton Township
Clarks Summit Borough	Old Forge Borough
Clifton Township	Olyphant Borough
Covington Township	Ransom Township
Dickson City Borough	Roaring Brook Township
Dunmore Borough	Scott Township
Elmhurst Township	Scranton City
Fell Township	South Abington Township
Greenfield Township	Springbrook Township
Jefferson Township	Taylor Borough
Jermyn Borough	Throop Borough
Jessup Borough	Vandling Borough
Lehigh Township	

LUZERNE COUNTY

Avoca Borough	Jenkins Township
Dupont Borough	Pittston City
Duryea Borough	Pittston Township
Hughestown Borough	

SUSQUEHANNA COUNTY

Ararat Township	Herrick Township
Clifford Township	Thompson Township
Forest City Borough	Union Dale Borough

WAYNE COUNTY

Canaan Township	Preston Township
Clinton Township	Sterling Township
Mount Pleasant Township	

gradually narrows as you travel northward to Carbondale and Forest City. Beyond the eastern ridge, that area drained by the Roaring Brook, the topography is that of rolling hills, with elevations ranging from 1,300 to 2,200 feet above sea level.

The Lackawanna River begins as two branches in northern Wayne and northeastern Susquehanna Counties. The West Branch begins at Ball and Romobe Lakes in Ararat Township, Susquehanna County at an elevation of 1,950 feet. The East Branch has its origin at Bone Pond in Preston Township, Wayne County at an elevation of 2,045 feet above sea level. The two branches converge at Stillwater Lake in Union Dale Borough, Susquehanna County -- the man-made lake created by the Stillwater Dam. The dam elevation is at 1,572 feet above sea level. From there the river flows southwesterly, through the urbanized Lackawanna Valley to its confluence with the Susquehanna River in Pittston City, Luzerne County, at an elevation of 540 feet above sea level.

3.1.3 Geology

The area within the Lackawanna River Watershed lies in two physiographic provinces. The majority of the watershed is within the Appalachian Mountain section of the Valley and Ridge Province. This Valley and Ridge section, known as the Anthracite Coal Region, averages about six miles in width. The remainder of the watershed lies in the Appalachian Plateaus Province.

The Appalachian Mountain section of the Valley and Ridge Provice is known as the Wyoming-Lackawanna Valley, and is a long synclinal trough with the outer rim made up of very hard resistant sandstone and conglomerate of the Pocono Formation. The inner rim is made up of bedrock of the Pottsville Formation. Between the two rims is a thin section of soft Mauch Chunk shale. The inner synclinal trough contains folded and faulted beds of post-Pottsville shale, sandstone, and some conglomerate and several mineable anthracite coal layers.

Most bedrock underlying the Appalachian Plateaus province in the survey area consists chiefly of red to brownish shale and sandstone of the Catskill Formation, which is upper devonian in age.

During the Pleistocene Epoch, a series of
ice sheets advanced and retreated, covering the
Watershed area with accumulations of glacial
rounded gravels, and boulders from melt water,
that was deposited directly from the ice wi
sorting or stratification is distributed uneven
region and is classified as glacial till. Thi
as 300 feet deep in some places, and the pres
the result of erosion of this glacial drift.

3.1.4 Soils

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

- Group A -- Soils with low runoff potential. Soils having a high infiltration rate even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels.

- Group B -- Soils having a moderate infiltration rate when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse texture.

- Group C -- Soils having a slow infiltration rate when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water or soils with moderately fine to fine texture.

- Group D -- Soils with high runoff potential. Soils having a very slow infiltration rate when thoroughly wetted and consisting chiefly of clay soils, with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material.

As the soil descriptions indicate, runoff potentials increase from a minimum for Group A soils to a maximum for Group D soils. In addition, to the soil groups listed above, the Lackawanna River Watershed also contains a vast area of urban land and strip-mine soils. Urban land consists of soil material excavated during construction of highways, buildings, etc. Earth-moving operations have destroyed soil profiles and mixed the surface layer and subsoil with raw and partly weathered rock. The characteristics of this soil type are highly variable. Strip-mine land is derived from soils that have been disturbed by coal-mining operations. The surface layer and subsoil of the original profile have been mixed with raw and
rock.

Approximately sixty percent of that a
located outside the urban areas contains Gr
another thirty percent contains Group D so
approximately ten percent of the soils with
classified as either Group A or Group B -- m
courses and within flood plains -- slow infiltr
throughout the watershed, tending to produce
rate of stormwater runoff.

3.1.5 Climate

The Lackawanna River Watershed is located in the northeastern part of Pennsylvania. Elevations range from 540 feet at the river's confluence with the Susquehanna River in Luzerne County to 2,656 feet at Mount Ararat in northern Wayne County -- part of the drainage divide between the Susquehanna and Delaware River basins. The area is not rugged enough for a true mountain climate, but it has many characteristics of such a climate.

Summer has warm days and cool nights. About sixty percent of possible sunshine is received during summer. The average daily maximum temperatures are generally in the low eighties and nighttime daily minimums average in the high fifties. Annual precipitation for the area is approximately 37 inches. Months late in spring and in summer receive more precipitation than the other months. An average of seven thunderstorms occurs during each of the summer months. Heavy rainfall associated with hurricanes or tropical storms moving up the east coast are occasional and result in flooding of the lower areas. The average daily noon relative humidity during the summer is about fifty-five percent.

Winter is cold and cloudy with daytime daily maximum temperatures in the mid-thirties and nighttime daily minimums in the high teens to the low twenties. Winter precipitation, which is light but frequent, is received as rain or snow. The annual snowfall for the area is about forty inches but may vary widely in short distances. The higher elevations of the watershed -- generally above 1,000 feet -- tend to receive greater amounts of snowfall. The annual total number of days with snow cover of one inch or more is fifty. The average daily noon relative humidity during the winter is about sixty percent. A summary of local climatic conditions is depicted in Figure 3-1.

3.2 Floodplain Information

3.2.1 Historical Floodplain Development

Floodplains exist along the low-lying areas of the Lackawanna River and along the various streams a
on Plate 2 of Appendix J entitled "Watershed
These areas experience significant flood damage d
events.

Development in the various floodplains
Lackawanna River Watershed was begun by the In
settlers of the Lackawanna River Valley area.
flat and agriculturally-friendly soils located
and stream valleys made these areas attractive.
flood hazards people settled and cultivated the

FIGURE 3-1

CLIMATIC CONDITIONS
NATIONAL WEATHER SERVICE
WILKES-BARRE/SCRANTON INTERNATIONAL AIRPORT
Pittston Township, Luzerne County, Pennsylvania
Elevation: 930 ft. above sea level

Month	Temperature			Precipitation	Humidity		Wind	
	high	low	average	water equivalent (inches)	am	pm	dir.	speed
J	32.1	18.2	25.2	2.27	75	67	SW	8.9
F	34.9	19.2	26.8	2.05	75	64	SW	9.0
M	44.1	28.1	36.1	2.63	73	59	NW	9.4
A	58.2	38.4	48.3	3.01	72	54	SW	9.5
M	69.1	48.1	58.6	3.16	76	56	WSW	8.5
J	77.8	56.9	67.4	3.42	82	61	SW	7.8
J	82.1	61.4	71.8	3.39	84	62	WSW	7.3
A	80.0	60.0	70.0	3.47	87	66	SW	7.0
S	72.7	52.8	62.8	3.36	88	70	SW	7.3
O	61.4	42.0	51.7	2.78	84	66	WSW	7.9
N	48.2	33.6	40.9	2.98	79	69	[illegible]	[illegible]
D	36.3	23.1	29.7	2.54	77	70	[illegible]	[illegible]
Av	58.0	40.0	49.0	35.06	79	64	[illegible]	[illegible]

turn attracted businesses and manufacturers to do the same. Over the years, development has branched off and expanded outward from the originally settled areas.

Urban expansion, culm piles, and strip-mining activities have strongly altered large portions of the watershed's floodplains. Areas such as the Olyphant Flats and Plot Section of Scranton are two prime examples of floodplain development. These areas are densely-populated and because of their close proximity to the Lackawanna River, feel the brunt of its flooding.

Development of the hillside areas along the floodplains has further increased water runoff potentials. Where development was previously non-existent, homes and businesses now stand. An outmigration of people from the City and Valley communities to the outlying areas of the watershed has further intensified stormwater runoff. For example: in 1930, during the City of Scranton's hay day, it had a population of 143,433. Estimated population statistics tell us that at present only 82,000 persons reside in the city. While not all the residents who left the city resettled in the area, a great number of them did relocate to the outlying areas of the watershed. Development caused by this outmigration has altered the hillside terrain, and ultimately allows water to flow more readily into the floodplain areas.

Other areas, including Leggetts and Keyser Creeks, are also flood prone. Commercial and residential developments along these two creeks have altered both the land and creek patterns, resulting in a higher frequency of flooding as well as flood damage.

3.2.2 Floodplain Delineation

The U.S. Department of Housing and Urban Development -- Federal Insurance Administration has prepared Floodplain Maps for each municipality in the Lackawanna River Watershed. Each of the maps is available at the Lackawanna County Planning Commission office, as well as the Luzerne, Susquehanna, and Wayne County Planning Offices for those watershed communities within their respective jurisdictions. A list of all the
including effective dates and type of map is lis

3.2.3 Existing and Future Floodplain Devel

Existing development along the floodplain
River from Forest City south to the river's co
Susquehanna at Pittston is characteristic of
area, with a mix of various densities of r
commercial districts, and some industrial and re
The river's floodplain above Forest City is
space or consists primarily of agricultural deve

TABLE 3-2
LACKAWANNA RIVER WATERSHED
MUNICIPAL FLOODPLAIN MAPS

Municipality	Date of Map	Type of Map (FIRM/FHBM)
Ararat Twp.	December 12, 1980	FHBM
Archbald Boro	January 16, 1980	FIRM
Avoca Boro	July 16, 1981	FIRM
Blakely Boro	January 16, 1980	FIRM
Canaan Twp.	September 30, 1987	FIRM
Carbondale City	December 16, 1980	FIRM
Carbondale Twp.	September 30, 1981	FIRM
Clarks Green Boro	June 25, 1976	FHBM
Clarks Summit Boro	December 18, 1979	FIRM
Clifford Twp.	March 16, 1989	FIRM
Clifton Twp.	February 2, 1990	FIRM
Clinton Twp.	February 4, 1983	FIRM
Covington Twp.	January 10, 1975	FHBM
Dickson City Boro	January 16, 1980	FIRM
Dunmore Boro	September 28, 1979	FIRM
Dupont Boro	June 15, 1981	FIRM
Duryea Boro	June 18, 1980	FIRM
Elmhurst Twp.	February 2, 1990	FIRM
Fell Twp.	September 30, 1981	FIRM
Forest City Boro	November 1974	FHBM
Greenfield Twp.	July 16, 1990	FIRM
Herrick Twp.	November 5, 1986	FIRM
Hughestown Boro	Unknown	Unknown
Jefferson Twp.	June 13, 1980	FIRM
Jenkins Twp.	May 16, 1977	FIRM
Jermyn Boro	December 18, 1979	FIRM
Jessup Boro	April 15, 1980	FIRM
Lehigh Twp.	June 15, 1981	FIRM
Madison Twp.	January 3, 1975	FHBM
Mayfield Boro	September 30, 1981	FIRM
Moosic Boro	November 1, 1979	FIRM
Moscow Boro	December 1, 1981	
Mount Pleasant Twp.	December 4, 1985	
Newton Twp.	July 3, 1990	
Old Forge Boro	October 16, 1979	
Olyphant Boro	September 28, 1979	
Pittston City	May 2, 1977	
Pittston Twp.	June 15, 1981	
Preston Twp.	October 15, 1985	
Ransom Twp.	April 15, 1980	

TABLE 3-2 (continued)

Municipality	Date of Map	Type of Map (FIRM/FHBM)
Roaring Brook Twp.	September 28, 1979	FIRM
Scott Twp.	May 17, 1990	FIRM
Scranton City	August 15, 1980	FIRM
South Abington Twp.	December 15, 1982	FIRM
Springbrook Twp.	January 20, 1982	FIRM
Sterling Twp.	August 19, 1991	FIRM
Taylor Boro	August 15, 1980	FIRM
Thompson Twp.	April 11, 1975	FHBM
Throop Boro	September 28, 1979	FIRM
Union Dale Boro	February 4, 1983	FIRM
Vandling Boro	February 14, 1975	FHBM

Existing development along the river's tributaries varies greatly. The tributary floodplains within the urbanized "valley" area consists of development similar to that of the river itself, while the outlying floodplains are basically open space, agricultural, or low-density residential areas.

Scattered undeveloped and previous "coal wasteland" areas within the floodplain of the Lackawanna River are continuously being transformed into developable land for various uses, mainly commercial and industrial uses, as well as some recreational facilities and low-density residential developments.

However, a review of development plans submitted to the county planning agencies within the last few years, indicates that no major developments are occurring in the floodplains; most new developments are outside the "valley" or on the hillsides above the floodplains. There is a potential for development along the floodplains outside the "valley" area; however, existing floodplain and floodway regulations play a major role in controlling the future development in those damage-sensitive areas -- unlike the existing development along the "valley" floodplains that pre-dates any floodplain regulations.

For the purposes of the Lackawanna River Stormwater Management Plan, the damage potential of existing and future floodplain development will be minimized using the following principles:

- o Damage potential of existing floodplain development will remain unchanged for storm events representing the two-year through 100-year return period events through implementation of the stormwater management criteria included in the Stormwater Management Plan for the Lackawanna River Watershed.

- o Damage potential for future floodplain development will be minimized by only permitting specific types of development which are damage resistant consistent with the Floodplain Management Act as implemented through municipal floodplain regulations and the Department of Environmental Resources Chapter 105 -- Dam Safety and Waterway Management Regulations and Chapter 106 -- Floodp
Regulations.

- o Damage potential of existing and fu
development may be reduced with implementa
measures for areas subject to inundation.
and design life of any remedial measures w
by implementation of the stormwater managem

3.3 <u>Water Obstructions</u>

Water obstructions are man-made or natural
a stream which affect its free-flow during times

flood flows. Examples of water obstructions include dams, bridges, culverts, retaining walls, and storm-sewer outfalls. Responses from a questionnaire distributed to every municipality in the watershed revealed that no section of the watershed is immune to water obstructions. Virtually every community that returned the survey indicated several water obstructions that impede natural drainage and hence intensify stormwater related problems. Culverts cluttered with debris and of now insufficient size due to increased upgradient development, along with older, inadequately-sized bridges, lead the list of water obstructions throughout the watershed. These man-made features tend to slow down the flow during peak stormwater runoff, subsequently causing street and neighborhood flooding.

The obstructions were identified through the municipal questionnaire process and by the county planning commission. They were considered as "points of interest" for the hydrologic modeling efforts. A total of 67 obstructions were identified, as shown on Plate 1 and identified in Appendix J. Twenty-four (24) of the obstructions were determined to be significant, rendering individual attention in terms of model input and structure performance. The basis for determining "significance" was a combination of the following:

1. Questionnaire identification; and,

2. Structure/obstruction resulted in backup or design storage of at least one-half the 100-year event volume from the upstream drainage area. Identification of this criteria was accomplished by any or all of the following:

   - Flood Insurance Study profiles;

   - USGS Quadrangle review to identify shallow slope and/or wetlands areas immediately upstream of the structure/obstruction;

   - Existing reservoirs where a Phase I Corps of Engineering study exists; and,

   - Field identification of verif
     obstruction.

The significant obstructions identified by
presented in the tables on the following pag
indicates those significant obstructions which
evaluated within one of the nine PSRM priority wa
3-4 identifies those that were included in the T
method of modeling is not relevant to the identi
obstructions. However, Section 4.0 of the p
expanded discussion of the modeling approach for

TABLE 3–3
LACKAWANNA RIVER WATERSHED – SIGNIFICANT OBSTRUCTIONS
(IN PRIORITY WATERSHED PSRM MODELS)

	SIGNIFICANT OBSTRUCTION LOCATION	SUBAREA LOCATION	DESCRIPTION	CAPACITY INFORMATION	FLOW AT STRUCTURE FOR FUTURE LANDUSE	SUMMARY OF CAPACITY
#1	STERRY CREEK	SA #9	ROAD CROSSING 8 FT x 5 FT BOX CULVERT MINE TAILING EMBANKMENT 125 FT HIGH	CAPACITY TO HEIGHT OF 45 FT = 1240 cfs	Q_{100} = 642 cfs	WILL PASS 100–YR STORM
#2	HULL CREEK	SA #3	CIRCULAR PIPE CULVERT, CMP DIAMETER = 42 INCHES	CAPACITY TO TOP OF ROAD = 55 cfs	Q_{100} = 43 cfs	WILL PASS 100–YR STORM
#3	HULL CREEK	SA #5	CIRCULAR PIPE CULVERT DIAMETER = 27 INCHES	CAPACITY TO TOP OF ROAD = 55 cfs	Q_{100} = 21 cfs	WILL PASS 100–YR STORM
#4	ROARING BROOK	SA #13	BRIDGE–ONE SPAN. 22 FT BOTTOM WIDTH 7.8 FT HEIGHT	CAPACITY TO TOP OF ROAD = 1320 cfs	Q_{100} = 31 cfs	WILL PASS 100–YR STORM
#5	ROARING BROOK	SA #56	BOX CULVERT 12 FT x 3.8 FT	CAPACITY TO TOP OF ROAD = 396 cfs	Q_{100} = 261 cfs	WILL PASS 100–YR STORM
#6	ROARING BROOK	SA #59	CIRCULAR PIPE CMP DIAMETER 4 FT	CAPACITY TO TOP OF ROAD = 135 cfs	Q_{100} = 14 cfs	WILL PASS 100–YR STORM
#7	ROARING BROOK	SA #63	BOX CULVERT 16 FT x 6 FT	CAPACITY TO TOP OF ROAD = 1280 cfs	Q_{100} = 69 cfs	WILL PASS 100–YR STORM
#8	ROARING BROOK	SA #80	BOX CULVERT 8.2 FT x 9.1 FT	CAPACITY TO TOP OF ROAD = 787 cfs	Q_{100} = 58 cfs	WILL PASS 100–YR STORM
#9	ROARING BROOK	SA #101	CIRCULAR PIPE CMP DIAMETER 4 FT	CAPACITY TO TOP OF ROAD = 135 cfs	Q_{100} = 21 cfs	WILL PASS 100–YR STORM
		SA #12	BOX CULVERT 4 FT x 6.3 FT	CAPACITY TO TOP OF ROAD = 360 cfs	Q_{100} = 106 cfs	WILL PASS 100–YR STORM
		SA #10	CIRCULAR OPENING IN CONCRETE BLOCK DIAMETER = 4 FT	CAPACITY TO TOP OF PIPE = 46 cfs ADDITIONAL 41 FT OF STORAGE TO TOP OF ROAD IS AVAILABLE	Q_{100} = 46 cfs	WILL PASS 100–YR STORM

.WK1

TABLE 3–4

LACKAWANNA RIVER WATERSHED – SIGNIFICANT OBSTRUCTIONS

(IN TR–20 MODEL SUBAREAS)

	SIGNIFICANT OBSTRUCTION LOCATION	SUBAREA LOCATION	CAPACITY INFORMATION	FLOW AT STRUCTURE FOR FUTURE LANDUSE	SUMMARY OF CAPACITY
#12	OLYPHANT RESERVOIR #2 DAM	SA #62	DAM OVERTOPPING STARTS AT ELEVATION 1349.0 AND Q=1124 cfs SPILLWAY CREST AT ELEVATION 1342.0	Q_5 = 861 cfs Q_{10} = 1546 cfs	WILL PASS 5–YR STORM
#13	LAKE SCRANTON DAM	SA #82	DAM OVERTOPPING STARTS AT ELEVATION 1287.5 AND Q=2625 cfs SPILLWAY CREST AT ELEVATION 1281.0	Q_{100} = 1536 cfs	WILL PASS 100–YR STORM
#14	DISTRICT #5 RESERVOIR DAM	SA #85	DAM OVERTOPPING STARTS AT ELEVATION 929.5 AND Q=5944 cfs SPILLWAY CREST AT ELEVATION 922.2	Q_{100} = 4466 cfs	WILL PASS 100–YR STORM
#15	WATRES RESERVOIR DAM	SA #115	DAM OVERTOPPING STARTS AT ELEVATION 1438.9 AND Q=10000 cfs SPILLWAY CREST AT ELEVATION 1426.0	Q_{100} = 3091 cfs	WILL PASS 100–YR STORM
#16	NESBITT RESERVOIR DAM	SA #106	DAM OVERTOPPING STARTS AT ELEVATION 1166.0 AND Q=19542 cfs SPILLWAY CREST AT ELEVATION 1156.0	Q_{100} = 8130 cfs	WILL PASS 100–YR STORM
#17	SPRING BROOK INTAKE DAM	SA #98	DAM OVERTOPPING STARTS AT ELEVATION 921.6 AND Q=28034 cfs SPILLWAY CREST AT ELEVATION 910.0	Q_{100} = 8788 cfs	WILL PASS 100–YR STORM
#18	CARBONDALE RESEVOIR #7 DAM	SA #38	DAM OVERTOPPING STARTS AT ELEVATION 1745.2 AND Q=2397 cfs SPILLWAY CREST AT ELEVATION 1741.7	Q_{100} = 545 cfs	WILL PASS 100–YR STORM
#19	CARBONDALE RESEVOIR #4 DAM	SA #38	DAM OVERTOPPING STARTS AT ELEVATION 1813.0 AND Q=480 cfs SPILLWAY CREST AT ELEVATION 1810.0	Q_{100} = 1313 cfs	WILL PASS 100–YR STORM
#20	BROWNEL RESERVOIR DAM	SA #48	DAM OVERTOPPING STARTS AT ELEVATION 1586.5 AND Q=1850 cfs SPILLWAY CREST AT ELEVATION 1583.4	Q_{100} = 861 cfs	WILL PASS 100–YR STORM
[illegible]	[illegible]RVOIR	SA #62	DAM OVERTOPPING STARTS AT ELEVATION 1349.0 AND Q=1124 cfs SPILLWAY CREST AT ELEVATION 1342.0	Q_{100} = 3380 cfs	WILL PASS 100–YR STORM
[illegible]	[illegible]OIR DAM	SA #65	DAM OVERTOPPING STARTS AT ELEVATION 1361.5 AND Q=1362 cfs SPILLWAY CREST AT ELEVATION 1352.9	Q_{100} = 475 cfs	WILL PASS 100–YR STORM
[illegible]	[illegible]	SA #69	DAM OVERTOPPING STARTS AT ELEVATION 1383.6 AND Q=286 cfs SPILLWAY CREST AT ELEVATION 1379.4	Q_{100} = 102 cfs	WILL PASS 100–YR STORM
[illegible]	[illegible]EEK DAM	SA #51	DAM OVERTOPPING STARTS AT ELEVATION 1162.6 AND Q= 229.0 cfs SPILLWAY CREST AT ELEVATION 1150.0	Q_{100} = 194 cfs	WILL PASS 100–YR STORM

.WK1

The significant obstructions summarized on the previous pages may or may not be a cause of a specific stormwater-related problem. The passing of large storm flows may not necessarily mean they are adequate or do not cause other problems. The effects of ponding behind the structure and altered outflows (including timing of water releases) would need to be considered in weighing the benefits of structure modifications (geared toward correcting existing problems) against the cost of construction modifications.

The municipalities in which each of the 67 obstructions is located may want to consider further evaluations of obstruction significance as part of their priorities for implementation of this plan. Further evaluations or planning considerations may include:

1. Structural integrity;

2. Capacity evaluations for existing and future land-use runoff contributions of the structure;

3. Current or proposed zoning within the contributing drainage area of the structure;

4. Structural modifications to the structure/obstruction (such as enlargement of culverts, embankments, etc.); and,

5. Cost benefit analysis.

3.4 Flood Control Projects

The federal government, through the U.S. Army Corps of Engineers, has undertaken and completed four major flood-control projects along the Lackawanna River. The largest being Stillwater Dam in Clifford Township, Susquehanna County, below the junction of the East and West Branches of the Lackawanna River. This earthen dam was designed to control river flooding in the Upper Valley communities, as far south as Archbald. The other projects along the river include the Mayfield Flood Control Project, South Scranton Flood Control Project, and Duryea Flood Control Project, all consisting of levees a
their respective communities to prevent floodi
areas.

In addition to the projects undertaker
itself, the federal government has also com
projects along tributaries of the river. A dai
Hulls Creek above the town of Blakely, and
constructed along the creek where it winds i
populated areas of the borough. The construc
Dam, on Aylesworth Creek in the northern se
Borough, not only has curtailed flooding even
has created a large lake with the surrounding a

a recreational park for swimming and picnicking. Thirdly, a system of levees has also been constructed along Spring Brook in Moosic Borough to alleviate flooding in that immediate area.

Additional federal flood-control projects have been proposed for the Lackawanna River in the Olyphant/Blakely area, and in the Albright Avenue and Plot Sections of North Scranton. Channel-dredging and the construction of levees are anticipated to prevent the inundation of those flood prone areas of the watershed. (Refer to Plate 3 of Appendix J for the exact locations of the flood control projects.)

3.5 Stormwater Collection Facilities

Stormwater collection facilities can be found in the municipalities along the Lackawanna River from Pittston in the south to Forest City in the north. The majority of these facilities are combined "sanitary/stormwater sewers". They have two functions: transport sanitary waste to plants for treatment and carry rainfall, as well. During heavy rain events the system's inability to handle excess water creates problems such as backups, minor flooding, and direct discharge of untreated sewage into the Lackawanna River.

Other portions of the Lackawanna River Watershed that contain stormwater collection facilities are the Clarks Summit/Abington and Moscow areas. While the Moscow system carries only stormwater, portions of the system in the Clarks Summit area still carry combined storm- and wastewater.

Data regarding proposed collection facilities within the next ten years is very sketchy. Typically, stormwater collection facilities would be constructed as either a part of a major subdivision and/or land development project (by the developer) or as remedial measures as part of municipal capital or maintenance programs on an as-needed basis. As-needed would most likely refer to the severity of the drainage problem and the public support or outcry for an improvement. In this manner, projects (including the reconstruction of existing systems into separate sanitary and storm sewers valley-wide) are constructed as money becomes available in the capital or maintenance budget. The effect of the approach is a piecemeal proc
improvements rather than one comprehensive p
future needs.

Through funding from the Pennsylvania
Community Affairs, the municipalities within t
addressing current sanitary and storm sewer
piecemeal basis. Basically, sections of old sa
being replaced with new ones, and the old
converted into separate stormwater collection
feasible (i.e., proximity to outfall structures).

Some of the projects involving sanitary and storm sewer reconstruction currently under contract with the Lackawanna County Community Development Agency on behalf of entitlement communities through the state's Community Development Block Grant program include the following:

- Archbald Borough -- Wayne Street
- Blakely Borough -- Brook and Union Streets
- Dickson City Borough -- Lincoln, Albert, and Carmalt Streets; Grant Court; Hufnagle Flats
- Fell Township -- Simpson sewer reconstruction engineering
- Jessup Borough - Church, Delaware, Hill, Basalyga, Blakely, Cherry, Hudson, Sturges, Spring Streets; Grassy Island and Constitution Avenues
- Mayfield Borough -- Park Street
- Moosic Borough -- Springbrook Avenue
- Old Forge Borough -- Dunn Avenue
- Olyphant Borough -- Gravity and East Scott Streets
- Taylor Borough -- Keyser Avenue, Church and East Taylor Streets
- Throop Borough -- Pancoast, Charles and Edgar Streets

In addition, the city of Carbondale, through its own community development program with funding from DCA, has undertaken similar projects on several city streets including: Brown, Richmond, Orchard, and Scott Streets; and, Fern, Sago, and Shamrock Avenues.

3.6 Stormwater Management Facilities

Stormwater management facilities on a watershed level are, for the most part, nonexistent within the Lackawanna River Watershed. Some on-site facilities have been constructed to handle stormwater runoff from individual developments. Examples of large developments recently proposed with on-site detention/retention basins within the watershed include: Harmony Hills, 169 residential lots in Moscow Borough; Hills of Archbald, 151 residential lots in Archbald Borough; Lake Scranton Estates, 92 residential lots in the City of Scranton; the expansion of the Viewmont Mall along the Scranton/Dickson City border; Mid-Valley Industrial Park in Jessup, Olyphant and Throop Boroughs; and the on-going residential, office-commercial, developments on Montage Mountain in Moosic stormwater facilities in these developments ar voluntarily by the respective developers.

While the majority of the developments wit voluntarily provide for detention/retention ba have provided storm sewer systems to direct th with little or no concern for downflow probler from the increased runoff.

3.7 Storm Drainage Problem Areas

An important goal of Act 167 is to prevent existing stormwater related problems from worsening.

The questionnaire distributed to the municipalities revealed that no community is immune from stormwater related problems, and a total of 65 drainage problem areas were documented. By far, residential flooding caused by obstructions in existing culverts and stream channels appears to be most recurring stormwater problem; however, commercial and industrial areas are also affected. The City of Scranton indicated through the questionnaire that there were nine areas with severe drainage problems, eight of which were located in residential areas. Other municipalities with several areas of recurring drainage problem areas included: Dunmore Borough, 8 areas; Archbald Borough, 6 areas; and Taylor Borough, 5 areas.

Major commercial area flooding within the watershed occurs along Routes 6 and 11 in South Abington Township, where development upstream of Leggetts Creek has drastically increased the runoff. Inadequately-sized culverts, and underground channelization of the stream through the commercial area is now impeding flow during large rain events, sending the creek over its natural channel and onto the roadway and parking lots. Other recurring stormwater related problems in commercial areas were reported in Scranton City, and the boroughs of Archbald, Dunmore, Mayfield, Olyphant, and Forest City. Industrial areas with drainage problems were documented in Archbald, Mayfield, and Olyphant Boroughs.

In the rural sections of the watershed, agricultural activities and the recent trend of residential development have increased the stormwater runoff and velocity, causing roadway flooding and accelerated soil erosion. Areas with these stormwater related problems were found in Covington, Elmhurst, Fell, Herrick, Jefferson, Ransom, Scott, and Springbrook Townships.

Plate 1 of Appendix J indicates the drainage problem areas as identified as a part of the stormwater management plan. The final column of the index to Plate 1 generaliz solutions to the identified problem areas.

3.8 Future Land-Use Patterns

Residential, commercial, and industrial grow rapidly throughout the Lackawanna River Watershed.

Primarily, residential expansion exists in North Pocono, and Montage Mountain areas of the L Watershed, with secondary development growth pa Upper- and Mid-Valleys and East and West Mountains Scranton. Included in these areas are a 1,500-u of Montage Mountain, a 151-lot development in the Archbald area of Mid-Valley and 200 lots available for development on the East and West Mountains of Scranton. Other lands readily available for development can be found in Covington, Springbrook, and Madison Townships which are located in the southeastern area of the watershed.

Highpoints of commercial development can be found primarily along Route 6 from Scranton to Carbondale. Expansion of the Viewmont Mall and the proposed mall at Steamtown will increase retail space in the area, while expansion of the Montage Executive Office Park will provide additional office space.

Industrial developments such as the Mid-Valley Industrial Park in Throop, Olyphant, and Jessup Boroughs; Keyser Valley Industrial Park in Scranton; Stauffer Industrial Park in Taylor Borough; and Keystone Industrial Park in Dunmore Borough are undergoing expansion and will provide opportunities for incoming industries.

4.0 WATERSHED TECHNICAL ANALYSIS

4.1 Modeling Approach and Goals

The purpose and benefit of this study and implementation plan is to provide all of the municipalities in the watershed (per the requirements of Pennsylvania Act 167) with an accurate and consistent plan for comprehensive stormwater management. Currently, many of the watershed municipalities do not enforce stormwater regulations and, for those that do, actual enforcement criteria vary considerably. Given the nature of storm runoff and its impacts, as described in Sections 4.8 and 4.9 of this chapter, a critical objective of sound stormwater management planning is to provide for consistency of implementation requirements throughout the watershed. Therefore, the primary objective of the Act 167 technical study of the Lackawanna River Watershed is to develop a technical and institutional support document to facilitate implementation of consistent regulations throughout the Lackawanna River Watershed. This includes the selection of consistent design event and performance standard criteria for each subwatershed, with the understanding that enforcement responsibility and authority will rest with the associated municipalities and the county planning department. However, because of the unique characteristics of the watershed (primarily its areal extent and the number of affected municipalities) it was necessary to apply two levels of modeling detail.

Watershed-level planning for stormwater management involves a complex process of goal setting, problem identification, and decision making. As with any planning program that leads to the decision-making step, the key aspect is the development of a sound database. That is, the only way to be able to accurately plan for future control of stormwater impacts is to develop accurate facts concerning existing and future stormwater characteristics.

The method that has been used to provide these facts for the development of the Lackawanna River Watershed stormwater management plan is runoff (i.e., stormwater) simulation modelling. Computer simulation models are very effective tools for analyzing the effects and impacts of stor
urbanizing areas. Computer technology now pro
to evaluate the critical elements of the rainfa
for an urbanizing area, such as the timing
throughout the watershed and the specific ch
detention and/or delay of runoff in various
watershed. It is only by evaluating these types
part of an overall stormwater management a
effective runoff control system can be developed

Developing detailed modeling throughout the
watershed would not only be extremely expensive
be unnecessary at this initial planning stage.

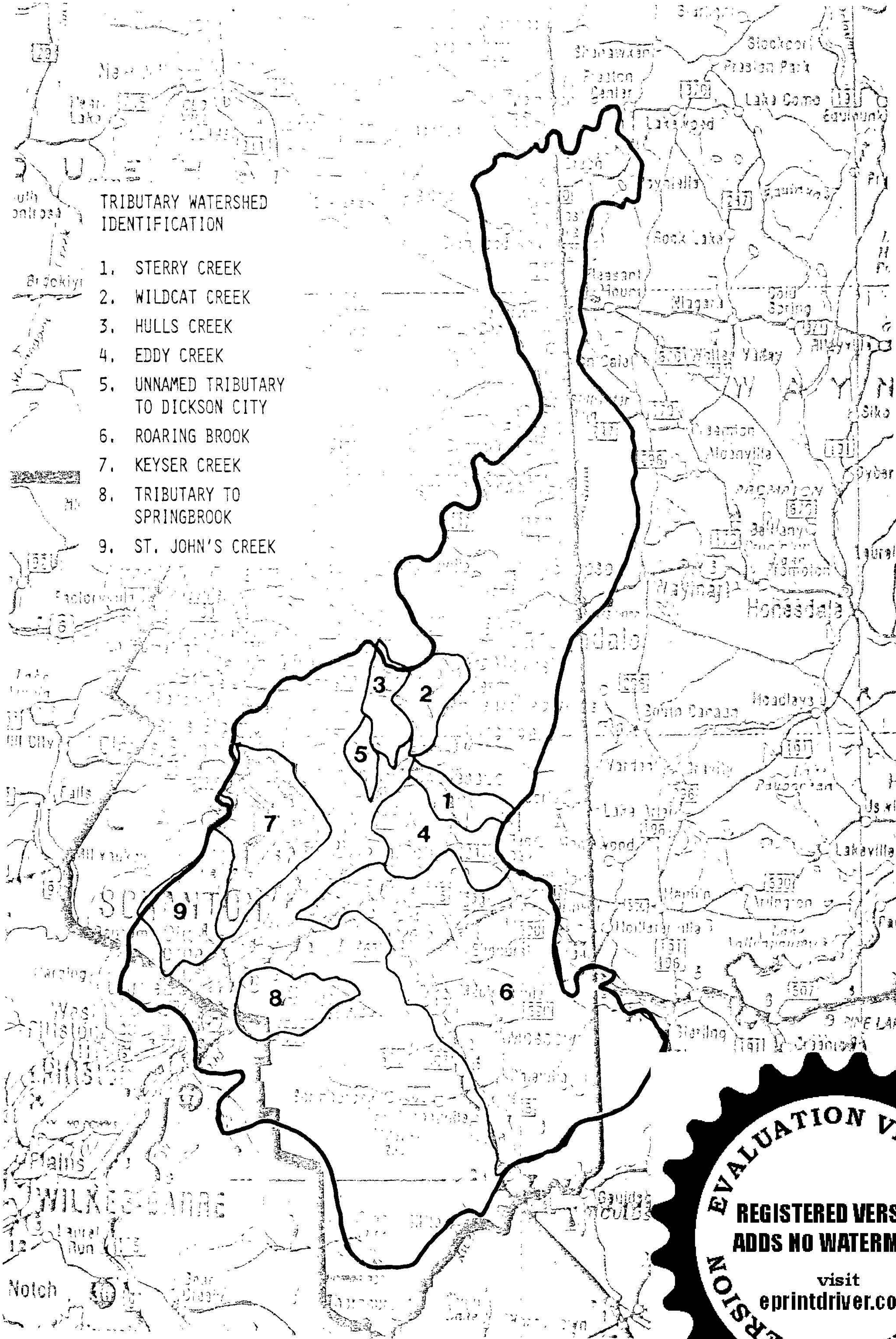
due to the overall size of the watershed, but more importantly is due to the fact that an extensive portion of the watershed is currently undeveloped steep sloped and forested areas, which are proposed to remain this way through the ten-year planning period for this initial Act 167 plan. In addition, one of the major items of importance for this Act 167 planning study is the fact that the Lackawanna River itself has been studied and evaluated and has, in fact, been addressed in studies resulting in flood control measures being implemented by both the Pennsylvania Department of Environmental Resources (PADER) and the U.S. Army Corps of Engineers (ACOE). Therefore, for purposes of the Act, especially as it relates to the individual municipalities (and particularly looking ahead to the implementation efforts that are necessary to make the plan work), a concentration was made on the storm flooding management efforts that are necessary outside of the river boundaries itself, i.e., for the tributary streams and brooks to the Lackawanna River. These "detailed" study areas were modeled using the Penn State Runoff Model (PSRM) and used as input to the approximate modeling of the remainder of the watershed. For the approximate study areas, the U.S. Soil Conservation Services TR-20 hydrologic model was applied (Reference 1)1.

4.2 Selection of Detailed Study Areas

In order to designate the detailed study areas within the Lackawanna River Watershed it was first necessary to identify the specific subwatershed with significant stormwater management concerns. This was accomplished using the municipal questionnaire process. The detailed study areas are those for which flooding problems exist and/or are projected for the immediate planning horizon. In addition, these areas are those for which significant growth and development are projected within the ten year planning period and, therefore, are those areas that may contribute to existing flooding problems, or be the source of new storm flooding problems. Through this process, the concept of the Act 167 program (i.e., the enactment of land development ordinances to implement technical standards and criteria for cost-effective storm runoff management) can be most successfully applied.

Nine tributary subwatersheds were identif
aforementioned considerations (that of existing
potential for future development within the
period). These subwatersheds are illustrated
also are more specifically outlined on the wate
included under separate cover. The existing ar
distributions in these nine watersheds are list
For the purposes of this study, the nine
subwatersheds have been designated as follows:

1 "TR-20, Project Formulation-Hydrology", Hydrology Unit, Engineering Division, S



LACKAWANNA RIVER WATERSHED
PRIORITY TECHNICAL STUDY AREAS

FIG

- <u>Subwatershed No. 1 - "Sterry Creek" and Tributaries</u>: The Sterry Creek watershed is located in the central part of the Lackawanna River watershed to the east of the Lackawanna River and has a drainage area of 4.5 square miles. Approximately one-tenth of the watershed is covered by residential development, the majority of which is concentrated along the Lackawanna River. The eastern part of the Sterry Creek drainage area contains a portion of the Moosic Mountains and over half of the watershed is covered by forests. The STerry Creek watershed covers portions of three municipalities; Jefferson Township, Jessup Borough, and Olyphant Borough.

- <u>Subwatershed No. 2 - "Wildcat Creek" and Tributaries</u>: The Wildcat Creek watershed is also located in the central part of the Lackawanna River watershed, above the Sterry Creek watershed and joins the Lackawanna River from the west. Its drainage area is 4.3 square miles. The residentially developed area lies along the river and occupies about one-fifth of the total watershed. A small part of the watershed is covered by commercial development, however, forest covers more than one-half of the area. The western part of the Wildcat Creek drainage area contains a portion of Hubbard Mountain. Roosevelt Highway passes through this watershed. The Wildcat Creek watershed covers portions of three municipalities: Archbald Borough, Blakely Borough, and Scott Township.

- <u>Subwatershed No. 3 - "Hull Creek" and Tributaries</u>: The Hull Creek watershed is located to the west of the Wildcat Creek watershed, and it contributes to the Lackawanna River from the west. This watershed coves 3.3 square miles, one-fifth which is residential, one half forest, and a small portion commercial development. Roosevelt Highway also passes through this watershed. Geographically, this watershed is flatter than the other detailed study areas, with a maximum elevation of approximately 1,900 feet above mean sea level. The Hull Creek watershed covers portions of three municipalities; Blakely Borough, Dickson City Borough, and Scott Township.

- <u>Subwatershed No. 4 - "Eddy Branch" and T</u> Eddy Branch watershed is also located in th of the Lackawanna River watershed, contigu Creek watershed. It contributes to the from the east and has a drainage area of Residential, commercial, and industrial a very small portion of the watershed, whi most of the remainder. There are three r in the eastern part of the watershed Mountains occupy about one-half of its Branch drainage area covers portions of si Dunmore Borough, Jefferson Township, Olyphant Borough, Roaring Brook Township, and Throop Borough.

- <u>Subwatershed No. 5 - "Dickson" Which Includes an Unnamed Tributary to the Lackawanna River and its Tributaries</u>: The Dickson City watershed is the smallest of the nine priority watersheds, covering only 1.6 square miles, and is situated in the central region of the Lackawanna River watershed. It is adjacent to he Eddy Creek watershed and contributes to the Lackawanna River from the west. Residential development covers about one-fifth of its area, while more than one-half is covered by forest. There is also a small portion of commercial development. Roosevelt Highway bisects this watershed and Bell Mountain also passes through the western boundary. The Dickson City watershed covers portions of three municipalities; Blakely Borough, Dickson City Borough, and Scott Township.

- <u>Subwatershed No. 6 - "Roaring Brook" and Tributaries</u>: The Roaring Brook watershed is the largest of the nine priority watersheds, covering nearly 56 square miles. It accounts for the majority of the south-east corner of the Lackawanna River watershed. Although forest conditions represent almost three-quarters of the watershed "land use", residential areas are distributed throughout its area. There are several reservoirs in this watershed, as well as several mountain ranges. The Roaring Brook watershed covers portions of twelve municipalities; Covington Township, Dunmore Borough, Elmhurst Township, Jefferson Township, Madison Township, Moscow Borough, Olyphant Borough, Roaring Brook Township, Scranton City, Springbrook Township, Sterling Township, and Throop Borough.

- <u>Subwatershed No. 7 - "Keyser Creek" and Tributaries</u>: The Keyser Creek watershed is situated in the lower portion of the Lackawanna River watershed along its western boundary and has a drainage area of 8.37 square miles. It is partially covered by Bald Mountain in the west. Residential developments are located along the Lackawanna River and cover approximately one-fifth of the watershed. The remainder of the watershed is mostly forest, with a small portion of industrial and commercial are
Creek watershed covers portions of four
Newton Township, Ransom Township, Scranton
Borough.

- <u>Subwatershed No. 8 - "Spring Brook" and T</u>
Spring Brook watershed is the only priorit
does not contribute directly to the Lacka
lies in the southeastern corner of the
watershed and has a drainage area of ap
square miles. Forest covers most of the wa
there is a small portion of commercial de
are several reservoirs in the watershed,

Mountains are located along its eastern boundary. The Spring Brook watershed covers portions of four municipalities; Moosic Borough, Pittston Township, Scranton City, and Springbrook Township.

- <u>Subwatershed No. 9 - "St. John Creek" and Tributaries</u>: The St. John Creek watershed is adjacent to the Keyser Creek watershed, and is also forms part of the western boundary of the Lackawanna River watershed. Its drainage area is 7.3 square miles. Residential areas cover only a small part of this watershed, while forest occupies the remainder. The northern part of the watershed is mountainous, with altitudes exceeding 2,200 feet above sea level and it is traversed by a segment which Roosevelt Highway crosses. The St. John Creek watershed covers portions of four municipalities; Newtown Township, Old Forge Borough, Ransom Township, and Taylor Borough.

A listing of each priority subwatershed and its affected municipalities is summarized in Table 4-1. To reiterate, the detailed study areas are those for which future growth and development potential is most significant and could, in fact, aggravate or initiate storm flooding problems. Therefore, it is these areas for which the Act 167 program, with its implementation requirements, was primarily developed. However, as was pointed out earlier, technical standards and criteria (supported by technical analysis) will be developed for each of the municipalities in the watershed.

4.3 <u>Overview of the Penn State Runoff Model</u>

The runoff simulation model that was used for the detailed Lackawanna River watershed study areas is the Penn State Runoff Model (PSRM). It can be applied on a watershed-wide basis and therefore satisfies the needs of comprehensive stormwater planning as mandated by the Pennsylvania 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
  - rainfall distribution, or pattern, dur a particular design storm event;

TABLE 4-1

LIST OF MUNICIPALITIES
WITHIN SUBWATERSHED AREAS

#1 Sterry Creek
- Jefferson Township
- Jessup Borough
- Olyphant Borough

#2 Wildcat Creek
- Archbald Borough
- Blakely Borough
- Scott Township

#3 Hull Creek
- Blakely Borough
- Dickson City Borough
- Scott Township

#4 Eddy Creek
- Dunmore Borough
- Jefferson Township
- Jessup Borough
- Olyphant Borough
- Roaring Brook Township
- Throop Borough

#5 Tributary Through Dickson City
- Blakely Borough
- Dickson City Borough
- Scott Township

#6 Roaring Brook
- Covington Township
- Dunmore Borough
- Elmhurst Township
- Jefferson Township
- Madison Township
- Moscow Borough
- Olyphant Borough
- Roaring Brook Township
- Scranton City
- Springbrook Township
- Sterling Township
- Throop Borough

#7 Keyser Creek
- Newtown Township
- Ransom Township
- Scranton City
- Taylor Borough

#8 Spring Brook
- Moosic Borough
- Pittston Township
- Scranton City
- Springbrook Township

#9 St. John's Creek
- Newtown Township
- Old Forge Borough
- Ransom Township
- Taylor Borough

- o 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 area storage characteristics.

Based on these inputs, the model approximates 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 stormwater 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:

- o The identification of the source of stormwater flows that combine in the downstream portion of a watershed and cause existing damages;
- o The identification of the changes in existing stormwater characteristics that will result from proposed future development; and,
- o 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 and its municipalities.

Additionally, the final outflow hydrographs from each of the detailed study subwatershed PSRMs can be reformatted for input to the approximate study TR-20 models. This ensures that the watershed basis is maintained for this Act 167 stormwater management plan.

4.4 Overview of the SCS TR-20 Model

As with the PSRM, the U.S. Soil Conservati
Computer Program for Project Formulation Hydrol
can be applied on a watershed basis to simulat
events. However, it differs from the PSRM i
computing runoff hydrographs. While the PSRM u
wave routing procedures to define the runoff hy
20 model applies the SCS unit-hydrogra
Accordingly, it is necessary to compute the ove
for runoff within each subarea, instead of p
slope and width information as required by PSRM.

Although the rainfall and watershed physical characteristics data inputs for the TR-20 model and PSRM are generally similar, the required inputs for the conveyance (i.e., stream) system representation are very different. Whereas the PSRM utilizes overbank/channel travel times, the input to TR-20 is in the form of a stream segment rating table. This flow quantity-area relationship is utilized to define appropriate coefficients in the Att-Kin (Attenuation-Kinematic) hydrograph routing process. This process transforms the upstream hydrograph to account for stream valley storage and travel time through the downstream "reach" or stream segment. A primary benefit of this routing technique is that one rating table can be used for multiple storm events assessments without an associated loss in routing accuracy.

The TR-20 model was selected for use in the approximate study areas due to the ease with which hydrographs can be directly input and its capability to generate "punched" outflow hydrograph files for input to downstream models. Given the fact that there are nine detailed watersheds to be included and the requirement to subdivide the approximate study area into two separate TR-20 models due to its areal extent, this ability to readily "read" and "write" hydrograph files was considered to be a valuable asset for this stormwater management plan.

4.5 Model of Existing Conditions, Detailed Study Areas

4.5.1. Selection of Subarea Breakpoints

The initial step in the construction of the nine detailed watershed models was the selection of "breakpoints". Breakpoints are locations along drainage paths and watercourses which are considered to be of interest for a variety of reasons. In each of the nine PSRM watersheds, breakpoints were selected based on:

- o The location of existing stormwater related problems, as identified by local officials in the municipal questionnaire process;
- o Municipal boundaries;
- o Road and railway crossings;
- o The location of major obstructions suc bridges, and dams; and,
- o Confluence points of tributaries with the m each watershed, including confluences dowr open areas where development can be anticipa

The breakpoints were used to divide each watershed into numerous subareas or "sub-basins" based on United States Geological Survey (USGS) topographic mapping (Reference 2)[2]. When combined, these subareas define the contributing drainage area to each of the selected points of interest. Where necessary, field investigations were performed to verify the identified subarea boundaries, and appropriate adjustments were made to reflect this information. Additionally, the subareas were chosen to be homogeneous in size wherever possible. They were also limited in areas so as to maintain a reasonable level of detail, while keeping them large enough to hold the total number of subareas to a manageable level for modeling purposes. The boundaries of the subareas within each watershed are shown on the maps in Appendix H.

4.5.2 Watershed Model Data Requirements

During rainfall events, an entire watershed responds as the "sum" of the responses of its subareas. As noted earlier, PSRM was used to calculate the response of the delineated subareas in the detailed study watersheds to the rainfall events of interest. Using this model, individual runoff hydrographs were computed for each subarea and moved; i.e., routed downstream. The time required for the runoff to reach any downstream point reflects the travel time required between subarea outlets and points downstream in the actual pipes or stream channels of the watershed. The flow rate for a point of interest at any time, is simply the sum of flow rates from contributing subareas that have arrived at the point at that moment. Using the watershed model, the tedious summation of these contributions of upstream subareas is performed at each of the specified points of interest. The model forms a time record of the flow rates passing the point, which forms the total (or cumulative) hydrograph for the contributing portion of the watershed. The PSRM performs this summation continuously for each design storm analysis throughout each watershed, calculating runoff hydrographs for all subareas and summing their contributions at all points of interest. At the outlet of each watershed, the model is effectively summing the individual contributions of runoff from all of the associated subareas.

Subarea Run-Off Characteristics

The initial step for the hydrologic model is the calculation of the (i.e., stormwater) hy subareas that result from the applied storm or To calculate the runoff hydrograph, the i hydrologic characteristics are required as inpu

2 See Attached U.S.G.S. Quadrangle Reference Sheet.

- The total acreage;

- A composite runoff curve number, computed using U.S. Soil Conservation Service (SCS) TR-55 methods (Reference 3)[3] for the areas of impervious and pervious cover (i.e., lawns, roads, rooftops, woods, meadows, pastures, croplands, etc.) and the associated hydrologic soil groups;

- The average land slope; and,

- A characteristic width of overland flow.

The first two of these items were obtained from detailed mapping of subarea boundaries, soils, slopes, and land use developed by the Lackawanna County Regional Planning Commission (LCRPC). To most efficiently assemble the input data for each subarea, the information on the maps was transformed by dividing the watershed into discrete homogeneous parcels of the same hydrologic soil group, slope, or land use and digitizing this information into a computerized Geographic Information System (GIS). The digitized boundaries of the subareas were superimposed over this watershed data, and the required inputs to the models for each subarea were computed within the GIS using an aggregation procedure which quantifies composite subarea characteristics. Using this procedure, the total acreage of each subarea was determined.

In this study, the land uses found in the watershed were subdivided into nine categories by the LCRPC. Runoff curve numbers corresponding to each hydrologic soil group were assigned to each land use type using values contained in Table 2-2A of the SCS TR-55 document (Reference 3)[3], and which are based on the land use classifications and the associated percentage of impervious cover. Table 4-2 shows each land use category, its percentage of impervious cover, and the associated runoff curve number value for the four hydrologic soil groups. A similar table is used by the GIS to assign runoff curve numbers to each cell in the digital map file. The computer accomplishes this by overlaying the land use and soil attributes for that cell, and assigning the appropriate curve number from the table. The GIS then obtains a composite runoff curve number by computing a weighted average of the curve numbers from all within a subarea.

---

3 United States Department of Agriculture Soil Conservation Service, Technical Rele Small Watersheds", June, 1986.

TABLE 4-2

LAND USE CATEGORIES

Designation	Land Use Description	Average Pct. Impervious	Runoff Curve Number By Soil Group A	B	C	D
H	1/4-acre residential	38	61	75	83	87
M	1/2-acre residential	25	54	70	80	85
L	1+-acre residential	20	51	68	79	84
O	Open Space includes: (agricultural land, landfills, junk yards, cemeteries, parks, golf courses, sports fields, sewage treatment plants, cleared land, schools with several acres of green areas	0	58	74	82	87
X	Strip Mined Areas	0	77	86	91	94
F	Forest Cover	0	30	55	70	77
I	Industrial	72	81	88	91	93
C	Commercial	85	89	92	94	95
W	Water Surface	100	100	100	100	100

Average land slopes for each subarea were calculated by averaging three representative slopes within each subarea as defined using the USGS quad maps (Reference 2, page 46). These were measured and computed by hand. The overland flow width represents a characteristic width of flow across the subarea to the collecting channels, and is directly related to the overland flow travel time. These values were also de... hand measurements on the USGS quad maps.

Runoff hydrographs for each subarea were
the PSRM by applying the total rainfall dept
event of interest with an SCS Type II distribut
responds to rainfall by allowing an appropria
rainfall to infiltrate into pervious areas, a
after initial abstraction and filling of surfa
run off down slope toward the subarea outle
falls, the runoff depth increases and it m
toward the outlet. The model computes and re

of the runoff arriving at the subarea outlet throughout the period of the storm event.

Watershed Travel Times

The total flow at the points of interest, as previously stated, is the sum of flow contributions arriving from upstream subareas. The PSRM simplistically looks at the watershed as a collection of individual subareas connected by drainage elements, generally the main waterway and its tributaries. In order to properly translate, or route, the subarea runoff hydrographs downstream to points of interest, the times required to travel through the drainage element's channels and overbanks to the associated points must be known. The travel times in the drainage network of the watershed were found by dividing the lengths of the stream easements between subarea outlets by the average velocities in the associated channels and overbanks. Travel times were calculated within each detailed study watershed for each drainage element that connects the associated subareas. The lengths, and slopes where necessary, of the main waterway and tributary drainage elements were developed using hand measurements of stream segments and flow paths depicted on USGS topographic mapping. The average velocities through these stream segments were obtained by one of three means.

Where possible, drainage element flow velocities were obtained from HEC2 water surface profile computations previously performed with the purpose of delineating floodplains for the National Flood Insurance Program. In these cases, velocities were extracted from available output files obtained from the Federal Emergency Management Agency (FEMA) using the relation:

$$H_v = v^2/2g$$

where: H_v = velocity head (ft)
v = velocity (ft/s)
g = gravitational acceleration (ft/s^2)

The HEC2 files contained several cross-sections for each corresponding drainage element, therefore, the velocity head values from associated cross-sections were averaged to arrive at a representative H_v value for each drainage eleme
was not possible to compute individual chann
velocities using this method so associated drain
assumed to be all "channel".

For the remainder of the drainage elements (
backwater computations were not available) eithe
was used to obtain channel velocities and associ
In the cases where a channel was defined on t
(i.e., represented by a blue line), an establis
assumed to exist. The basic cross-sections were
the maps and supplemented with more detailed, gen
configurations developed from field inspections

calculations were applied to these sections to define velocities and capacities for both the channel and overbank portions of the cross-section. The associated channel travel times were calculated by dividing the computed velocities into the appropriate reach lengths. PSRM does not allow for direct input of separate channel and overbank travel times. Therefore, this is accounted for by adding a parameter referred to as the "CTS" ratio which is a ratio of the overbank travel time to the channel travel time. The appropriate CTS ratio for each of these drainage elements was also calculated in this step.

For drainage elements which had no channel designated on the USGS mapping, the SCS TR-55 method (Reference 3, page 37) for computing shallow concentrated flow was used to obtain the velocity. The average watercourse slopes were measured from the USGS quads, and applied to the TR-55 (Reference 3, page 37) velocity curve for the appropriate "paved" or "unpaved" condition to obtain the velocities. As with the other techniques, the associated travel times were computed by dividing the drainage element lengths by the associated flow velocity. This technique precluded differentiation between channel and overbank flow.

It should be noted that the input travel times for non-HEC2 stream segments with defined channels, per the USGS mapping, reflect average values for a range of flows that include the storm events of interest. This was accomplished by applying the normal depth equation for several different depths of flow in the cross-section (i.e., at the channel banks, two feet above the channel banks, etc.), and computing the average velocity and channel capacity for use in the travel time computations.

Other Input

An important attribute of PSRM is its capability to model the effects of dams or other detention areas within a drainage area. In order to reflect the associated hydrograph attenuation (i.e., flow reduction and delay) properties of these structures within each watershed, the associated storage-discharge relationships must be identified. It is not practical or cost effective to model every structure in the watershed. Therefore, criteria were used to determine whether a structure is hydrologically "significant." The initial crit this evaluation were as follows:

- Identified as a significant flow obstr stormwater questionnaires;

- Causes backwater elevation changes greater t the Flood Insurance Study (FIS) profiles; an

- Has significant volume for stormwater storag on USGS quad maps) in terms of associat drainage area.

The application of these criteria resulted in the identification of 27 "significant" obstructions.

The necessary storage-discharge information required for the PSRM was collected for some of these structures during the Phase I study. The remainder of the "significant" structures storage information was obtained by planimetering the contour lines on the USGS quad mapping and determining the volume of storage for incremental elevations. Elevation-discharge curves were calculated based on pressure flow and weir flow using structure measurements obtained in the field. This data was combined with the elevation-storage curves to define the required storage-discharge relationships for input to the PSRM.

Calibration

All simulation models involve a significant degree of subjective input in their development. Values are chosen for varies 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 reproduce the recorded response of an actual storm event. To simulate a specific 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 flow recordings were made.

In order to maximize the accuracy of the PSRM models developed for this Act 167 program, a calibration effort was undertaken. Where possible, the detailed study are PSRM generated flows were compared to discharges utilized in the associated FEMA Flood Insurance Studies. As a result of these comparisons, it was noted that the detailed, preliminary PSRM computed peak discharges were significantly greater than the FEMA flows. Accordingly, the PSRM input streams were
generate lower peak flows. There are s
calibration points within the PSRM. These
abstraction, surface roughness, overland flow
curve numbers and hydrograph routing travel
extensive efforts, it was determined that incre
abstraction and surface roughness factors resul
of computed peak flows to a level consistent wit
in the previously developed FEMA analyses. Si
were also made to the PSRM of watersheds with
studies.

Appendix D presents comparison hydrographs of pre- and post-calibration PSRM peak flows to those reflected in the earlier FEMA studies for each subwatershed. Although there were still several points where flows differ significantly between the FEMA and PSRM analyses, additional calibration could not be accomplished without detailed hydraulic analysis which was outside the scope of this project. Rainfall events equivalent to the mean annual, 5-, 10-, 25-, 50-, and 100-year events were applied to the calibrated PSRMs using an SCS Type II distribution.

4.6 Model of Existing Conditions, Approximate Study Areas

In order to satisfy both the intent and requirements of Pennsylvania Act 167, it is necessary to develop a watershed-wide basis for assessing and controlling the impacts of land development on stormwater. However, as was previously discussed in Section 4.1 of this report, the areal extent of the Lackawanna River watershed within Lackawanna County precluded development of a detailed hydrologic model of the entire watershed. Therefore, in order to provide the required watershed basis for stormwater management regulation, an approximate hydrologic model was developed for those portions of the Lackawanna River watershed which were determined to have limited foreseeable development potential. These areas were modeled using the U.S. Soil Conservation Service TR-20 program (Reference 1, page 38). The details of this approach are included in Appendix B. This watershed wide model was developed and used to verify that the proposed performance standards will not increase existing flows along the main stem of the Lackawanna River.

4.7 Model of Future Conditions, Detailed Study Areas

4.7.1 Summary of Future Stormwater Characteristics

The potential stormwater impacts of anticipated development in each of the nine selected detailed study watershed were assessed by developing a model of expected future development conditions. The LCRPC developed land use mapping of the projected future conditions based on a 10-year planning period. The items taken into consideration were as follows:

- o Present land use configuration (USGS qua municipal maps);
- o Current zoning classification from ordinances;
- o Historical growth patterns determined th submissions, building permits and popula and,
- o Proposal information from other agencies, I

Land use was assumed to remain as defined under existing conditions within the TR-20 study areas.

Data files for future conditions were prepared for input to PSRM by digitizing the future land use maps in the same manner as was applied to existing land uses. The GIS was then used to calculate composite runoff curve numbers based on this future land use information. For the purposes of this study, the soils and slope information for each subarea remained the same as under existing conditions. The computed runoff curve numbers for both existing and future land use conditions used for each subarea in the models are listed in Appendix C.

Model runs of future land use conditions were made for the mean annual, 5-, 10-, 25-, 50-, and 100-year SCS Type II storm events and compared to the associated existing conditions runs. Tables listing the existing and future flow rates at selected points of interest can be found in Appendix D along with a corresponding graph of the existing and future condition design event hydrographs at the watershed outfalls.

4.7.2 Impact of Future Development Without Stormwater Management

As development takes place, significant changes in the Stormwater generating characteristics of a watershed will occur. These are usually related to the increases of impervious surfaces and the modification of stormwater conveyance systems. These conditions combine to not only increase the volume of runoff that can be anticipated for a storm event, but also to increase the speed at which this runoff moves to the watershed outflow point. Although these development related "modifications" usually result in increases to associated peak flows, exceptions were noted within this watershed. As can be seen by a review of the tables in Appendix D, there were numerous subareas where the future land use conditions peak flows were in fact determined to be less than the existing levels. A detailed investigation was undertaken in order to confirm the accuracy of these results. In most cases, this potential decrease in flows under development conditions resulted from conversion of existing agricultural land uses to low and moderate density residential land uses. Although there were numerous occurrences of this situation, eac watersheds were shown to have a significan increased main stem flows under future developme

As runoff moves across the surface areas o will pick up impurities which have been depc surfaces. The majority of these pollutants a atmospheric deposition, however, surface fertilizers and pesticides can also be sign dispersed pollutant sources are referred to pollution sources. Recent research indicates th portion of these pollutant loads comes from imp Therefore, as development occurs it would be e potential generation of non-point source pollutants would increase accordingly.

In order to assess the potential impacts of development on non-point sources pollutant loads, the "Simple Method" developed by the Washington Metropolitan Council of Governments (WMCOG) for estimating stormwater pollutant export was applied (Reference 4)[4]. This allowed for the quantification of the associated pollutant export potential under both existing and future land use conditions. This information is presented in Appendix E, and can be used to evaluate adverse stormwater quality impacts of watershed development.

4.8 Summary of Modeling Results

As has been previously discussed, the primary application of the hydrologic models (both approximate and detailed) developed for the Lackawanna River Watershed was to provide a basis for assessing the impacts of foreseeable development on stormwater related flows. To accomplish this, peak flows for the storm events of interest were developed for both existing and future land use conditions within each of the detailed study sub-watersheds. The associated resultant flows are compared in the tabulations included in Appendix D. Two sets of flow information are included in the tables associated with the detailed study areas. The first set, labelled "Watershed Flows", presents cumulative flows along the stream systems. The second set of flows, labelled "Subarea Runoff", presents the individual subarea generated peak flow information. A primary conclusion drawn from this information is that each of the detailed study watersheds can anticipate increases in flows, and associated flooding and erosion problems, as a result of predicted development. Although the degree of these impacts varies throughout the associated watershed, it is obvious that significant benefits will be realized through the application of a sound watershed-wide stormwater management regulatory system.

Each of the provided subwatershed tabulations includes the mean annual, 5-, 10-, 25-, 50-, and 100-year storm events. By evaluating these tables, it was noted that the percentage of variation between existing and future flows varies significantly between these storm events. This variation is a the initial existing condition flow to which future flows is compared. However, as was pr each of the detailed study watersheds exhibit potential for increases to peak flows under t development conditions.

Outflow hydrographs from the detailed stud of the storm events of interest were input to tl 20 "macro" watershed model. This was done so

4 "Controlling Urban Runoff: A Practical Manual for Planning and Designing Metropolitan Council of Governments, July, 1987.

watershed-wide basis for evaluating future development flow impacts as presented in Appendix B.

4.9 <u>Additional Uses of the Lackawanna River Watershed Model</u>

Calibrated watershed models are a very useful "tool" for effectively managing water resources in a watershed. The calibrated PSRM's for the detailed study subwatersheds can be utilized for the following types of evaluations, the results of which can serve as direct input into the water resource decision-making process.

- Development Impact Evaluations:

  As part of this project a geographic information system (GIS) was developed for each of the detailed study subwatersheds. The integral watershed database includes existing land use, hydrologic soil groups and subarea boundaries. It is accessed through a menu-driven, interactive program that allows users with a minimum degree of training to modify specific data so as to reflect potential developed conditions. The system can then be used to modify the existing conditions PSRM input stream to reflect the "post-development" runoff curve numbers. Subsequent execution of this revised input stream will allow the planner to quantify the <u>potential</u> impacts on stormwater flows associated with the proposed development. This initial "quick look" at a proposed land use change can be very beneficial in providing direction to the developer concerning potential requirements for stormwater management.

- Encroachment Analyses:

  In this case, the calibrated watershed PSRM's can be used to evaluate potential impacts that a stream encroachment may have on downstream flows. The calibrated hydrologic model for the watershed can, therefore, allow the County to evaluate/quantify the downstream hydrologic impacts of significant activity if desired.

- Stormwater Management Facility Assessments:

  A primary problem associated with the i
  stormwater detention facilities within a
  potential for exacerbating downstream flo
  direct result of the extended duration of
  result from attenuation of future land use
  to existing levels. These potential downst
  be evaluated by modifying the calibrated P
  the proposed facility. Although a prelimin
  this potential has been performed as part
  can still be beneficial to assess these p
  on a case by case basis.

- o Drainage Design:

  The calibrated PSRM models can also be used to provide design level data for:

  - Highway design;
  - Development of stormwater management plans; and,
  - Verification of stormwater management plans.

5.0 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 contamina longer meet consumptive demands. The initia program designed to develop this resource is from which the runoff can be withdrawn ar recharge areas. In addition, these stor provide recreational opportunities.

- Water Pollution Control Measures are Essentia

  In order to derive the full potential a streams, as well as form natural and arti areas, both point and non-point sources of pol controlled.

- 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 Lackawanna River Watershed, applicable structural and non-structural stormwater management techniques were evaluated. Structural methods are those that employ physical facilities that are designed and constructed for the purpose of controlling stormwater flows. Non-structural control techniques, for the purposes of this plan, may be broadly classified as either floodplain management or comprehensive watershed management planning.

5.1 Non-Structural Stormwater Management Techniques

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 Lackawanna River watershed.

5.1.1 The Release Rate Percentage Concept

For new development sites, the most common design criterion for stormwater management facilities is control of the peak discharge rate generated by the 100-year rainfall event in a post-development land use condition to the pre-development rate. However, recent research has 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 control facilities are designed with consideration for the dynamic interaction and combination of sub-drainage areas (subareas) within a watershed, these adverse flow combinations may occur. The following example illustrates why this is so.

The sample watershed, with five subareas, is shown on Figure 5-1. The figure also includes a hydrograph generated by a rainfall event on the watershed, which present
hydrographs for Subarea No. 3 and the cumulati
for the total watershed.

As can be seen by investigating Subarea 3,
for runoff flow from Subarea 3 through Subarea N
minutes. This represents the time at which
contributing flow to the downstream point of i
3's maximum discharge of 500 cfs arrives at the
60 minutes, and the contributing rate to the w
400 cfs, occurring at 70 minutes.

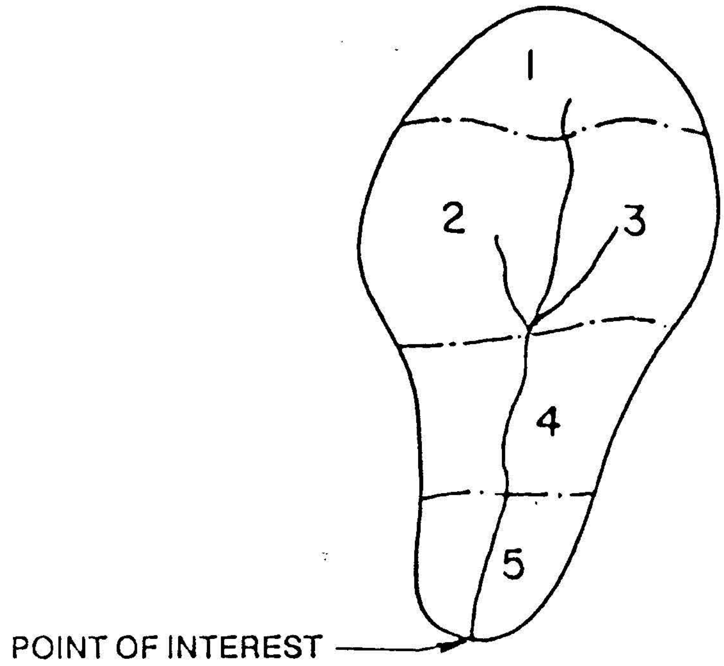


FIGURE 5-1

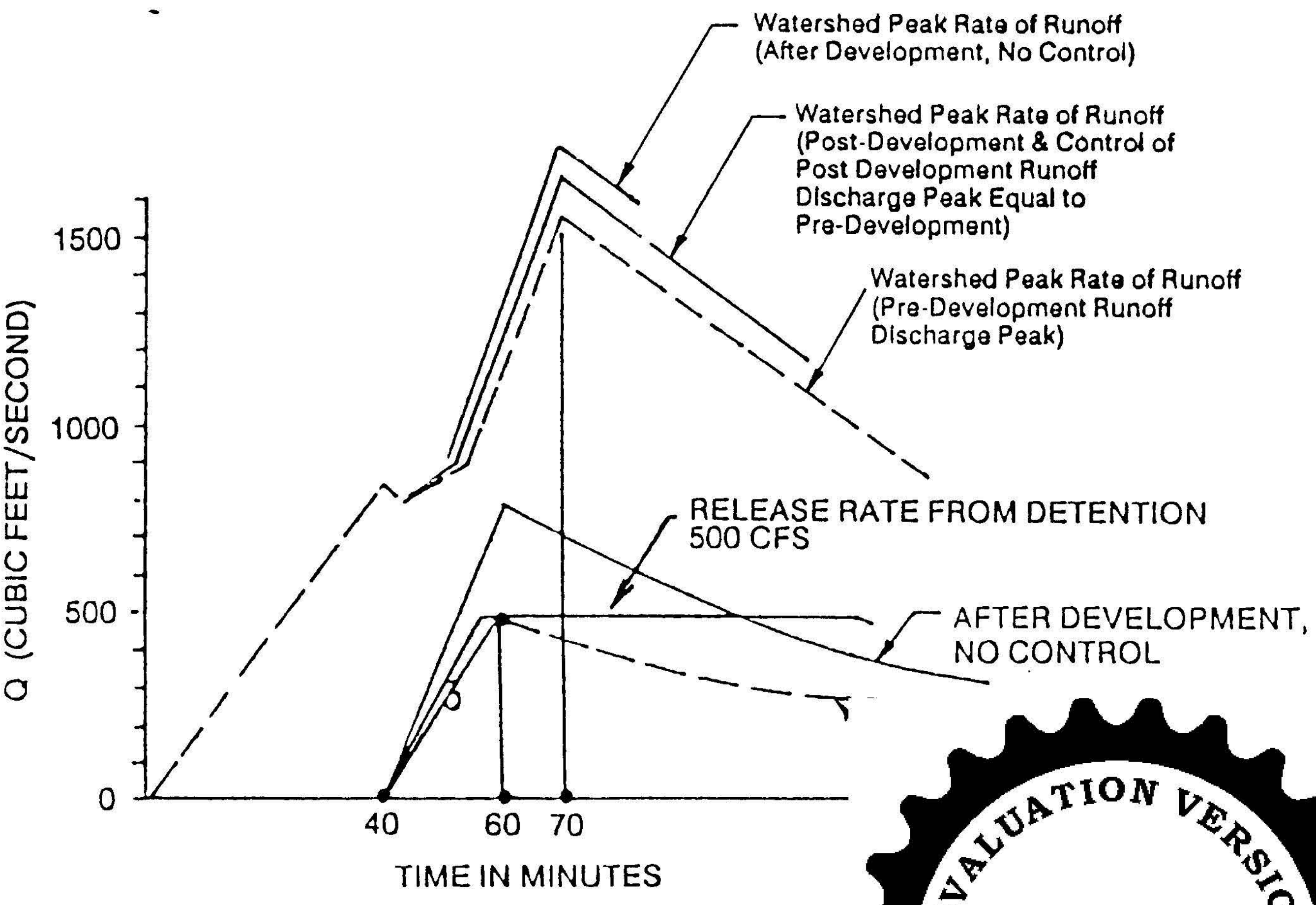


FIGURE 5-2

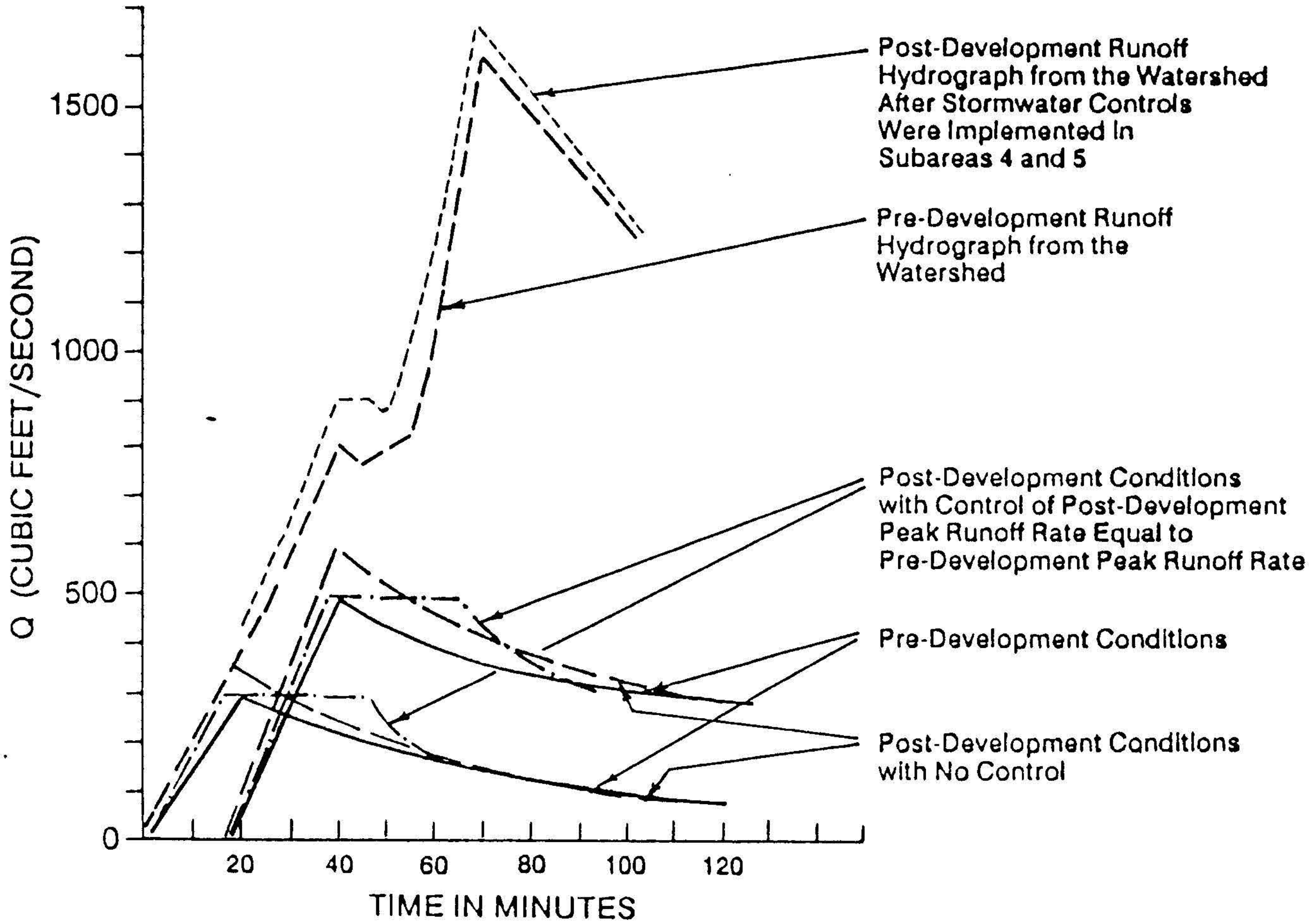
WATERSHED HYDROGR

Now assume a new land modification within Subarea 3 increases Subarea 3's maximum discharge rate to 800 cfs (Figure 5-2). 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. 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 is to increase the peak rate of runoff at the downstream point of interest.

A more complex situation is created if development is proposed for Subarea Nos. 4 or 5. Figure 5-3 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 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. Through close inspection of Figure 56-3, it can be seen 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 (Figure 5-4) will generate an increase in the peak rate of runoff at the watershed outlet.

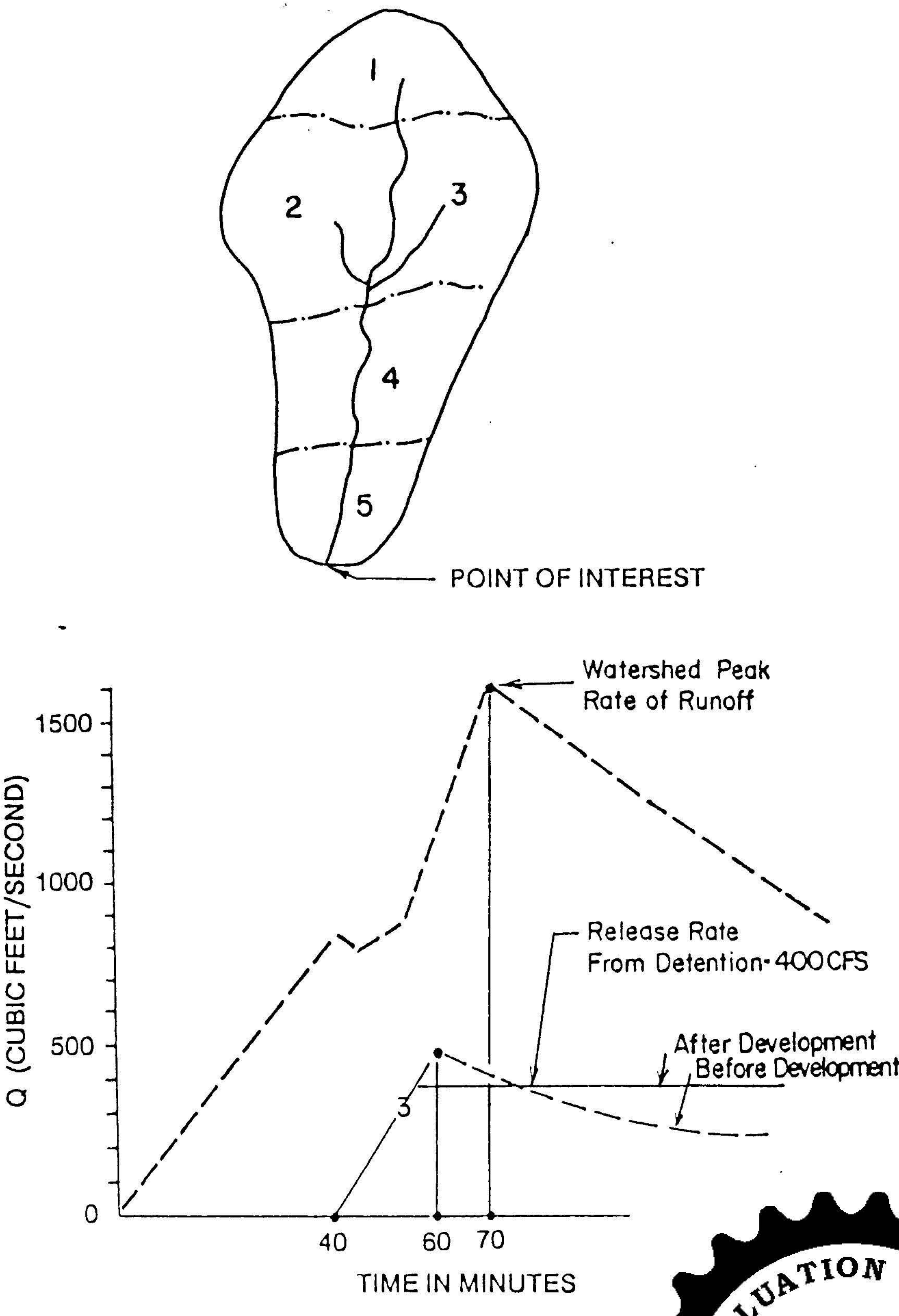
During the 30-minute period of time prior to and coincident with the occurrence of the watershed peak runoff rate, the projected post-development peak runoff rates from Subarea Nos. 3 and 4 will result in an increase of the peak flow rate at the watershed outlet. This same condition will occur in most watershed. However, the duration of this sensitive time period prior to occurrence of the watershed peak runoff rate will vary for each watershed depending on its shape, size, slope, terrain, current land use, and projected development trends.

The release rate percentage, which comprehensive watershed management planning, wa potential method for regulating the stormwater subarea within a watershed having runoff timinc to Subarea Nos. 3 and 4 illustrated in the ex release rate for Subarea 3 is determined by cor of the subarea rate of runoff that is contributi the downstream point of interest to the pre-deve of runoff for the subarea itself.



WATERSHED IMPACT WITH CONTROL OF
POST-DEVELOPMENT PE
EQUAL TO PRE-DEVELOPMEN
IN SUBAREAS 4 AND 5

WALTER B. SATTERTHWAITE ASSOC., INC.
720 NORTH FIVE POINTS ROAD · WEST CHESTER, PA. 19380 · (215)692-5770
BRANCH OFFICE: 9418 ANNAPOLIS ROAD · LANHAM, MD. 20706 · (301)731-056C



WATERSHED AND SUBAREA HY

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

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

In order to demonstrate specifically how the release rate percentage is applied, an example is most effective.

A person interested in developing a tract of land located in Subarea 1 desires to preliminarily design his stormwater management system. First the pre-development peak runoff (Q-pre) for all design rainfall events must be determined. Knowing that the 80% release rate was assigned to this subarea, the pre-development peak discharges (Q-pre) for all design events is then multiplied by 0.80 to define the maximum allowable peak runoff rates from the site after development. A stormwater management facility is, therefore, required to reduce the post-development uncontrolled peak runoff rates from the design rainfall events to 80 percent of the pre-development peak runoff rates prior to leaving the development site. This 80 percent release rate is the "performance standard" applied to Subarea 1.

5.1.2 <u>The Direct Discharge Concept</u>

The "Direct Discharge Concept" provides an alternative to normal on-site stormwater management techniques/standards. It allows for the discharge without attenuation of flows from a developed area so as to get the associated runoff volume out of the adjacent stream prior to the peak flow from the remainder of the watershed reaching the site. This can be very significant when the extended duration of existing level peak flows from stormwater management facilities is considered.

For the purposes of this study, only those subareas contiguous to main stem stream segments were considered as candidates for direct discharge. The runoff generating characteristics of these subareas were evaluated in detail. Primarily, this evaluation centered around comparison of the "time to peak" for the individual subarea and for the cumulative flows along the contiguous stream main stem.
which have peaks occurring significantly prior
cumulative watershed peak were identified and
direct discharge from them was tested using the
which reflected the preliminary distributed sto
Those subareas which, through this detailed
found to have no negative downstream impacts (i.
of existing stormwater problems) associated with
have been identified for consideration by the
County for relief from specific on-site storm
attenuation facility controls.

The direct discharge concept relates only to the application of stormwater attenuation facilities. It does not relieve the developer from responsibility for ensuring that the associated discharges will not adversely affect the stream system through scour and erosion. Accordingly, outfall control structures are still recommended for these subareas.

5.1.3 The Downstream Impact Evaluation

Many private developers feel that excessive regulations limit the potential for innovative site planning. In response to this potential concern for future development in the Lackawanna River Watershed, an alternative to the release rate performance standard has been developed. It permits the party interested in land development to have a professional engineer, experienced in stormwater management planning and design, define the required level of stormwater runoff control. This level is to be defined by one of the following criteria.

a. In those areas of the watershed identified as "direct discharge candidates" where man-made stormwater conveyance channels (i.e., closed storm sewers, concrete-lined channels, rip-rap protected channels, etc.) discharging directly into the main stem or primary watercourse exist or will be constructed, the total stormwater runoff flow 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 does 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 Lackawanna River Watershed, a post-development discharge rate which is greater than the prescribed release rate percentage may be allowed if it can be shown that there is no potential for excaberating storm runoff damage to downstream areas of the watershed. However, in no case development discharge rate to exc development discharge rate from the downstream impact evaluation must be demonstrates that at any point in time, on the existing conditions runoff hyd outlet of the subarea(s) are not incr discharges resulting from future condit runoff for the design rainfall events.

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 (for the design rainfall events) for the following conditions:

   a. Pre-development conditions;

   b. Post-development conditions; and,

   c. Post-development conditions with a proposed stormwater management system;

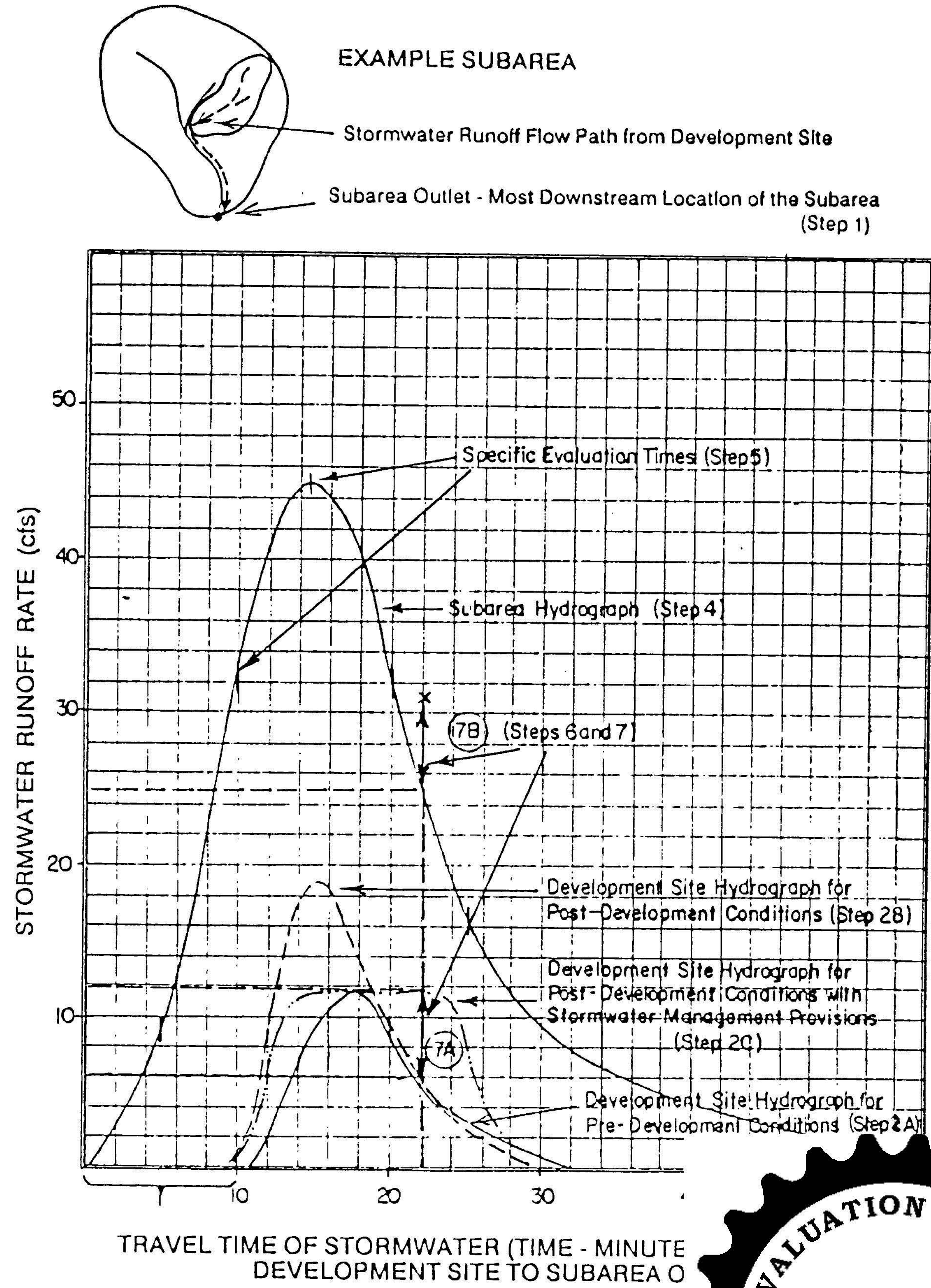
   A recommended method for developing these hydrographs is provided in the TR-55 document (Reference 3, page 37).

3. Determine the time required (i.e., the "travel time") for a unit or 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 design rainfall events from the Lackawanna County Planning Commission (see Figure 5-5). The subarea runoff hydrographs are a direct output of the watershed model that has been developed and calibrated for this study.

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 duratio
   rainfall/runoff events (see Figure 5-5)

6. If, at any specific time, a runof
   development site post-development hyd
   stormwater management system) is gr
   runoff rate at the same time on the
   hydrograph, this increase should be
   subarea hydrograph at that specific t
   5-5).



ILLUSTRATIONS OF THE HYDROGRA
FOR THE DOWNSTREAM IMPACT

WALTER B. SATTERTHWAITE ASSOC., INC.
720 NORTH FIVE POINTS ROAD · WEST CHESTER, PA. 19380 · (215)692-5770
BRANCH OFFICE: 9418 ANNAPOLIS ROAD · LANHAM, MD. 20706 · (301)731-0560

7. If, at any specific time, the increase in runoff rate on the subarea hydrograph is calculated to be greater than the original runoff rate on the subarea hydrograph, then the proposed stormwater management system should be modified to eliminate the increase as required.

   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 subarea stormwater runoff rate at 22 minutes is greater than the pre-development stormwater runoff rate. 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
   eliminated for the post-development
   the stormwater management system in pl
   specific times during the rainfall/ru
   downstream impact evaluation standard i

The procedure described above is one of
engineering analyses for completing the do
evaluation. Other procedures include computer
subarea divided into "sub-subareas" or the
presented in SCS Technical Release No. 55,
objective of presenting this specific procedur

illustrate the general content of the downstream impact evaluation.

5.1.4 On-Site Infiltration

Rainfall reaching the ground moves downward through the soil surface, a process which is called infiltration. Infiltration occurs both prior to and during the occurrence of surface runoff. Water which has infiltrated the surface passes first through the belt of soil water and then proceeds downward under the action of the gravity until it reaches the water table. If water is added from above, the volume in underground storage increases, which is called groundwater recharge. The relatively slow movement of water from the zone of saturation to a stream channel is called groundwater or base flow. When the rate of rainfall exceeds the infiltration capacity, overland flow begins.

The process of urbanization has been observed to generate a number of detrimental changes to the hydrologic equilibrium, among others decreasing the base flow volumes in receiving streams and water quality. Mitigative measures such as infiltration in the past did not gain wide acceptance because they were not effective in controlling increases in the peak flow discharges. However, the application of infiltration practices in conjunction with various flow attenuation and detention practices can help to meet requirements on base flow, groundwater recharge, water quality control, low flow augmentation and ecological protection.

The incorporation of infiltration practices has been considerably hindered by the absence of detailed standards and specifications in the past. Presently, there are planning and design procedures, along with inspections and maintenance programs that can guide the planner and designer in the successful application of these practices. Structural techniques for providing infiltration capacity include:

- o Infiltration basins;
- o Infiltration trenches;
- o Dry wells;
- o Porous asphalt pavement;
- o Vegetated swales with check dams; and,
- o Vegetative filters.

However, non-structural infiltration controls c limiting the amount of impervious cover that development site.

5.2 Structural Stormwater Management Techniques

Structural stormwater management control either on-site (serving one particular si (collectively serving more than one site). This a short discussion of on-site techniques which a use in the Lackawanna River watershed. The designer is not restricted to the listed on-site techniques and is encouraged to apply innovative techniques when appropriate and feasible, particularly in unique situations. A process for developing a coordinated on-site stormwater management system for a development site, incorporating some non-structural techniques is also presented.

5.2.1 On-Site Techniques

Table 5-1 presents a list of on-site stormwater management techniques that are considered to be appropriate for controlling increases in peak runoff rates and decreases in Infiltration resulting from urban development in the Lackawanna River 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.

TABLE 5-1

ON-SITE STORMWATER CONTROL TECHNIQUES
FOR THE LACKAWANNA RIVER 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 Infiltration Trench Porous paving - asphalt Precast concrete lattice blocks and bricks.
Increase time of concentration by increasing length of overland flow	Terraces, diversions, runoff spreaders, etc.
Infiltration of runoff after preliminary concentration	Seepage pits or dry wells, pits usually filled with gravel or rubble, so Infiltration Seepage beds Seepage areas
Peak runoff rate reduction	Detention bas Parking lot s

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.

- 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 5-6). 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 where they are gently sloped to the drain.

If 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 connections along the Dutch drain, allowing runoff to flow into other facilities in the development site's stormwater management system during excessively heavy rainfall.

- Infiltration Trenches

Infiltration trenches are similar to Dutch drains in that they are excavated trenches backfilled with aggregate. However, they are generally much larger in terms of storage volume and are used for larger drainage areas. Additionally, they usually do not conduct water along their length. They are generally two to ten feet deep, located either at or below the ground surface. It is recommended that the soils contiguous to the trench have an infiltration rate greater than 0.27 inches per hour and have clay content less than 30%. For optimum performance, the slope of the site should be less than 5% for surface and less than 20% for underground trenches. It is recommended that calculations be based on the 2-year storm event and that the trench drains within 72 hours following a storm event. The aggregate should consist of clean 1.5 to 3.0 inch stone. It is also recommended to place filter fabric with a covering of topsoil on top of the trench to protect the trench and to facilitate its maintenance.

- Porous Paving - Asphalt

porous pavement is a special asphalt mix
pass water to a specially prepared subbase. Th
is thicker than a normal gravel subbase and
coarsely graded stone which supplies a large amo
for runoff storage capacity. Figure 5-7 shows
pavement cross-section and design elements.

The passage of runoff through porou
significantly reduce runoff from paved areas.
rates have been reported through new porous p

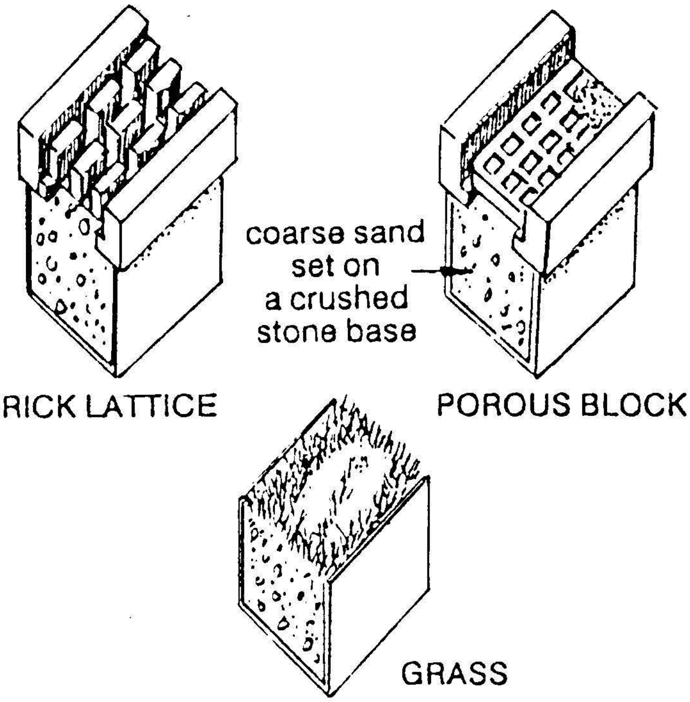


FIGURE 5-6

DUTCH DRAINS

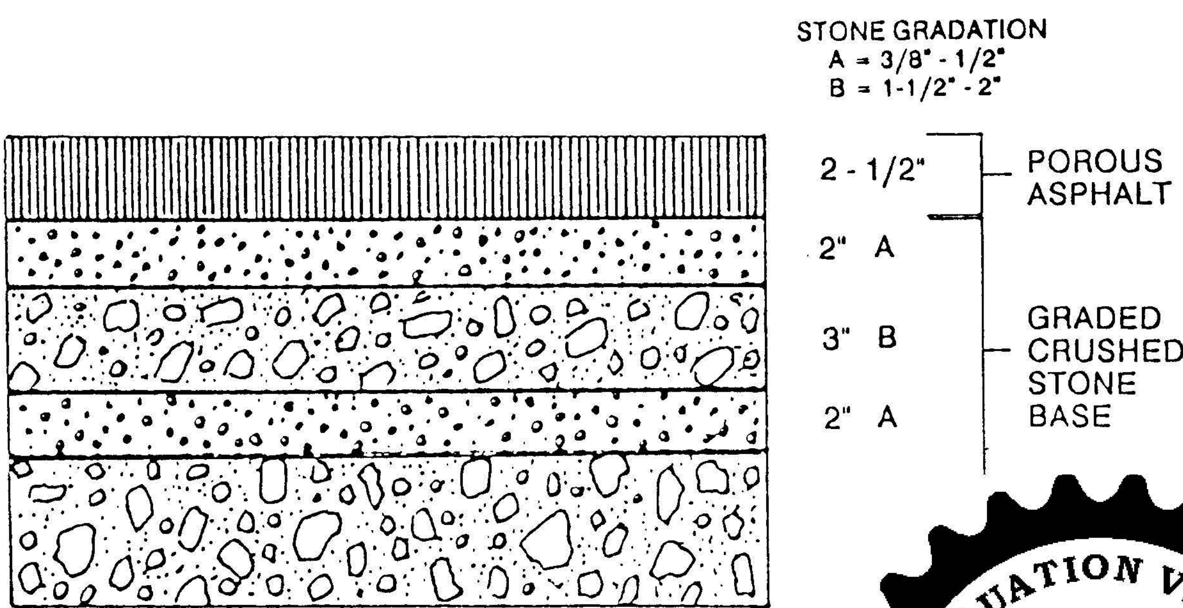


FIGURE 5-7

TYPICAL CROSS-SECTION OF PORC

WALTER B. SATTERTHWAITE ASSOC., INC.
720 NORTH FIVE POINTS ROAD · WEST CHESTER, PA. 19380 · (215)692-5770
· BRANCH OFFICE: 9418 ANNAPOLIS ROAD · LANHAM, MD. 20706 · (301)731-056

and pavement and subbase storage may provide control for over seven inches of runoff. However, special attention must be given to maintaining the porous pavement. Under certain circumstances the surface may become clogged and its permeability and associated infiltration rates 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 or infiltration trenches between areas of impermeable paving (e.g., making a lattice of permeable paving through a parking area). Tree pits covered with brick strips may be used in a similar manner. Various types are shown in Figure 5-8.

- Terraces, Diversions, and Run-Off Spreaders

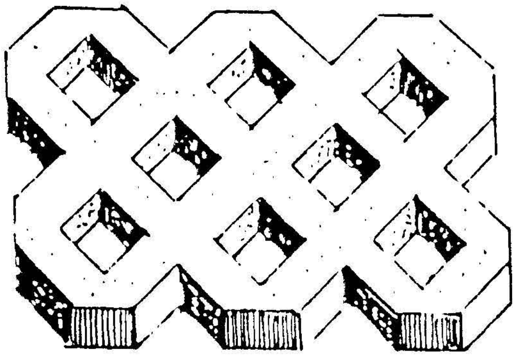
By increasing the time of concentration of runoff (that is, increasing the overland flow time), the runoff hydrograph from a development site can be flattened, thereby reducing associated peak runoff rates. This can be achieved by spreading runoff or by directing it into a system of trenches. The increased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

- Seepage Pits or Dry Wells

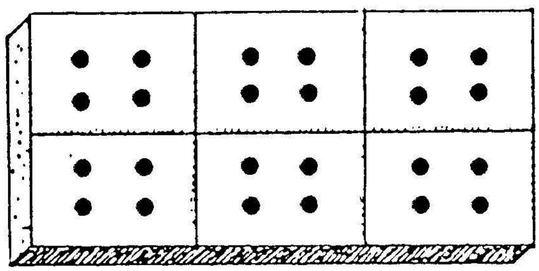
Seepage pits collect runoff and store it until it infiltrates into the soil. However, unlike Dutch drains, seepage trenches do not conduct water along their length when filled. Unless the seepage pit is designed to take the total amount of anticipated runoff for a design storm, some provision for "positive" (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 (Figure 5-9).

- Seepage Beds or Ditches

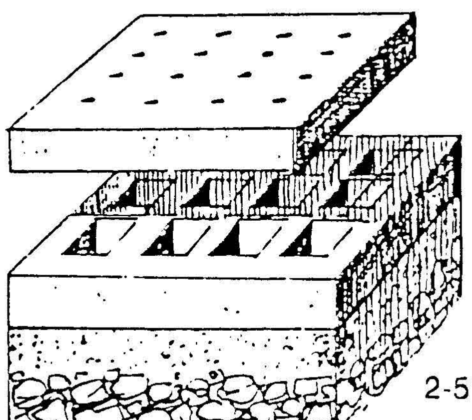
Seepage beds (Figure 5-10) provide for runoff into the soil via a system of drains gravel. These systems only reduce the volume runoff and, therefore, require a positive ove excess runoff. There are several advantages systems resulting from the fact that they distr larger area than can be achieved with ot techniques. As a result, a lower potential exi In fact, a seepage bed system may be placed unc the bearing capacity of the pavement is not dec



CONCRETE
LATTICE
BLOCK



MODULE
PAVERS

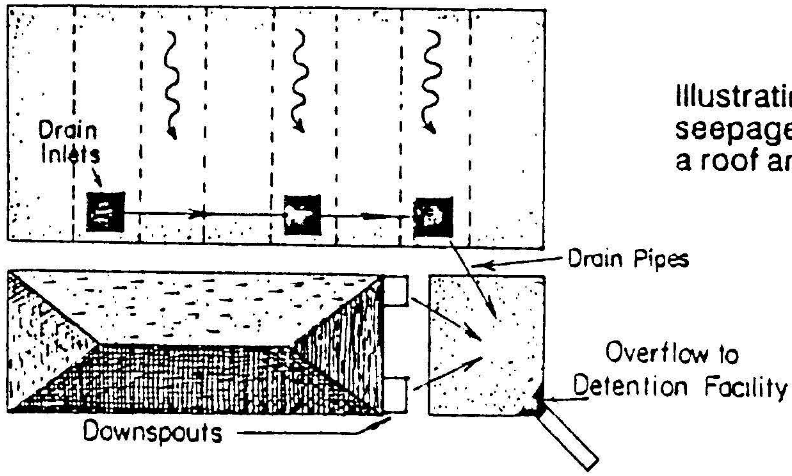


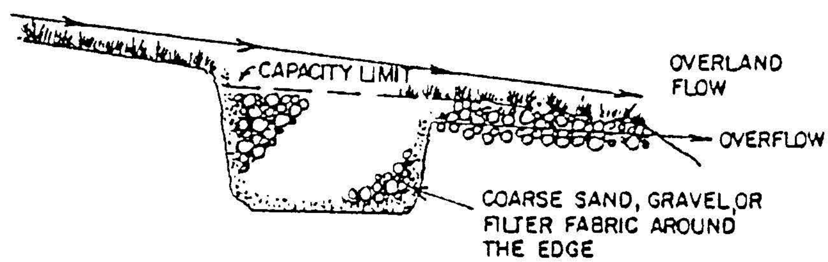
CONCRETE PAVER
LAID OVER
CONCRETE
LATTICE BLOCK

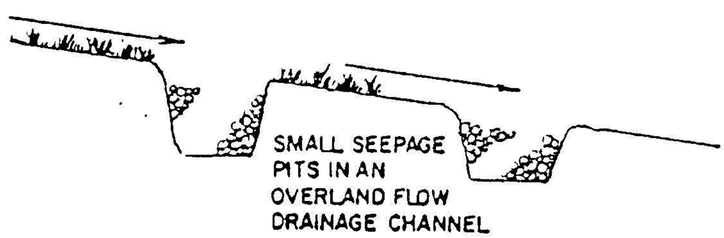
CONCRETE PAV

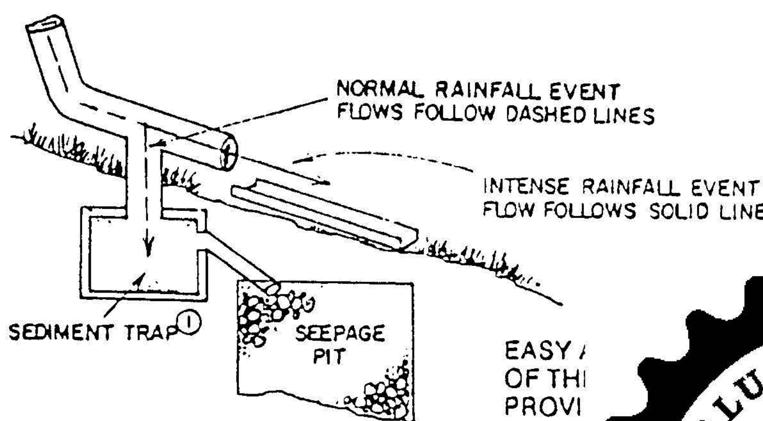
WALTER B. SATTERTHWAITE ASSOC., IN
720 NORTH FIVE POINTS ROAD · WEST CHESTER, PA. 19380 · (215)692-57
BRANCH OFFICE: 9418 ANNAPOLIS ROAD · LANHAM, MD. 20706 · (301)731-

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









EASY
OF THI
PROVI

SEEPAGE PIT CONFIGUR

WALTER B. SATTERTHWAITE ASSOC., IN

720 NORTH FIVE POINTS ROAD · WEST CHESTER, PA. 19380 · (215)692-577
BRANCH OFFICE: 9418 ANNAPOLIS ROAD · LANHAM, MD. 20706 · (301)731-0

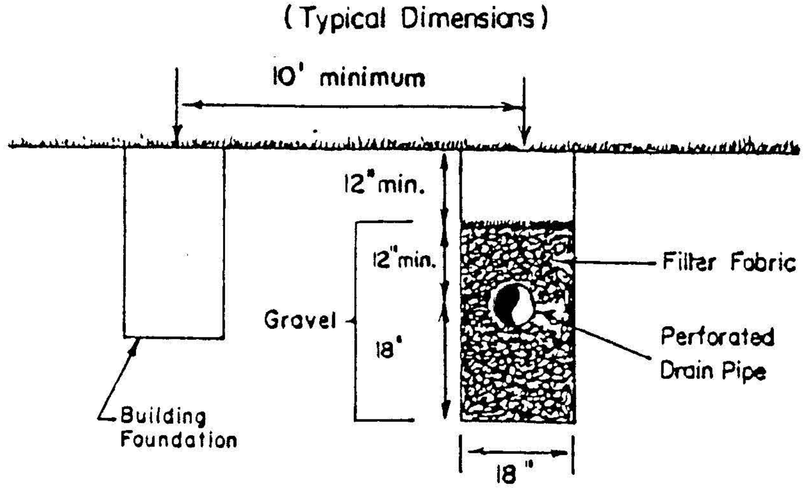


FIGURE 5-10

SEEPAGE BEDS

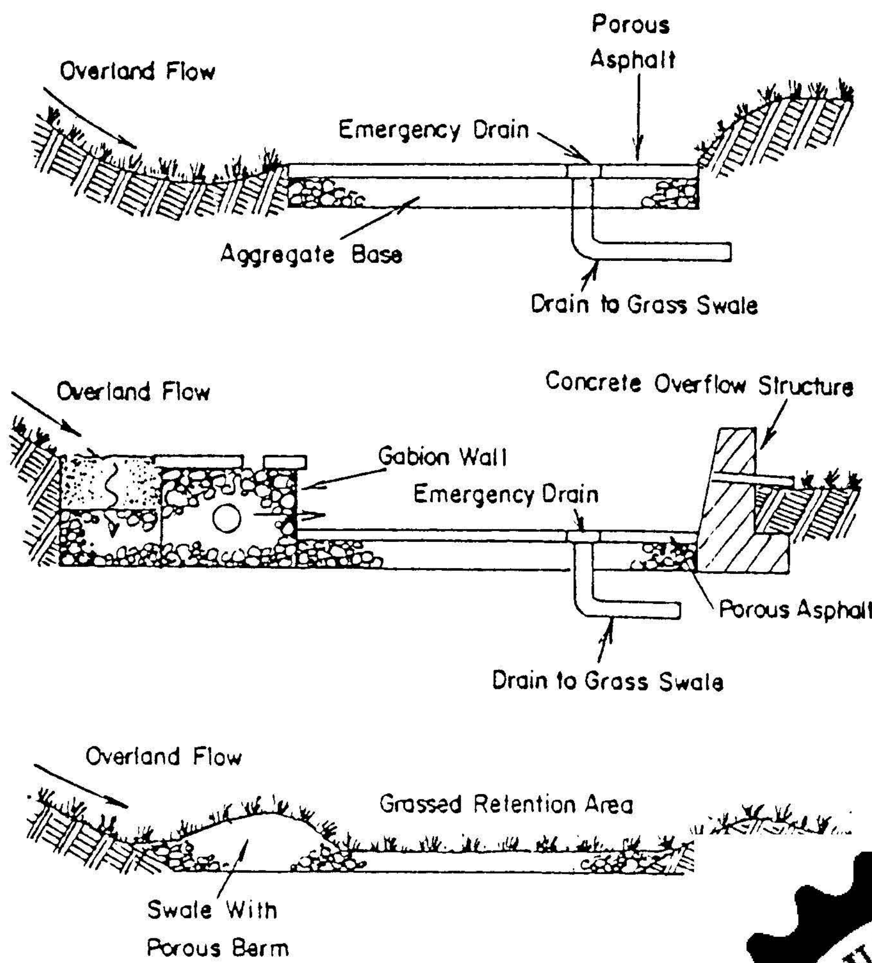


FIGURE 5-11

MULTI-PURPOSE SEEPAGE A

WALTER B. SATTERTHWAITE ASSOC., INC.

720 NORTH FIVE POINTS ROAD · WEST CHESTER, PA. 19380 · (215)692-5770

BRANCH OFFICE: 9418 ANNAPOLIS ROAD · LANHAM, MD. 20706 · (301)731-0560

o <u>Seepage Areas (Multi-Use)</u>

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 5-11).

o <u>Detention Basins</u>

Properly designed detention basins reduce the peak rate of runoff discharging from a developed area by temporarily storing a portion of the stormwater runoff volume and attenuating the hydraulic response of the developed area. A term often confused with detention basins is "retention" basins. Retention basins require a significantly larger impoundment volume to provide permanent storage of stormwater, and are 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".

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 Lackawanna River watershed is provided. A typical design procedure 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 design rainfall events. (NOTE: The post-development runoff quantity can be reduced by the amount proposed for on-site infiltration, where applicable.);

3. Develop pre- and post-developed runoff hydrographs, as opposed to only peak flow rates, for the design rainfall events (pre- and post-development);

4. Determine a preliminary basin size an
vs. storage relationship for the
configuration to satisfy defined p
attenuation) standards;

5. Select an outlet control structure
detention basin (e.g., an outlet pip
define its hydraulic characteristics (
depth vs. discharge relationship);

6. Using the information developed in steps 4 and 5 (i.e., the reactions between storage and discharge), route the inflow hydrographs through the basin and develop associated outflow hydrographs; and,

7. Evaluate adequacy/effectiveness of 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 subject watershed, the following criteria should be used for the evaluation of the basin design.

1. The peak discharge from the basin shall be no greater than the pre-development peak runoff rate from the development site during the design rainfall events. (A person involved in the site design should be certain that all site runoff from these rainfall events is conveyed to the detention basin via storm sewers or appropriate surface drainage channels.) This may require that the detention basin outlet structures have multiple control capacity.

2. 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 design rainfall events.

3. The stormwater detention basin shall have the capability of safely passing the 100-year peak stormwater runoff rate through an emergency spillway. "Safely" is being used here to mean "in a manner that will not result in physical damage" to the detention basin. This design provision will protect the structure if the primary outlet works become nonfunctional.

4. The water surface elevation in the during the 100-year rainfall event sha be at the crest of the emergency spill embankment height above the crest (spillway should be sufficient to pa design storm flows "safely" through th with one foot of free-board.

o Parking Lot Storage

Parking lot storage involves the design of pavement surfaces, curbing, and stormwater inlet structures to temporarily detain 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 associated parking area, to drain completely and to avoid the formation of ice so as to minimize the impacts of the impounded water on vehicular movement.

5.2.2 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 provide an effective and coordinated system of runoff control facilities that is responsive to the specific hydrologic characteristics and needs of a watershed.

The distributed storage concept for watershed-level stormwater management relies on the selection of multiple 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 new development sites. 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 to increase downstream flows, 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, will require a detailed assessment of potential advantages and disadvantages of desired facility locations and the associated assessme impacts.

6.0 TECHNICAL STANDARDS AND CRITERIA FOR CONTROL OF STORMWATER RUNOFF

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

- o Return period or frequency;
- o Duration; and,
- o 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 10-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 PADER recommend that complete flood frequency analyses, 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 has been adopted for stormwater management measures, therefore, they must be adopted by each municipality in accordance with approved watershed plans.

6.1 <u>Design Storm Event Selection</u>

Design storm event selection was based on the analysis of the six assessed storm events. Basic rationales/considerations applied during the preliminary selection and further evaluation of the various storm events included the following:

- o The selected event(s) should reflect sign under post-development conditions (in te quality) over existing conditions if provided.

- o The event(s) should be logically consiste stormwater management programs and ini watershed so that compatible planning and measures can truly deter adverse future i in this case, impacts on the main stem o River.

- o The control standards should consider existing stormwater problems in, and concerns of, the affected municipalities. The impacts of the selected design criteria should also consider practical variables such as implementation costs from the engineering and site development standpoints.

6.1.1 Design Storm Basis

In evaluating the modelling results for the individual "priority" watersheds as well as the main stem, each assessed storm event resulted in a greater peak discharge at the mouth of the associated drainage area. Though this seems a logical result of development, it is not always the case. A summary of the percent increases is included in Appendix D and detailed discussion is included in Section 4.0 of this Plan.

In order to facilitate assessment of the potential impacts associated with defined development within the Lackawanna River Watershed, Appendix D provides comparisons of stormwater runoff and stream flows which can be expected to occur under existing land use conditions and those which are anticipated in the future. It should be noted that both existing and future land use conditions were defined by the County as part of this project. The information presented in this Appendix was developed using the calibrated PSRM models, revised as necessary so as to reflect the required storm event and land use information as is discussed in Section 4.10 of this Plan.

Currently, there are both physical and regulatory stormwater controls within the Lackawanna River drainage basin. Physical controls include the channelization and detention facilities constructed by the U.S. Army Corps of Engineers, (ACOE). Regulatory controls include the existing Federal Emergency Management Agency (FEMA) Flood Insurance Program and municipal regulations. The FEMA program and ACOE facilities are directed at controlling flooding related to the 100-year storm event. There are also varying degrees of municipal control, applied by over 60 percent of the watershed municipalities, related to stormwater control to preserve the capacity of the storm drain systems. However, no municipality has a design storm event for discharge control.

The characteristics of the Lackawanna Rive
rocky and steep) supports the need for con
acceleration of runoff rates and increases i
resulting from continued development.
municipalities' input was control of potent
increased runoff rates and volumes. Groundwate
been a concern for this watershed. Due to the
and caverns in the watershed, timing delay a
applied to larger volume storm events would,
implementation, have some renewal affect to bas

Municipal input identified additional concerns within this watershed over the impacts of future developments on stream scouring, sedimentation and water quality. Stream scour is usually associated with the more frequently occurring storm event referred to as the "2-year" or mean annual storm. The associated flows generally define the configuration of stream channels. As these flows increase, stream channel scouring and associated sediment transport will be accelerated as the system attempts to re-establish an equilibrium between flows and channel size. By controlling post-development 2-year flows to existing levels, this future development impact can be minimized. The attention to a quality analysis was incorporated due to erosion and sediment washoff from steep areas being an existing and ongoing "uncontrolled" problem foreseen to worsen under increased development.

ADDENDUM - INSERT (see pages 81A-81B)

6.1.2 <u>Design Storm Standard</u>

In order to ensure compatibility of the stormwater management regulatory system with the existing watershed programs/facilities, stormwater management controls are identified to minimize future development impacts during several events. Accordingly, the primary design storm event selected for the basis of stormwater management regulations within the Lackawanna River Watershed study is the 100-year event.

It is understood that the 100-year event is a stringent control with respect to stormwater management. However, municipal input supported the plan approach to evaluate this event for release rates. Input from a technical applications viewpoint was also reviewed from the engineering community. A special solicitation of input from engineering representatives of developers as well as municipal engineers was also evaluated. Preparation of related construction costs for various events, presented as Appendix H, have been circulated and discussed with the municipal and engineering communities. Concerns related largely to the need for consistent controls throughout the watershed.

In following with the previous rationales a
for design event selection, and based on expre
the municipal and engineering communities in t
standard design control events for the Lackawann
are as follows:

The results of applying the three basic rationales under Section 6.1, were that a full range of impacts from future increased runoff were likely to occur for storm events ranging from the 2-year through the 100-year storms. In further application of the rationale as well as the modelling results, the major concerns along with the associated rain event of most "cause" can be summarized as follows:

1. Stream scouring erosion - more frequent events (2-year, 5-year).

2. Preservation of storm drain capacity to avoid future localized flooding and road icing caused by uncontrolled stormwater - storm sewer design storms (10-year, 25-year).

3. Rain which causes severe flood damage on less frequent but more costly repair basis given the size of the river and its tributaries (50-year, 100-year).

4. Increase in stormwater flows and volumes from infill development - all storms.

In evaluating the cross-section of peak flow increases at the nine watershed outlets, the peak flow increase percentage (as read from the Appendix D, Watershed Peak Flow tables) remained consistently high from the 5- through the 100-year event. However in the majority of cases, the amount of peak flow increase lessens with the decrease in frequence of event. This is illustrated in the following table.

Flow Increase for Each Event from
Pre- to Post-Development

Storm Return Frequency	2	5	10	25	50	100
Sterry	16	71	111	132	164	195
Wildcat	Decrease	Decrease	8	15	21	38
Hull	Decrease	Decrease	Decrease	Decrease	Decrease	Decrease
Eddy	39	59	70	50	[illegible]	71
Dickson City	Decrease	27	59	85	[illegible]	[illegible]
Roaring Brook	95	198	308	400	[illegible]	[illegible]
Keyser	26	47	59	65	[illegible]	[illegible]
Spring Brook	Decrease	24	79	82	[illegible]	[illegible]
St. John	Decrease	Decrease	44	75	[illegible]	[illegible]

The 10- and 25-year events generally have marked increases in flows which in conjunction with concerns of maintaining storm sewer design capacity and preventing exacerbation of local impacts would be beneficial to control at a minimum. The other major concern, in more flood type situations would be the 50- and 100-year events. Note that in all cases, the peak flow increase between the 25-year and 100-year storms is less than the increase from the 2-year to the 25-year storm. In most site design situations, facilities should be designed to "safely pass the 100-year event". Since volume and outlet sizing is usually a requirement to achieve this widely accepted criteria, expansion of this to provide a range of zero (Roaring Brook) to a 65 cfs maximum flow increase (St. John) for control of the 100-year event appears to be of minimal impact in terms of facility sizing. With the combination of a first-flush control criteria to address erosion and scour, final site controls may well achieve the 100-year peak control by virtue of controlling more frequent storms.

In various subwatersheds, the economy of scale in providing a cross-section of control for this large watershed will address the full realm of local and regional flooding and scour/erosion problems which will only worsen if not controlled.

It can often be beneficial to develop a stormwater management regulatory system that includes more than a single design event. Since included events should be directed at controlling problems of significant historical and ongoing concern to the affected municipalities, it is appropriate that the County and municipalities implement multiple event controls.

1. New land development controls are to incorporate infiltration of the first 1.5 inches of runoff (i.e., one-half of the mean-annual event) from impervious surfaces. At a minimum, infiltration facilities design/overflow capacity should be for the 10-year event. Post-to-pre flow control should be provided for the design capacity of the receiving storm sewer systems, but in no case less than the 10-year storm event. This design criteria applies to small infill type developments (i.e., up to two single-family homes), or new driveways, additions or impervious surfaces less than 2,000 square feet total.

   Where infiltration is not feasible, based on demonstration of site constraints and approved by the reviewing agency, post-to-pre control of the mean annual and 10-year events is required. Where the receiving storm sewer system is designed for the 25-year event, post-to-pre control for the mean annual and 25-year event shall prevail.

2. Unless qualified under 1 above, 100-year control with applied release rates is required in addition to the previous requirements.

6.2 Storm Event Release Rate Rationale

As stormwater management facilities are constructed within a watershed, flows in contiguous downstream watercourse segments can be reduced to a pre-defined level. These facilities usually consist of detention basins which function by temporarily storing portions of the stormwater flow and subsequently releasing these flows over an extended period of time. Although this results in a reduction in peak flows at the facility, the extended duration of "high" flows can lead to increases in flows further downstream due to the timing of combination with flow from other portions of the watershed. This situation is discussed in detail in Section 5.1.1 of this report. In order to mitigate this potential negative impact of flow attenuation, a detailed release rate analysis was performed for the Lackawanna River watershed for the 100-year control event.

Individual subarea release rates are
computing the ratio of the subarea's contribu
flow at a downstream point of interest to
runoff rate. By setting release rates for de
within the associated subarea at this level,
reduce the potential for the extended duratio
increase flows within downstream watershed stre

The work steps applied in the release rate evaluation of the Lackawanna River detailed study area watersheds are as follows:

1. Identification of points of interest along each stream system, based on significant obstruction and flooding problem information provided by the County, with the potential for significant increases in existing land use condition peak flows due to the identified future development;

2. Identification of stream confluence points with the potential for significant existing land use condition flow increases due to identified future watershed development;

3. Computation of release rates for each subarea within the watershed associated with each downstream point of interest;

4. Identification of the most restrictive release rate for each subarea based on the associated downstream points of interest;

5. Hydrologic model based assessment/modification of defined release rates so as to maximize acceptable flows thereby minimizing associated control costs within each subarea; and,

6. Identification of those subareas where direct discharge (i.e., no flow attenuation requirement is applicable.

In order to assess/modify the defined release rates, it was necessary to perform a preliminary distributed storage evaluation for the watershed. This was accomplished by modifying the watershed hydrologic models to reflect detention facilities within each subarea for which increases to peak flows are anticipated due to the defined future development. The Penn State Runoff Model was modified to "shave off" the portion of the subarea runoff hydrograph above the defined release rate. The associated runoff volume was then added to the receding limb of the runoff hydrograph so as to reflect a 24-hour draining time or "bleed off" period. Through this process, extended duration high flows were approximate points of interest. Additionally, the initial rates were adjusted so as to maximize allowable subarea detention facilities. The recommende developed through the aforementioned procedure Appendix F.

6.3 Sample Implementation of Recommended Performance Criteria

The recommended release rates within the Lackawanna River Watershed (Appendix F) are applied to each development site within the associated subarea. For example, if a development site is within a subarea with an 80 percent release rate then its maximum design event(s) discharge would be 80 percent of the associated existing land use conditions peak outflow or "discharge". Included as Appendix H is an example of applying the performance criteria on the site development level.

7.0 EXISTING INSTITUTIONAL/REGULATORY SYSTEMS

7.1 Review of Existing Ordinances

7.1.1 Stormwater Management Standards

Act 167 requires that the individual municipalities adopt, or amend, and implement ordinances or regulations necessary to regulate development within the watershed in a manner that is consistent with the stormwater management plan and the Act.

To assist the municipalities in implementing the provisions of the stormwater management plan within the framework of their existing regulations, it is important to be familiar with the existing related ordinances and how they pertain to stormwater management.

A municipal inventory was conducted to compile information on each municipality within the four counties included in the Lackawanna River Watershed. Included in the inventory is a list of existing regulatory stormwater controls, cited by sections of the specific ordinance in which they are addressed (i.e., zoning, floodplain, etc.), and a review of each ordinance as it pertains to specific stormwater management provisions (i.e., design standards for storm sewers, calculation methods, etc.).

Following this section, Table 7-1, are the summaries of the above-mentioned information compiled for each municipality. Lackawanna County communities are listed first, followed by Luzerne, Susquehanna, and Wayne County communities, respectively.

7.1.2 Ordinance Administration and Enforcement

There are not specific stormwater management ordinances in effect for any of the 51 municipalities within the Lackawanna River watershed, but an assortment of other regulatory controls exists watershed-wide. Administration and enforcement of the stormwater ordinance can be conducted in the same manner as the current land-use regulations (i.e., zoning and subdivision ordinances).

In Lackawanna County, there are no cou
ordinances, and the administration and enfo
regulations are strictly done on the municipa
Lackawanna County municipalities within the wa
administer and enforce subdivision and
regulations on an individual basis. The sam
zoning regulations, where 32 of the 33 communi
ordinances with the municipal Zoning Office
Hearing Boards responsible for enforcement.

Luzerne County communities within the watershed are basically split between county and municipal administration/enforcement of land-use laws. Th boroughs of Avoca, Duryea, and Hughestown have no local regulations; administration/enforcement is conducted by the Luzerne County Planning Commission and/or Zoning Hearing Board. The remaining four municipalities (Dupont Borough, Jenkins Township, Pittston City, and Pittston Township) administer their own land-use controls.

In Susquehanna County, all of the municipalities within the Lackawanna River watershed follow county-wide subdivision regulations, and with the exception of Forest City Borough, are unzoned. In Wayne County, all five municipalities within the Lackawanna River Watershed are unzoned. Canaan an Clinton Townships follow county-wide subdivision regulations, while Mount Pleasant, Preston, and Sterling Townships administer their own subdivision controls.

7.2 Existing Agencies/Organizations and Their Stormwater Management Functions

The following is a list of agencies directly, or indirectly, involved in the stormwater management process for the Lackawanna River Watershed.

7.2.1 Federal Agencies and Their Functions

Environmental Protection Agency (EPA) -- regulates development in wetlands. The Lackawanna River Watershed, as part of the Susquehanna River Basin, is handled through the Philadelphia Regional Office.

U.S. Army Corps of Engineers (ACOE) -- regulates fill and/or construction activities within all national waterways, including wetlands. The Corps is also responsible for the issuance of permits for water obstructions and construction control devices. The Lackawanna River Watershed area is handled through the Baltimore Office.

Federal Emergency Management Agency (FEMA) -- delineates floodplains and provides guidelines for develc
within the floodplain areas. (See also Depart
Affairs under Commonwealth Agencies.)

Soil Conservation Service (SCS) -- provid
regulations for erosion and sedimentation con
reviews all erosion and sedimentation control p

7.2.2 Interstate Agencies and Their Functions

Cheasapeake Bay Commission (CBC) -- agency comprised of various federal-government and private organizations, as well as the states of Maryland, Pennsylvania, Virginia, and the District of Columbia, for the effort of reducing pollution and protecting the water quality of the Chesapeake Bay.

Susquehanna River Basin Commission (SRBC) -- agency comprised of representatives from the states of Maryland, New York, and Pennsylvania, for the purpose of protecting the Susquehanna River watershed area.

7.2.3 Commonwealth Agencies and Their Functions

Department of Environmental Resources (DER) -- regulates and enforces stormwater management, water quality, sewer facilities, and the disturbance of land (earth-moving activities) on sites of twenty-five acres or greater. Local enforcement and issuance of permits conducted through the Wilkes-Barre Regional Office; however, earth moving permits are issued through the Department's Pottsville Office.

Department of Community Affairs (DCA) -- interprets FEMA floodplain regulations and provides guidelines and assistance to municipalities for the adoption of floodplain management ordinances. The Lackawanna River Watershed area is under the guidance of DCA's Northeast Region with its offices located in Scranton.

7.2.4 County Agencies and Their Functions

Lackawanna, Luzerne, Susquehanna, and Wayne County Conservation Districts -- local county agencies responsible for the enforcement of the guidelines and regulations for erosion and sedimentation control measures of the SCS. The conservation districts also review erosion and sedimentation control plans designed for developments within their respective jurisdictions.

WALTER B. SATTERTHWAITE ASSOCIATES, INC.

TABLE 7-1

LACKAWANNA COUNTY
EXISTING ORDINANCE SUMMARIES

TABLE 7-1
LACKAWANNA COUNTY

INVENTORY OF EXISTING REGULATORY CONTROLS
LACKAWANNA WATERSHED 1,2

MUNICIPALITY	ZONING	SUBDIVISION AND LAND DEVELOPMENT	GRADING	EROSION/ SEDIMENTATION	FLOODPLAIN	OTHER
ARCHBALD BOROUGH	Article 4 Sec. 4.300 pp. 4-15	Article 3 Sec. 312 p. 28-30	Subdivision Article 3 Sec. 307 p. 24	Subdivision Article 3 Sec. 312 pp. 28-30 E/S Ordinance		
BLAKELY BOROUGH		Article 3 Section 311	E/S Ordinance Article 4 Sec. b p. 6	E/S Ordinance		
CARBONDALE CITY	Article 6 Sec. 6.717 pp. 73-79 Floodplain	Article 6 Sec. 6.19 p. 43 Article 7 Secs. 7.6, 7.72 p. 47 Article 8 Sec. 8.6 pp. 57-59	Subdivision Article 7 p. 47 Article 5 Sec. 5.21 p. 14		Subdivision Article 8 pp. 57-59 Zoning Article 6 Sec. 6.717 pp. 73-79	
CARBONDALE TOWNSHIP	Article 8 Sec. 807 p. 4	Article 5 Sec. 503 PV-6 Sec. 510 PV-11 E/S Article 6 Sec. 602 PVI-1		Subdivision Article 5 Sec. 510		
CLARKS GREEN BOROUGH	Article 5 Sec. 5.805 pp. 43-46 E/S	Article 4 Sec. 4.700 pp. 34-35 Sec. 4.800 pp. 35-36 E/S		Zoning Article 5 Sec. 5.805 pp. 43-46 Subdivision Article 4 Sec. 4.800 pp. 35-36		
CLARKS SUMMIT BOROUGH	Part 5 Sec. 505.I p. 295	Part 3 Sec. 302.6 p. 210 Part 4 Sec. 407 P. 222 Part 4 Sec. 408 Part 4 PP. 223-224		Subdivision Part 4 Sec. 408 pp. 223-224		
CLIFTON TOWNSHIP		Article 5 Secs. 502.6, 502.7 pp. V5-V6 App. B				
COVINGTON TOWNSHIP		Article 3 Sec. 3.800 p. 13		Article 3 Section 3.700 p. 13		
DICKSON CITY		Part 5 Section 507 p. 44 Part 5, Sec. 506 p. 41 Part 6, Sec. 606 p. 60		Subdivision Part 5, Section 512 p. 49		

INVENTORY OF EXISTING REGULATORY CONTROLS
LACKAWANNA WATERSHED (continued)

MUNICIPALITY	ZONING	SUBDIVISION AND LAND DEVELOPMENT	GRADING	EROSION/ SEDIMENTATION	FLOODPLAIN	OTHER
DUNMORE BOROUGH	Article 6 Sec. 6.717 pp. 74-80 Floodplain	Article 5 Sec. 5.21 p. 14 Grading Article 6 Sec. 6.19 p. 40 Article 7 Sec. 7.6 p. 44 Article 8 Sec. 8.6 p. 52 Floodplain	Subdivision Article 5 Sec. 5.21 p. 14		Zoning Article 6 Sec. 7.717 pp. 74-80 Subdivision Article 8 Sec. 8.6 p. 52	
ELMHURST TOWNSHIP	Article 7 Sec. 700 pp. 2-21 Floodplain	Article 6 Sec. 6.5, p. 34 Article 7 Sec. 7.5, p. 38	Article 7 Sec. 7.6 7-62 p. 40 p. 40	Article 7 Sec. 7.6 7.63, p. 40	Zoning Article 7 Sec. 700 pp. 2-21 Subdivision Article 8 Sec. 8.2, p. 45	
FELL TOWNSHIP		Article 3 Sec. 3.206 p.12 Article 4 Sec. 4.700 pp. 36-37 Sec. 4.800 pp. 37-40 E/S		Article 4 Sec. 4.800 pp. 37-40		
GREENFIELD TOWNSHIP	Article 5 Sec. 5.9 pp. 5-16	Article 3 Sec. 3.206 p. 7 Article 4 Sec. 4.700 p. 21 Sec. 4.800 pp. 22-23 E/S		Subdivision Article 4 Sec. 4.800 P. 22-23		
JEFFERSON TOWNSHIP	Article 6 Sec. 6.712 p. 52 Floodplain	Article 7 Sec. 7.500 pp. 53-54	Subdivisio Article 7 Sec. 7.602 pp. 54-55	Subdivision Article 7 Sec. 7.603 p. 55		
JERMYN BOROUGH		Article 3 Sec. 3.206 p. 9 Article 4 Sec. 4.700 p. 28				
JESSUP BOROUGH	Article 5 Sec. 5.890 pp. 5-45 to pp. 5-48	Article 3 Sec. 311 p. 25				
LEHIGH TOWNSHIP	Article 5 Secs. 541- 563 pp. 5.13-5.20 Floodplain	Article 5 Sec. 502.6 Floodplain p. 24 Sec. 504 p. 28				

LACKAWANNA COUNTY

INVENTORY OF EXISTING REGULATORY CONTROLS
LACKAWANNA WATERSHED (continued)

MUNICIPALITY	ZONING	SUBDIVISION AND LAND DEVELOPMENT	GRADING	EROSION/ SEDIMENTATION	FLOODPLAIN	OTHER
MADISON TOWNSHIP	Unzoned	Article 6 Sec. 6.19 p. 43 Article 7 Sec. 7.5 p. 48		Subdivision Article 7 Sec. 7.63 p. 49	Floodplain Ordinance	
MAYFIELD BOROUGH						
MOOSIC BOROUGH	Article 5 Sec. 5.890 pp.5-31 to 34 Floodplain	Article 3 Sec. 307 p. 24 Grading Sec. 312 pp. 28-30	Subdivision Article 3 Sec. 307 p. 24	Zoning Article 5 Sec. 5.890 pp.5-31 to 34		
MOSCOW BOROUGH	Article 6 Sec. 6.712 p. 52 Floodplain	Article 5 Sec. 5.21 p. 14 Grading Sec. 5.22 p. 14 Article 6 Sec. 619 p. 40 Article 7 Sec. 7.6 p. 44 Sec. 7.72 p. 44 Article 8 Sec. 8.5 pp. 52-54	Subdivision Article 5 Sec. 5.21 p. 14		Zoning Article 7 p. Z-19, Z-20 Subdivision Article 8 Sec. 8.5 p. 52-54	
NEWTON TOWNSHIP		Article 5 Sec. 504.1 pp. 25-26 Sec. 511 p. 29 E/S Article 6 Sec. 603 p. 31		Subdivision Article 5 Sec. 511 p. 29		
OLD FORGE BOROUGH		Article 3 Sec. 3.206 p. 12 Article 4 Sec. 4.700 pp. 34-35 Sec. 4.800 pp. 35-37 E/S		Subdivision Article 4 Sec. 4.800 pp. 35-37		
OLYPHANT BOROUGH		Article 3 Sec. 311 p. 28				
RANSOM TOWNSHIP	Article 5 Sec. 5.890 pp. 5-47 to 5-50 Floodplain	Article 5 Sec. 502.6 PV1-V2 Floodplain Sec. 504 PV5-V6 Sec. 511 PV10 E/S Article 6 Sec. 603 PVI-1 Sec. 609 PVI-3,4 E/S		Subdivision Article 5 Sec. 511 PV-10 Article 6 Sec. 609 P. VI-3,4		

LACKAWANNA COUNTY

INVENTORY OF EXISTING REGULATORY CONTROLS
LACKAWANNA WATERSHED (continued)

MUNICIPALITY	ZONING	SUBDIVISION AND LAND DEVELOPMENT	GRADING	EROSION/ SEDIMENTATION	FLOODPLAIN	OTHER
ROARING BROOK TOWNSHIP	Article 7 Sec. 700 P. Z-18,19 Floodplain	Aricle 5 Sec. 502.6 PV1-V2 Floodplain Sec. 503.12 PV-6-1 Sec. 504 PV-6-1, 6-2 Sec. 511 PV-11, 13 E/S Article 6 Sec. 603 PVI-1 Sec. 609 PVI-3,5 E/S		Subdivision Article 5 Sec. 511 PV-11, 13 Article 6 Sec. 609 PVI-3,5	Zoning Article 7 Sec. 700 PZ-18, 19 Article 5 Sec. 502.6 PVI-V2	
SCOTT TOWNSHIP		Article 3 Sec. 308		Article 3 Sec. 307		
SCRANTON CITY	Article 6 Sec. 6.900 pp. 70-76 Floodplain	Article 5 Sec. 2 p. 21 Floodplain Sec. 6 pp. 23-25 Sec. 7 p. 26 E/S		Subdivision Article 5 Sec. 7 p. 26	Zoning Article 6 Sec. 6.900 pp. 70-76 Article 5 Sec. 2 p. 21	
S. ABINGTON TOWNSHIP	Article 6 Sec. 6.717 p. 85 Floodplain	Article 7 Sec. 7.500 pp. 38-39	Subdivision Article 7 Sec. 7.602 p. 40	Subdivision Article 7 Sec. 7.603 pp. 40-41	Floodplain Ord. Zoning Article 6 Sec. 6.717 p. 85 Subdivision Article 5 Sec. 502.6	
SPRINGBROOK TOWNSHIP	Article 5 Sec. 502.2 p. 51 Floodplain Sec. 505.2	Article 5 Sec. 504 p. V6 Sec. 511 V11-V12 E/S Article 6 Sec. 603 PVI-1 Sec. 609 PVI3-VI5		Subdivision Article 5 Sec. 511 V11-V12 Article 6 Sec. 609 PVI3-VI5	Zoning Article 5 Sec. 502.2 p. 51	
TAYLOR BOROUGH	Article 5 Sec. 5.890 pp. 5-48 to 5-51 Floodplain	Article 3 Sec. 311 pp. 28-34		Subdivision Article 3 Sec. 311 p. 34		

LACKAWANNA COUNTY

INVENTORY OF EXISTING REGULATORY CONTROLS
LACKAWANNA WATERSHED (continued)

MUNICIPALITY	ZONING	SUBDIVISION AND LAND DEVELOPMENT	GRADING	EROSION/ SEDIMENTATION	FLOODPLAIN	OTHER
THROOP BOROUGH		Chapter 5 Sec. 5.08 pp. 52-59 Chapter 7 pp. 79-85 Floodplain	Subdivision Chapter 5 Sec. 5.06 (A)	Subdivision Chapter 5 Sec. 5.06 (B) Sec. 5.08 (F)	Subdivision Article 8 Sec. 8.5 pp. 52-54	
VANDLING BOROUGH		Article 4 Sec. 4.700 p. 23				

1 Blank spaces indicate that a municipality does have an ordinance but that stormwater management is not addressed.
2 Where not specified as a County ordinance, a specified section is from the municipality's ordinance.

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED

	ARCHBALD BOROUGH	BLAKELY BOROUGH	CARBONDALE CITY	CARONDALE TOWNSHIP
Stormwater Control Documents	1. Drainage in zoning 2. Drainage E/S and grading in sub-division ordinance	1. Drainage in sub-division 2. E/S Ordinance	1. Drainage, floodplain grading from sub-division ordinance 2. Floodplain from zoning	1. Drainage from zoning 2. Drainage from sub-division
Design Standards for Storm Sewers	No	1. PennDOT Specs. 15" Min. Diameter 0.5% Min. Grade 2. Approval by Comm. Eng. in subdivision 3. General Stnds. from E/S	No	Township Design Stnds. from roads and streets from subdivision
Specify Design Storm	Drainage adequate for a 50-year storm in sub-division	Storm Drain System 10 Year Peak Flow Rate	No	No
Specify Calculation Method	No	SCS Method	No	No
Uses Rate of Runoff Standard	No	No	No	No
Emphasizes Groundwater Recharge; On-site	No	No	No	No
	No	Design Subject to approval from PADER & Lackawanna Co. Soil & Conser. Service	No	Design standard PA Dept. of Waterways for 300 acres or larger area from subdivision ordinance
	No	E/S refers to County stnd.	No	No
	1. SW review by Planning Commission 2. E/S Review by Planning Commission	No	SW review by Planning Commission	Review by Twp. Eng. and Sanitary Officer

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED (continued)

	ARCHBALD BOROUGH	BLAKELY BOROUGH	CARBONDALE CITY	CARONDALE TOWNSHIP
Fees				
Regular Inspection Schedule	No	Inspection by Zoning Officer from E/S ord.	No	No
Maintenance Provisions	No	Owners must maintain system from E/S ord.	No	No
Land Use Planning Controls				
- Permits PRD, Cluster, Etc.	No	No	PRD from zoning	No
- Steep Slope, Soils Stnd.	No	No	No	No
- Impervious Cover Limits	No	No	No	No
Misc. Comments, Observations on Ordinances				

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED

	CLARKS GREEN BOROUGH	CLARKS SUMMIT BOROUGH	CLIFTON TOWNSHIP	COVINGTON TOWNSHIP
Stormwater Control Documents	1. E/S in zoning 2. Drainage E/S in subdivision ordinance	1. Drainage from zoning 2. Drainage E/S from subdivision ordinance	Drainage from subdivision ordinance	1. Drainage from sub-division ordinance 2. Floodplain from zoning
Design Standards for Storm Sewers	Current specs. from PennDOT approval by Comm. Eng. from subdivision ordinance	Current specs. from PennDOT approval by Comm. Eng. from sub.	Street receptors dsgn. to intercept 80% flow from design storm from subdivision ordinance	PA DER & PennDOT specs., mini 15" pipe under streets; 12" under driveways from subdivision ordinance
Specify Design Storm	No	No	No	No
Specify Calculation Method	No	No	Rational formula from subdivision ordinance	No
Uses Rate of Runoff Standard	No	No	Yes from subdivision ordinance	No
Emphasizes Groundwater Recharge; On-site	No	No	No	No
Design Standard Deten-tion Facility Other SW	No	No	No	PA DER design stnd. from subdivision ordinance
Uses Co. Conser. Dist. or Refer to SCS Standard	No	No	No	Refers to both from subdivision ordinance
	No	No	Planning Comm., Twp. Eng. from subdivision ordinance	Drainage system approved by Twp. Eng. and Supervisors from subdivsion ordinance
	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED (continued)

	CLARKS GREEN BOROUGH	CLARKS SUMMIT BOROUGH	CLIFTON TOWNSHIP	COVINGTON TOWNSHIP
Regular Inspection Schedule	No	No	No	No
Maintenance Provisions	Maintenance resp. of owner until accepted by Borough	Responsibility of owner until accepted by Borough	No	No
Land Use Planning Controls				
- Permits PRD, Cluster, Etc.	No	No	No	No
- Steep Slope, Soils Stnd.	No	No	No	Steep slope regulation from zoning
- Impervious Cover Limits	No	No	No	Impervious covers kept to minimum from zoning ordinance
Misc. Comments, Observations on Ordinances				

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED

	DICKSON CITY BOROUGH	DUNMORE BOROUGH	ELMHURST TOWNSHIP	FELL TOWNSHIP
Stormwater Control Documents	Drainage from subdivision ordinance	1. Grading Drainage from subdivision ordinance 2. Floodplain from zoning	Floodplain from zoning	Drainage E/S from subdivision ordinance
Design Standards for Storm Sewers	No	No	No	Specifications from PennDOT from subdivision
Specify Design Storm	No	No	10 Year Peak Flow Rate	No
Specify Calculation Method	Talbot's formula from subdivision ordinance	No	No	No
Uses Rate of Runoff Standard	No	No	No	No
Emphasizes Groundwater Recharge; On-site	No	No	No	No
Design Standard Detention Facility Other SW	Based on Comprehensive Plan	No	No	No
Uses Co. Conser. Dist. or Refer to SCS Standard	No	No	No	No
Plan Review SW Management E/S Controls	Borough Engineer gives opinion on drainage plan	Storm sewer outlets approved by Planning Commission	Submitted to Township Planning Commission & Engineer for review	No
	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED (continued)

	DICKSON CITY BOROUGH	DUNMORE BOROUGH	ELMHURST TOWNSHIP	FELL TOWNSHIP
Regular Inspection Schedule	No	No	No	No
Maintenance Provisions	Maintenance	No	No	Maintenance
Land Use Planning Controls				
- Permits PRD, Cluster, Etc.	No	PRD from subdivision	No	No
- Steep Slope, Soils Stnd.	Steep slopes from sub-division ordinance	No	No	No
- Impervious Cover Limits	No	No	No	No
Misc. Comments, Observations on Ordinances				

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED

	GREENFIELD TOWNSHIP	JEFFERSON TOWNSHIP	JERMYN BOROUGH	JESSUP BOROUGH
Stormwater Control Documents	1. Drainage E/S from subdivision ordinance 2. Floodplain from zoning	1. Drainage from subdivision ordinance 2. Floodplain from zoning	Drainage from subdivision ordinance	1. Drainage from subdivision ordinance 2. Floodplain from zoning
Design Standards for Storm Sewers	Specifications from PennDOT approved by Commission Engineer from subdivision ordinance	Specifications from PennDOT approved by Commission Engineer from subdivision ordinance	Specifications from PennDOT from subdivision ordinance	No
Specify Design Storm	No	No	No	10 Year Peak Flow Rate
Specify Calculation Method	No	No	No	SCS Method
Uses Rate of Runoff Standard	No	No	No	No
Emphasizes Groundwater Recharge; On-site	No	No	No	No
Design Standard Detention Facility Other SW	No	No	No	No
Uses Co. Conser. Dist. or Refer to SCS Standard	No	No	No	No
	No	No	No	No

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED (continued)

	GREENFIELD TOWNSHIP	JEFFERSON TOWNSHIP	JERMYN BOROUGH	JESSUP BOROUGH
Fees	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule
Regular Inspection Schedule	No	No	No	No
Maintenance Provisions	Responsibility of owner until accepted by the Borough from subdivision ordinance	No	No	No
Land Use Planning Controls				
- Permits PRD, Cluster, Etc.	No	No	No	No
- Steep Slope, Soils Stnd.	No	No	No	No
- Impervious Cover Limits	No	No	No	No
Misc. Comments, Observations on Ordinances				

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED

	LEHIGH TOWNSHIP	MADISON TOWNSHIP	MAYFIELD BOROUGH	MOOSIC BOROUGH
Stormwater Control Documents	1. Floodplain from zoning 2. Drainage from subdivision ordinance	Drainage E/S from subdivision ordinance	No	1. Floodplain from zoning division ordinance
Design Standards for Storm Sewers	Minimum pipe 15" from subdivision ordinance	Twp. design standard for roads and streets from subdivision ordinance	No	No
Specify Design Storm	No	No	No	50-year storm for culverts from subdivision ordinance
Specify Calculation Method	Talbots's formula from subdivision ordinance	No	No	No
Uses Rate of Runoff Standard	No	No	No	No
Emphasizes Groundwater Recharge; On-site	No	No	No	No
Design Standard Detention Facility Other SW	Standard from PA Dept. of Forest & Waters for entire system from subdivision	Drainage area over 300 acres use standard from Water Power Resource Board for entire system from sub.	No	No
	No	Refers to SCS stnd. from subdivision	No	No
	Drainage system appvd. by Reviewing Engineer and Twp. Sanitary Officer from subdivision ordinance	Drainage system appvd. by Reviewing Engineer and Twp. Sanitary Officer from subdivision ordinance	No	Planning Commission review for open drainage way from subdivision ordinance

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED (continued)

	LEHIGH TOWNSHIP	MADISON TOWNSHIP	MAYFIELD BOROUGH	MOOSIC BOROUGH
Fees	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule
Regular Inspection Schedule	No	No	No	No
Maintenance Provisions	No	No	No	No
Land Use Planning Controls				
- Permits PRD, Cluster, Etc.	No	No	No	No
- Steep Slope, Soils Stnd.	No	No	No	Cut and fill slopes not greater than 2:1 unless stabilized
- Impervious Cover Limits	No	No	No	No
Misc. Comments, Observations on Ordinances				

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED

	MOSCOW BOROUGH	NEWTON TOWNSHIP	OLD FORGE BOROUGH	OLYPHANT BOROUGH
Stormwater Control Documents	1. Drainage floodplain from subdivision ordinance 2. Floodplain from zoning	Drainage E/S from subdivision ordinance	Drainage E/S from subdivision ordinance	1. Drainage from zoning 2. Drainage from subdivision ordinance
Design Standards for Storm Sewers	No	Twp. specifications for roads and bridges from subdivision ordinance	1. Specifications from PennDOT 2. Approved by Commission Eng. from subdivision ordinance	15" Min. Diameter 0.5% Min. Grade
Specify Design Storm	No	No	No	10 Year Peak Flow Rate
Specify Calculation Method	No	No	No	Talbot's Formula or SCS
Uses Rate of Runoff Standard	No	No	No	No
Emphasizes Groundwater Recharge; On-site	No	No	No	No
Design Standard Detention Facility Other SW	No	No	No	No
Uses Co. Conser. Dist	No	Refers to both from subdivision ordinance	No	No
	1. Drainage outlets approved by Commission	Approval of drainage by Twp. Engineer	No	Drainage outlets approved by Planning Commission from subdivision
	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED (continued)

	MOSCOW BOROUGH	NEWTON TOWNSHIP	OLD FORGE BOROUGH	OLYPHANT BOROUGH
Regular Inspection Schedule	No	No	No	No
Maintenance Provisions	No	No	Responsibility of developer until accepted by borough from subdivision ordinance	No
Land Use Planning Controls				
- Permits PRD, Cluster, Etc.	PRD from zoning	No	No	No
- Steep Slope, Soils Stnd.	No	No	No	No
- Impervious Cover Limits	No	No	No	No
Misc. Comments, Observations on Ordinances				

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED

	RANSOM TOWNSHIP	ROARING BROOK TOWNSHIP	SCRANTON CITY	SCOTT TOWNSHIP
Stormwater Control Documents	1. Floodplain drainage E/S from subdivision ordinance 2. Floodplain from zoning	1. Floodplain from zoning 2. Floodplain drainage E/S from subdivision ordinance	1. Floodplain from zoning 2. Floodplain drainage E/S from subdivision ordinance	No
Design Standards for Storm Sewers	Twp. Design Standard for roads and streets from sub-division ordinance	Twp. Standard for roads and streets Minimum size 15" follow PennDOT Specs. from sub-division ordinance	Minimum size 12" follow PennDOT Standard from sub-division ordinance	No
Specify Design Storm	No	No	50-year storm for culvert from subdivision ordinance	10 Year Peak Flow
Specify Calculation Method	No	No	Manning formula from sub-division ordinance	No
Uses Rate of Runoff Standard	No	No	No	No
Emphasizes Groundwater Recharge; On-site	No	No	No	No
Design Standard Detention Facility Other SW	For areas over 300 acres, drainage from subdivsion. System shall follow PA Dept. of Forest & Waters Standard	Drainage areas over 300 acres follow standards of Water Power Resource Board from subdivsion ordinance	No	No
Uses Co. Conser. Dist. or Refer to SCS Standard	Refers to SCS Standards from subdivision ordinance	Refers to SCS Standards subdivision ordinance	Refers to SCS Standards subdivision ordinance	No
[illegible]	1. Drainage system approved by Reviewing Engs. and Sanitary officer. 2. Twp. Engineer approved E/S Controls	Drainage system approved by Reviewing Eng. and Twp. Twp. Sanitary Officer	No	Conform with Chapter 102 of PADER regulations in consultation with Lackawanna County Conserv. Dist. & Soil Conserv. Dist.

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED (continued)

	RANSOM TOWNSHIP	ROARING BROOK TOWNSHIP	SCRANTON CITY	SCOTT TOWNSHIP
Fees	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule	No
Regular Inspection Schedule	No	No	No	No
Maintenance Provisions	Responsibility of Developer until accepted by Twp. from subdivision ordinance	Responsibility of owners until accepted by Twp. from subdivision ordinance	No	No
Land Use Planning Controls				
- Permits PRD, Cluster, Etc.	No	No	No	No
- Steep Slope, Soils Stnd.	No	No	No	No
- Impervious Cover Limits	No	No	No	No
Misc. Comments, Observations on Ordinances				

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED

	S. ABINGTON TOWNSHIP	SPRINGBROOK TOWNSHIP	TAYLOR BOROUGH	THROOP BOROUGH	VANDLING BOROUGH
Stormwater Control Documents	1. Floodplain from zoning 2. Floodplain drainage E/S grading from subdivision ordinance 3. Floodplain ordinance	1. Flooplain drainage from zoning 2. Drainage E/S from subdivision ordinance	1. Drainage E/S from subdivision ordinance 2. Floodplain from zoning	Drainage, grading floodplain from subdivision ordinance	No
Design Standards for Storm Sewers	Twp. Design Standard for roads and streets from subdivision ordinance	Twp. Design Standard for roads and streets from subdivsion ordinance	PennDOT specification approved by Commission engineer from subdivision ordinance	No	No
Specify Design Storm	No	No	No	No	No
Specify Calculation Method	No	No	No	No	No
Uses Rate of Runoff Standard	No	No	No	No	No
Emphasizes Groundwater Recharge; On-site	No	No	No	No	No
Design Standard Detention Facility Other SW	Drainage areas over 300 acres follow PA Dept. of Forests and Waters Standards for drainage system from subdivsion ordinance	Areas over 300 acres use PA Dept. of Forest and Waters Standards for drainage system from subdivision ordinance	No	No	No
[illegible]	[illegible] ndards from [illegible] nce	Refers to SCS Standards from subdivision ordinance	No	No	No
[illegible]	[illegible] proved by [illegible] and Twp. [illegible] Floodplain [illegible] o. conser- [illegible]	1. Drainage approved by Reviewing Eng. and Twp. Sanitary Officer 2. E/S Plan approved by Board of Supervisors from Subdivision ordinance	No	Drainage outlets approved by Commission from subdivision	No
[illegible]	[illegible]	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule	No

LACKAWANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED (continued)

	S. ABINGTON TOWNSHIP	SPRINGBROOK TOWNSHIP	TAYLOR BOROUGH	THROOP BOROUGH	VANDLING BOROUGH
Regular Inspection Schedule	Building in Floodplain inspected by Building Permit Officer from subdivsion	No	No	No	No
Maintenance Provisions	No	Responsibility of Developer until accepted by Township from subdivision ordinance	Developers responsibility until accepted by Borough from subdivision ordinance	No	No
Land Use Planning Controls					
- Permits PRD, Cluster, Etc.	No	No	No	No	No
- Steep Slope, Soils Stnd.	No	No	No	No	No
- Impervious Cover Limits	No	No	No	No	No
Misc. Comments, Observations on Ordinances					

TABLE 7-1
(continued)

LUZERNE COUNTY
EXISTING ORDINANCE SUMMARIES

LUZERNE COUNTY
INVENTORY OF EXISTING REGULATORY CONTROLS
LACKAWANNA WATERSHED 1,2

MUNICIPALITY	ZONING	SUBDIVISION AND LAND DEVELOPMENT	GRADING	EROSION/ SEDIMENTATION	FLOODPLAIN	OTHER
AVOCA		County Ordinance Article 6 Sec. 6.115 P. 19-25 Sec. 14 P. 38-42 App. A PA1-A5			County Sub-division Ord. Sec. 14 P. 38-42	
DUPONT	Article 6 Sec. 6.540	Article 4 Sec. 440				
DURYEA		County Ordinance Article 6.115 P. 19-25 Sec. 14 App. A PA1-A5			County Subdivision Ord. Sec. 14 P. 38-42	
HUGHESTOWN		County Ordinance Article 6.115 P. 19-25 Sec. 14 App. A PA1-A5			County Subdivision Ord. Sec. 14 P. 38-42	
JENKINS		Article 6 Sec. 6.06 P. 17-18 Spec Sh-201 P. 9-10				
PITTSTON CITY		Sec. 7F P. 14				
PITTSTON TOWNSHIP		Article 6 Sec. 6.115			Floodplain Ord. All	

1 Blank spaces indicate that a municipality does have an ordinance but that stormwater management is not addressed.

2 Where not specified as a County Ordinance, a specified section is from the municipality's ordinance.

LUZERNE COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED

	MUNICIPALITY Avoca Borough	Dupont Borough	Duryea Borough	Hughestown Borough
Stormwater Control Documents	Storm Drainage, Stormwater Detention and Flood Control in Luzerne County Subdivison Ordinance Section 6.115	Storm Drainage in Zoning and Subdivision Ordinance	Storm Drainage, Stormwater Detention and Flood Control in Luzerne County Subdivision Ordinance Section 6.115	Storm Drainage, Stormwater Detention and Flood Control in Luzerne County Subdivision Ordinance Section 6.115
Design Standards for Storm Sewers	No - To convey peak runoff from future development in all tributary areas for a 25-year planning period. Should consider runoff controls already in effect. Co. SD/LD Ordinance Section 6.11532	No	No	No
Specify Design Storm	Drainage system for 10 to 100-year storms determined by County Eng. from County subdivision ordinance depending on potential damage impact Co. SD/LD Ord. Section 6.11551	No	Drainage System for 10 to 100-year storms determined by County Eng. from County subdivision ordinance	Drainage System for 10 to 100-year storms determined by County Eng. from County subdivision ordinance
Specify Calculation Method	. Mannings Equation for water courses and storm sewers except culverts . SCS soil cover complex method for > 200 acres . Rational Method for <= 200 acres Co. SC/LD Ordinance Sections 6.11552, 53, 54	No	Mannings Equation from County subdivision ordinance	Mannings Equation from County subdivision ordinance
	s to be ill over- ms or ncreased ream, then noff shall opment nance	No	No	No

LUZERNE COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED

	Avoca Borough	Dupont Borough	Duryea Borough	Hughestown Borough
Emphasizes Groundwater Recharge; On-site	No - County Planning may require underground systems for storage of frequent flood flows. Co. SD/LD Ord. Section 14.32	No	No	No
Design Standard Detention Facility Other SW Management Techniques	In accordance with County Eng. from subdivision ordinance. Co. SD/LD Ord. Section 6.1154	No	In accordance with Co. Eng. from County subdivision ordinance	In accordance with Co. Eng. from County subdivision ordinance
Uses Co. Conser. Dist. or refers to SCS Standards	SCS method of calculation for runoff. Co. SD/LD Ordinance Section 6.11553	No	No	No
Plan Review SW Management E/S Controls	Ordinance requires complete detailed drainage calculations certified by engineer & submitted to County Eng. Co. SD/LD Ord. Sect 6.11555	No	Improvement Specs in accordance with County Engineer from County subdivision ordinance	Improvement Specs in accordance with County Engineer from County subdivision ordinance
Fees	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule
Regular Inspection Schedule	No	No	No	No
Maintenance Provisions	No - If developed lands are conveyed to one or more owners, developer is to provide written assurances to County that detention ponds will be maintained. Co. SD/LD [illegible] 8	No	No	No
		No	No	No
		No	No	No
		No	No	No
		Storm sewer systems to be provided where runoff and erosion cannot be controlled satisfactorily by surface drainage facilities		

LUZERNE COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED

	MUNICIPALITY		
	Jenkins Twp.	Pittston City	Pittston Township
Stormwater Control Documents	Storm drainage from Jenkins Twp. subdivision Ord. Section 6.062	Drainage from subdivision Ord. Section F., pg. 14	1. Drainage from subdivision Ord. Section 6.115 2. Floodplain Ordinance only for construction in the floodplain; no stormwater control measures except to prevent discharge of excess runoff onto adjacent properties Section 4.02 B.
Design Standards for Storm Sewers	Standards for laying pipe from subdivision Ord. Specification SH - 101	No	No
Specify Design Storm	No - Storm drainage facilities designed to remove increased runoff from adjacent higher elevation properties when fully developed. SD/LD Ord. Section 6.063	No	No
Specify Calculation Method	No	No	No
Uses Rate of Runoff Standard	No	No	No
Emphasizes Groundwater	No	No	No
		No	No
		No	No

LUZERNE COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED

	MUNICIPALITY		
	Jenkins Twp.	Pittston City	Pittston Township
Plan Review SW Management E/S Controls	Drainage outlets approved by Township Supervisors	Drainage outlets approved by the Planning Commission	Drainage outlets approved by the Planning Commission
Fees	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule
Regular Inspection Schedule	No	No	No
Maintenance Provisions	No	No	No
Land Use Planning Controls			
- Permits PRD, Cluster, Etc.	No	No	No
- Steep Slope, Soils Stnd.	No	No	No
- Impervious Cover Limits	No	No	No
Misc. Comments, Observations on Ordinances	Storm sewer systems to be provided where runoff and erosion cannot be controlled satisfactorily by surface drainage facilities. Borough	Identical to Dupont and Jenkins stormwater provisions.	

WALTER B. SATTERTHWAITE ASSOCIATES, INC.

TABLE 7-1
(continued)

SUSQUEHANNA COUNTY
EXISTING ORDINANCE SUMMARIES

SUSQUEHANNA COUNTY
INVENTORY OF EXISTING REGULATORY CONTROLS
LACKAWANNA WATERSHED 1,2

MUNICIPALITY	ZONING	SUBDIVISION AND AND DEVELOPMENT	GRADING	EROSION/ SEDIMENTATION	FLOODPLAIN	OTHER
ARARAT	Unzoned	County Ordinance Article 6 Sec. 602.06 p. 29 Article 9 Sec. 906 p. 57	From Co. SD/LD Ord. Sec. 903.02 Refers to Susque- hanna Conservation District Specs.	From Co. SD/LD Ord. Sec. 903.02 Refers to Susque- hanna Conservation District Specs.		
CLIFFORD	Unzoned	County Ordinance Article 6 Sec. 602.017 p. 29 Sec. 602.06 p. 30 Article 9 Sec. 906 p. 57	From Co. SD/LD Ord. Sec. 903.02 Refers to Susque- hanna Conservation District Specs.	From Co. SD/LD Ord. Sec. 903.02 Refers to Susque- hanna Conservation District Specs.	Floodplain Ord. All	
FOREST CITY		County Ordinance Article 6 Sec. 602.06 Sec. 602.017 Article 9 Sec. 906	From Co. SD/LD Ord. Sec. 903.02 Refers to Susque- hanna Conservation District Specs.	From Co. SD/LD Ord. Sec. 903.02 Refers to Susque- hanna Conservation District Specs.		
HERRICK	Unzoned	County Ordinance Article 6 Sec. 602.017 p. 29 Sec. 602.06 p. 30 Article 9 Sec. 906 p. 57	From Co. SD/LD Ord. Sec. 903.02 Refers to Susque- hanna Conservation District Specs.	From Co. SD/LD Ord. Sec. 903.02 Refers to Susque- hanna Conservation District Specs.	Floodplain Ord. All	
THOMPSON	Unzoned	County Ordinance Article 6 Sec. 602.017 p. 29 Sec. 602.06 p. 30 Article 9 Sec. 906 p. 57	From Co. SD/LD Ord. Sec. 903.02 Refers to Susque- hanna Conservation District Specs.	From Co. SD/LD Ord. Sec. 903.02 Refers to Susque- hanna Conservation District Specs.	Floodplain Ord. All	
UNIONDALE	Unzoned	County Ordinance Article 6 Sec. 602.017 p. 29 Sec. 602.06 p. 30 Article 9 Sec. 906 p. 57	From Co. SD/LD Ord. Sec. 903.02 Refers to Susque- hanna Conservation District Specs.	From Co. SD/LD Ord. Sec. 903.02 Refers to Susque- hanna Conservation District Specs.		

1 Blank spaces indicate that a municipality does have an ordinance but that stormwater
2 Where not specified as a County Ordinance, a specified section is from the municipal

SUSQUEHANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED

	MUNICIPALITY					
	Ararat	Clifford	Forest City	Herrick	Thompson	Uniondale
Stormwater Control Documents	1.Drainage from County SD/LD Ordinance 2.County Floodplain Ordinance	1.Drainage from County SD/LD Ordinance 2.County Floodplain Ordinance	1.Drainage from County SD/LD Ordinance 2.County Floodplain Ordinance	1.Drainage from County SD/LD Ordinance 2.County Floodplain Ordinance	1.Drainage from County SD/LD Ordinance 2.County Floodplain Ordinance	1.Drainage from County SD/LD Ordinance 2.County Floodplain Ordinance
Design Standards for Storm Sewers	No	No	No	No	No	No
Specify Design Storm	No	No	No	No	No	No
Specify Calculation Method	No	No	No	No	No	No
Uses Rate of Runoff Standard	No	No	No	No	No	No
Emphasizes Groundwater Recharge; On-site Infiltration	No	No	No	No	No	No
Design Standard Detention Facility, Other SW Management Techniques	No	No	No	No	No	No
Uses Co. Conser. Dist. or Refer to SCS Stnd.	No	No	No	No	No	No
Plan Review SW Management E/S Controls	No	No	No	No	No	No
[illegible]	[illegible]	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule
[illegible]	[illegible]	No	No	No	No	No
[illegible]	[illegible] ce e	County SD/LD Ordinance Section 906 - Provide for adequate maint-enance	County SD/LD Ordinance Section 906 - Provide for adequate maint-enance	County SD/LD Ordinance Section 906 - Provide for adequate maint-enance	County SD/LD Ordinance Section 906 - Provide for adequate maint-enance	County SD/LD Ordinance Section 906 - Provide for adequate maint-enance

SUSQUEHANNA COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED
(continued)

MUNICIPALITY

	Ararat	Clifford	Forest City	Herrick	Thompson	Uniondale
Land Use Planning Controls						
- Permits PRD, Cluster, Etc.	PRD from County SD/LD Ordinance	PRD from County SD/LD Ordinance	PRD from County SD/LD Ordinance	PRD from County SD/LD Ordinance	PRD from County SD/LD Ordinance	PRD from County SD/LD Ordinance
- Steep Slope, Soils Stnd.	No	No	No	No	No	No
- Impervious Cover Limits	No	No	No	No	No	No
Misc. Comments, Observations on Ordinances	Stormwater drainage plans and erosion and sediment control plans to be in accordance with County Conservation District Specifications	Stormwater drainage plans and erosion and sediment Control plans to be in accordance with County Conservation District Specifications	Stormwater drainage plans and erosion and sediment control plans to be in accordance with County Conservation District Specifications	Stormwater drainage plans and erosion and sediment control plans to be in accordance with County Conservation District Specifications	Stormwater drainage plans and erosion and sediment control plans to be in accordance with County Conservation District Specifications	Stormwater drainage plans and erosion and sediment control plans to be in accordance with County Conservation District Specifications

TABLE 7-1
(continued)

WAYNE COUNTY
EXISTING ORDINANCE SUMMARIES

WAYNE COUNTY
INVENTORY OF EXISTING REGULATORY CONTROLS
LACKAWANNA WATERSHED 1,2

MUNICIPALITY	ZONING	SUBDIVISION AND LAND DEVELOPMENT	GRADING	EROSION/ SEDIMENTATION	FLOODPLAIN	BUILDING CODE	STORMWATER	PRD	OTHER
Canaan	Unzoned	Wayne County Subdivision Article 4, Section 4.204 p. 34 Article 4, Section 4.600 p. 40 Article 4 Section 4.900 p. 42 Article 4 Section 4.1000 p. 42 Article 4 Section 4.1100 pp. 42-43 Article 6 Section 6.400 p. 48		Wayne County Subdivsion Article 4, Section 4.900 p. 42	Wayne County Subdivision Article 4, Section 4.1100 pp. 42-43		Wayne County Subdivision Article 4, Section 4.1000 p. 42		
Clinton TWP	Unzoned	Wayne County Subdivision Article 4, Section 4.204 p. 34 Article 4, Section 4.600 p. 40 Article 4 Section 4.900 p. 42 Article 4 Section 4.1000 p. 42 Article 4 Section 4.1100 pp. 42-43 Article 6 Section 6.400 p. 48		Wayne County Subdivsion Article 4, Section 4.900 p. 42	Wayne County Subdivision Article 4, Section 4.1100 pp. 42-43		Wayne County Subdivision Article 4, Section 4.1000 p. 42		
Mt. Pleasant TWP	Unzoned	Subdivision Article 3 Section 0.1-0.4 pp. 24-25							
Preston TWP	Unzoned	Subdivision Article 3 Section 1.H p. 12 Section 1.0 p. 14			Floodplain Ordinance				
Sterling TWP	Unzoned	Article 6 Section 605 p. 59							

1 Blank spaces indicate that a municipality does have an ordinance but that stormwater ma
2 Where not specified as a County Ordinance, a specified section is from the municipality

WAYNE COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED

	MUNICIPALITY				
	Canaan Township	Clinton Township	Mt. Pleasant Township	Preston Township	Sterling Township
Stormwater Control Documents	Drainage, E/S, SWM Floodplain from County Subdivision Ordinance	Drainage, E/S, SWM Floodplain from County Subdivision Ordinance	Drainage from Subdivision Ordinance	Drainage from Subdivision Ordinance	Drainage from Subdivision Ordinance
Design Standards for Storm Sewers	Minimum inside diameter of culverts 15"; Minimum 12" of cover under cartway	Minimum inside diameter of culverts 15"; Minimum 12" of cover under cartway	Minimum inside diameter of culverts 15"	Minimum inside diameter of culverts 15"	Minimum Pipe Size 15" diameter
Specify Design Storm	Culverts designed for minimum 10-year storm	Culverts designed for minimum 10-year storm	No	No	Culverts designed for minimum 10-year storm
Specify Calculation Method	Current SCS Method	Current SCS Method	No	No	Current SCS Method
Uses Rate of Runoff Standard	Assure postdevelopment runoff = or < predevelopment runoff or manage quantity velocity and direction of resulting stormrunoff in a manner which otherwise adequately protects health and property from possible injury	Assure postdevelopment runoff = or < predevelopment runoff or manage quantity velocity and direction of resulting stormrunoff in a manner which otherwise adequately protects health and property from possible injury	No	No	Assure postdevelopment runoff = or < predevelopment runoff or manage quantity velocity and direction of direction of resulting storm runoff in a manner which otherwise adequately protects health and property from possible injury
[illegible]	[illegible]	No	No	No	No
[illegible]	[illegible]	No	No	No	No
[illegible]	[illegible] Stnds. [illegible] storm- [illegible]	Refers to SCS Stnds. in computing stormwater runoff	No	No	No

WAYNE COUNTY
REVIEW OF EXISTING MUNICIPAL ORDINANCES
LACKAWANNA WATERSHED
(continued)

	Canaan Township	Clinton Township	Mt. Pleasant Township	Preston Township	Sterling Township
Plan Review SW Management E/S Controls	No - does not specify	No - does not specify	Drainage system improvements approved by Twp. Engineer	Drainage system improvements approved by Twp. Engineer	Bridges & culverts serving drainage areas > 1/2 square mile must have approval of PA State Power and Resources Board.
Fees	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule	Set Fee Schedule
Regular Inspection Schedule	No	No	No	No	No
Maintenance Provisions	No	No	No	No	Private owners responsibility for maintenance provided
Land Use Planning Controls					
- Permits PRD, Cluster, Etc.	No	No	No	No	No
- Steep Slope, Soils Stnd.	No	No	No	No	No
- Impervious	No	No	No	No	No
	...nagement ...o specs. ...nty and/ ...cipality. ...ision ...ticle 4, ...2	Stormwater management plans drawn to specs. of state, county and/ or local municipality. County Subdivision Ordinance, Article 4, Section 4.1002	Drainage control addressed in this subdivision ord. are the exact wording that is also in the Preston Township Subdivision Ordinance		Subdivision Ordinance states subdivider shall eliminate swampy areas or stagnant pools & shall guard against their creation. Planning Commission may require fill or channel improvements to forestall such problems.

8.0 INSTITUTIONAL PLAN - DEVELOPMENT OF MODEL STORMWATER ORDINANCE PROVISIONS

The Stormwater Management Act emphasizes locally administered stormwater programs with the watershed municipalities taking the lead role. Enforcement of the watershed plan standards and criteria will require the municipalities to incorporate them into their applicable ordinances which address land development. Provided as part of the plan is a model stormwater ordinance. This model ordinance is a single purpose stormwater ordinance that could be adopted by each municipality with minor changes to fulfill the needs of a particular municipality and time implement the Plan.

In addition to adopting the ordinance itself, the municipalities would also have to revise their existing subdivision, land development and zoning ordinances to incorporate the necessary linking provisions. These linking provisions would refer to any applicable regulated activities within the watershed to the single purpose ordinance. Key provisions of the model stormwater ordinance include the drainage standards and criteria, performance standards for stormwater management, and maintenance provisions for stormwater facilities.

Finally, the model stormwater ordinances should be understandable, applied fairly and uniformly throughout the watershed, and should not discourage creative solutions to stormwater management problems. It would be desirable for the municipalities to adopt a uniform regulatory approach for the Lackawanna River Watershed.

9.0 PRIORITIES FOR IMPLEMENTATION OF THE PLAN

The Lackawanna River Stormwater Management Plan preparation process will be complete with the adoption of the draft plan by Lackawanna, Luzerne, Wayne, and Susquehanna Counties and submission of the final Plan to DER for approval, which sets in motion the mandatory schedule of adoption of municipal ordinance provisions needed to implement stormwater management criteria. Lackawanna River Watershed municipalities would have six months from DER approval to adopt the necessary ordinance provisions. Additional priorities for implementation of the Lackawanna River Watershed Management Plan are as follows:

9.1 Priority One: DER Approval of the Plan

Submission of the watershed plan by Lackawanna County on behalf of Wayne, Luzerne and Susquehanna Counties to the Pennsylvania Department of Environmental Resources for approval. The DER has 90 days upon receipt to approve or disapprove the Plan. Should the Plan be neither approved or disapproved within the specified time frame, the Plan will be automatically approved by default. Upon submission, the DER will insure that all of the activities specified in the approved Scope of Study have been included in the Plan. The DER will also review the Plan in terms of consistency with municipal floodplain management plans, State programs which regulate dams, encroachments and other water obstructions and State and Federal flood control programs, that the Plan is compatible with other watershed stormwater plans in the basin in which the watershed is located and that the Plan is consistent with the policies of Act 167.

9.2 Priority Two: Publishing the Plan

Upon DER approval, Lackawanna County will, on behalf of Luzerne, Wayne and Susquehanna Counties publish additional copies of the Watershed Management Plan and will submit two copies of the Plan and Executive Summary to all 51 municipalities within the watershed, along with mapping relevant to the individual municipalities.

9.3 Priority Three: Development of Local Programs to Coordinate with DER Regarding Chapter 105 and 106 P[illegible] Reviews

Upon notification through Pennsylvania [illegible] review of permits regarding items such as stre[illegible] enclosures, waterway diversions, obstructi[illegible] activities regulated by Chapter 105 and 106 of [illegible] Regulations which could possibly alter the eff[illegible] runoff control strategy developed for the [illegible] Watershed will be undertaken in conjunction w[illegible] process. Lackawanna County will cooperate wit[illegible] review, if deemed appropriate, based on the [illegible] proposed activities.

9.4 Priority Four: Adoption of Ordinance Provisions for the Purpose of Plan Implementation

The adoption of necessary provisions included in the Lackawanna River Watershed Act 167 stormwater Management Ordinance by the various municipalities involved is a key ingredient for implementation of the Stormwater Management Plan. The municipalities may choose to:

A. Adopt the single purpose ordinance itself as well as the essential linking provisions into their existing subdivision and land development and zoning ordinance; or,

B. Incorporate the necessary provisions into existing ordinances rather than adopt a separate ordinance.

9.5 Priority Five: Development of Step by Step Process for Correction of Existing Storm Drainage Problem Areas

The development of the watershed plan has provided a framework for the correction of existing drainage problems, a logical first step in the process of implementation of a storm water management ordinance. It will prevent the worsening of existing drainage problems and prevent the creation of new drainage problems as well. The step by step outline below is by no means a mandatory action to be taken by the municipalities with watershed plan adoption options, it is just one method of solving problems uniformly throughout the watershed in order to solve current runoff situations.

1. Prioritize a list of storm drainage problems within the municipalities based on frequency of occurrence, potential for injury, as well as damage history.

2. Develop a detailed engineering evaluation to determine the exact nature of the top priority drainage problems within the municipalities in order to determine solutions cost estimates and a recommended course of municipal action.

3. Incorporate implementation of recomm regarding stormwater runoff in the capital or maintenance budget.

10.0 PLAN REVIEW, ADOPTION AND UPDATING PROCEDURES

10.1 Steps for Plan Review and Adoption

Prior to county adoption of the completed draft Stormwater Management Plan, reviews of the documentation on a local level are required by the Lackawanna River Watershed Advisory Committee, the fifty-one (51) municipalities involved, the four (4) county Boards of Commissioners and all Conservation Districts. The process described below is summarized in Figure 10-1.

Step One: Watershed Advisory Committee Review

The Watershed Advisory Committee (WAC) has played an essential role in the formation of the Lackawanna River Watershed Stormwater Management Plan. With help from the municipal members of the committee, the WAC has not only helped to prepare the plan but has also identified several storm drainage problem areas and gathered storm sewer documentation. Throughout the planning process it has been the responsibility of the Municipal Representatives who attended the meetings to report on the Plan's progress to their respective municipalities.

Once the draft plan is submitted to the Advisory Committee, it will be reviewed and a letter containing the Committee's comments and suggestions will be included along with the draft plan for municipality and county consideration.

Step Two: Municipal Review

As per Act 167, prior to County adoption of the draft Plan, a review by each planning commission and governing body of the municipalities involved is required. During the review process, consideration must be given to the plan's consistency with other plans and programs affecting the watershed.

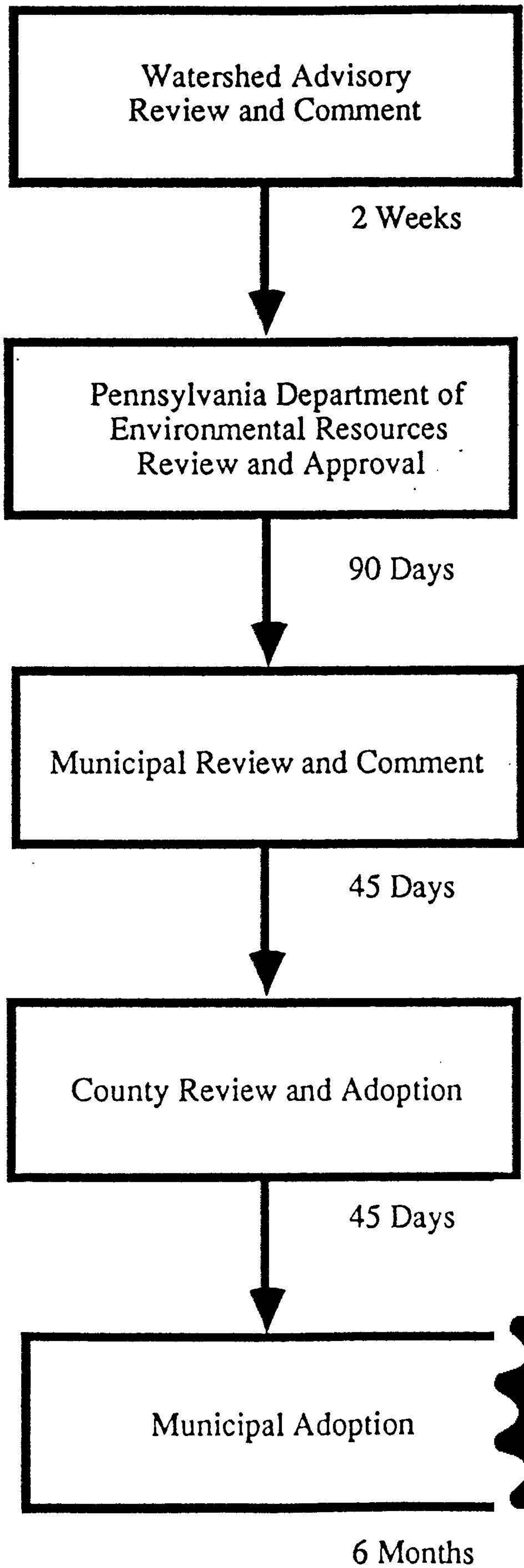
Upon review it will be the responsibility of the municipalities to compose a letter directed to the county addressing concerns and suggestions they may have regarding the plan.

Step Three: County Review and Adoption

After the Watershed Advisory Committee an
have reviewed and reported their concerns to
county Boards of Commissioners it is the respo
counties to review the plan and schedule a publ
held with at least two weeks prior notice give
public. At such time, copies of the Plan will
available for general public review. Any modi
Plan will be based upon input from the pub
comments received from the municipalities in t
county review.

PLAN REVIEW, ADOPTION & UPDATING PROCEDURES TIME LINE

FIGURE 10-1



Adoption of the Plan will be by way of resolution and will require an affirmative vote by the majority of members of the Boards of Commissioners respectively.

Upon adoption, the Plan will then be submitted to the Pennsylvania Department of Environmental Resources (PADER) for their review, comment and approval.

10.2 Steps for Updating the Plan

Step One: County Update

As per Act 167, Counties must review and, if necessary, revise the adopted watershed plan once every five (5) years at a minimum. Prior to making any changes, municipal and public review is required.

It will be the responsibility of the individual counties to monitor the implementation of the Plan by maintaining a record of all development activities which are activities regulated by the Stormwater Management Plan.

Records to be monitored include:

A. Subdivision and land developments subject to review by the Plan.

B. All building permits subject to review by the Plan.

C. All DER permits issued under Chapter 105 and 106.

Step Two: Watershed Advisory Committee Review

It will be the responsibility of the Watershed Advisory Committee to review the Plan. Possible reasons for changes or amendment are such areas as changes in zoning, the occurrence of additional storm drainage problem areas and changes in administrative responsibilities within the municipalities involved.

Upon such a review, the Committee will t
findings to the counties involved who will in
plan subject to the same rules as the adoption
Plan.

WALTER B. SATTERTHWAITE ASSOCIATES, INC.

GLOSSARY OF TERMS

Confluence	The point at which two stream channels meet and combine into one.
Design Storm	The storm event or events to which performance standards are relocated.
Encroachment	An obstruction located within two stream's floodplain.
Erosion	The "washing away" of soils and other surface materials by Stormwater runoff.
Evaporation	The process by which water is removed from an open surface by its conversion into water vapor.
Floodplain	The inundated portion of a stream valley during a storm event.
Gage	A device that records precipitation or stream flow rates.
Hydrograph	A recording of two stream's flow rate over time.
Hydrology	The science of evaluating 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.
Hyetograph	A recording of a precipitation event over time.
Impervious	A surface that allows no water to penetrate.
Infiltration	The volume of precipitation that enters into the ground over a specific land area.
Initial Abstraction	The portion of rainfall th the beginning of stormwater
Permeability	The capacity of a soil to pass through.
Pervious	A surface that allows water
Precipitation	Water that falls to the ea or hail.