

**COCALICO CREEK
ACT 167
STORM WATER MANAGEMENT PLAN
VOLUME I - EXECUTIVE SUMMARY**



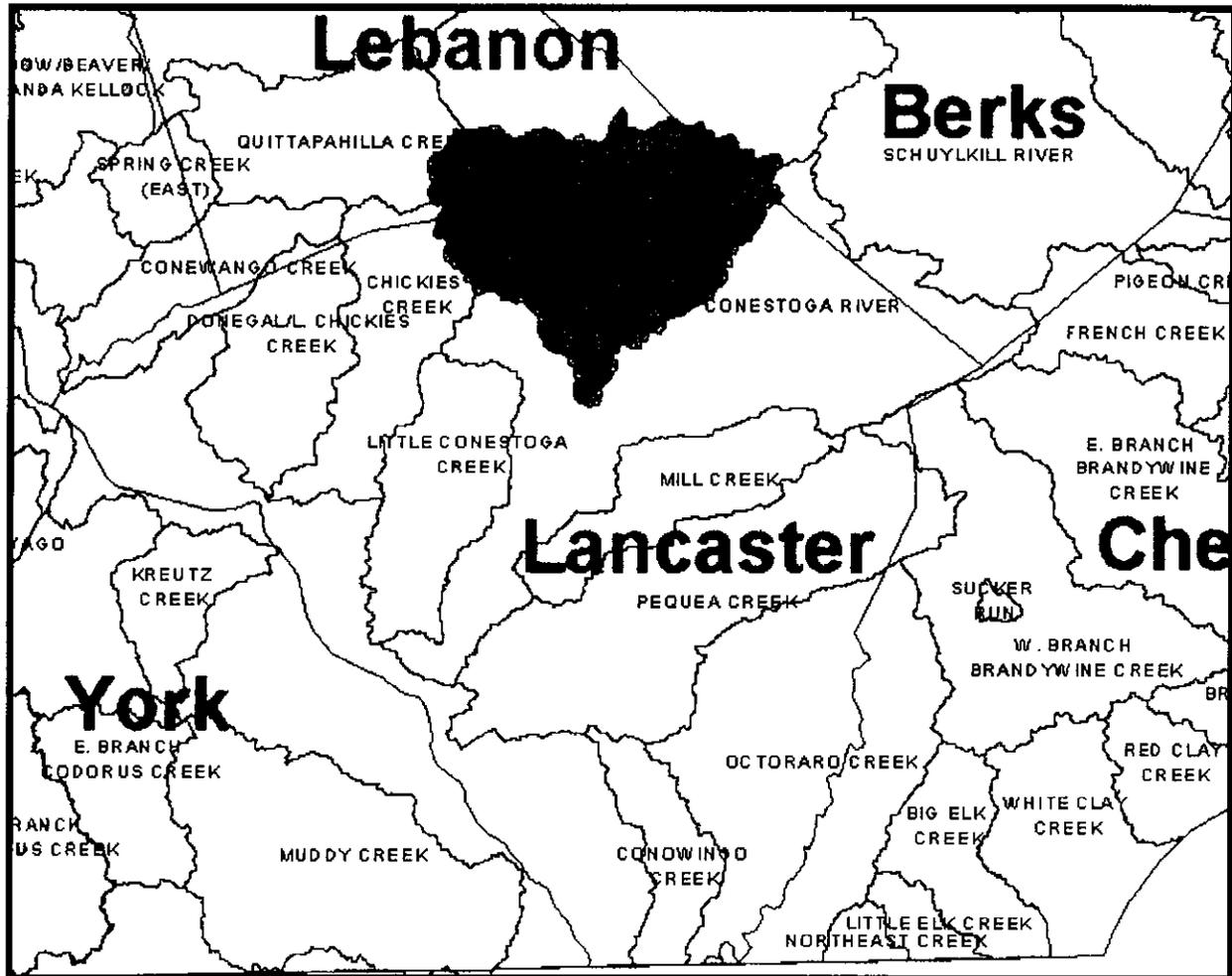
**LANCASTER COUNTY, PENNSYLVANIA
FILE NO. SWMP (061:36)
AGREEMENT NO. 359242**

June 2002

PREPARED FOR:

**LANCASTER COUNTY COMMISSIONERS
50 NORTH DUKE STREET
LANCASTER, PA 17602**

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VOLUME I

SECTION I

INTRODUCTION

A. Introduction

The Cocalico Creek Watershed is located in the Northern portion of Lancaster County and parts of Berks and Lebanon Counties. The Cocalico Creek drains into the Conestoga River.

Portions of this watershed are developed, but vast areas are still undeveloped with a potential for extensive growth under existing zoning. The effects of this potential growth and development on drainage, flooding, and erosion problems are a major concern for municipal officials and affected property owners. Extensive commercial/industrial growth along U.S. Routes 322, 222, and 501, and around the Reading - Lancaster exit of the Pa. Turnpike, can result in accelerated storm water runoff which has the potential of causing flooding and erosion problems for property owners along Cocalico Creek. Stream water quality can also become degraded as impervious areas grow throughout the watershed.

B. Storm Water Management

Storm water management entails bringing surface runoff caused by precipitation events under control. In past years, storm water control was viewed only on a site-specific basis. Recently, local perspectives and policies have changed, with the realization that proper storm water management can only be accomplished by evaluating the comprehensive picture (i.e. by analyzing what adverse impacts a development located in a watershed's headwaters may have on flooding downstream). Proper storm water management reduces flooding, soil and stream bank erosion and sedimentation and improves the overall quality of the receiving streams.

Storm water management requires cooperation between the state, county and local officials and involves proper planning, engineering, construction, operation and maintenance. This includes educating the public, local officials and developers and requires program development, financing, revising policy, developing workable criteria and adopting ordinances. The Cocalico Creek Watershed Storm Water Management Plan, prepared under the Pennsylvania Storm Water Management Act, will enable continued development to occur within the Watershed, utilizing both structural and nonstructural measures to properly manage storm water runoff in the watershed.

SECTION II

ACT 167

A. Storm Water Management Act

The Pennsylvania General Assembly, recognizing the adverse effects of inadequate management of excessive rates and volumes of storm water runoff resulting from development, approved the Storm Water Management Act, P.L. 864, No. 167, October 4, 1978. Act 167 provides for the regulation of land and water use for flood control and storm water management purposes. It imposes duties and confers powers to the Department of Environmental Protection (DEP), municipalities and counties and provides for enforcement and appropriations. The Act requires the DEP to designate watersheds and develop guidelines for storm water management and model storm water ordinances (the designated watersheds were approved by the Environmental Quality Board July 15, 1980, and the guidelines and model ordinances were approved by the Legislature May 14, 1985). The Act provides for grants to be appropriated by the General Assembly and administered by the Department for 75% of the allowable costs for preparation of official storm water management plans and administrative, enforcement and implementation costs incurred by any municipality or county in accordance with Chapter III - Storm Water Management Grants and Reimbursement Regulations (adopted by the Environmental Quality Board August 27, 1985).

Each county must prepare and adopt a watershed Storm Water Management Plan for each of its designated watersheds in consultation with the municipalities, and will periodically review and revise such plans at least every five years when funding is available. Within six months following adoption and approval of a watershed storm water plan, each municipality is required to adopt or amend, and implement ordinances and regulations as are necessary to regulate development within the municipality in a manner consistent with the applicable watershed storm water plan and the provisions of the Act.

Developers are required to manage the quantity, velocity, and direction of resulting storm water runoff in a manner which adequately protects health and property from possible injury, and must implement control measures that are consistent with provisions of the watershed plan and the Act. The Act also provides for civil remedies for those aggrieved by inadequate management of accelerated storm water runoff.

B. Purpose of the Study

There is increased sentiment statewide, as well as local recognition, that a sound and effective Act 167 Plan should be a diversified multiple-purpose plan. This plan should address the full range of hydrologic consequences resulting from development instead of simply focusing on controlling site-specific peak flow, without consideration of tributary timing, flow volume reduction, base flow augmentation, water quality control and ecological protection.

Managing storm water runoff on a site-specific basis does not meet the requirements of watershed-wide storm water management objectives. The timing of flood peaks for each subbasin within a watershed contributes greatly to the flooding potential of a particular storm. Each storm water control site within a subbasin should be managed by evaluating the comprehensive picture. The overall objective of the Plan is to maintain storm water peak flows, volumes, and quality throughout the watershed to existing conditions as the watershed becomes developed.

By developing the Cocalico Creek Watershed Act 167 Plan, reasonable regulation of development activities can be administered to control accelerated runoff, erosion, and sedimentation and thus protect the health, safety and welfare of the public. The Plan shall include recognition of the various rules, regulations and laws at the federal, state, county and municipal level. Once implemented, the Plan will aid in reducing costly flood damages by reducing the source and cause of local uncontrolled runoff. The Plan will make municipalities and developers more aware of comprehensive planning in storm water control and will also help maintain the quality of both the Cocalico Creek and its tributaries.

C. Plan Format

The plan format of the Cocalico Creek Act 167 Plan consists of Volume I, Executive Summary, and Volume II, Plan Content. Volume I provides an overview of Act 167 and Watershed Level Storm Water Management.

Volume II provides the purpose of the study, data collection, identification of existing problems, present conditions, projected and alternative land development patterns and the model ordinance. Volume II also assesses the impact of managing storm water by utilizing the criteria and standards set forth in this Plan, and provide all of the supporting data, procedures, parameters and watershed modeling.

SECTION III

COCALICO CREEK WATERSHED CHARACTERISTICS

The Cocalico Creek Watershed is located in the Northern portion of Lancaster County and parts of Berks and Lebanon Counties, and contains nineteen municipalities as listed below. Thirteen of these municipalities are in Lancaster County, four are in Lebanon County and two are in Berks County.

COCALICO CREEK WATERSHED - MUNICIPALITIES

1. Adamstown Borough, Lancaster County
2. Akron Borough, Lancaster County
3. Clay Township, Lancaster County
4. Cornwall Borough, Lebanon County
5. Denver Borough, Lancaster County
6. East Cocalico Township, Lancaster County
7. Elizabeth Township, Lancaster County
8. Ephrata Borough, Lancaster County
9. Ephrata Township, Lancaster County
10. Heidelberg Township, Lebanon County
11. Manheim Township, Lancaster County
12. Millcreek Township, Lebanon County
13. Penn Township, Lancaster County
14. South Heidelberg Township, Berks County
15. South Lebanon Township, Lebanon County
16. Spring Township, Berks County
17. Warwick Township, Lancaster County
18. West Cocalico Township, Lancaster County
19. West Earl Township, Lancaster County

A. Drainage Area

The Cocalico Creek drains a watershed area of approximately 140 total square miles (110 square miles are in Lancaster County, 25 square miles are in Lebanon County and 5 square miles are in Berks County). The major tributaries to the Cocalico Creek are Hammer Creek, Middle Creek, Indian Run, and Little Cocalico Creek.

B. Land Use

The Lancaster County GIS database shows that land use in the watershed consists of 24.2% crop land, 37.2% woodland, 30.9% pasture land, and 2.3% wetlands and water (ponds, reservoirs, etc.). Commercial and industrial uses account for 1.1% of the area, and residential use is 4.3% of the area.

Much of the woodland is part of the State Game Land System and will not be developed. The privately held woodland is currently under development pressure to provide dwellings in a forested locale.

The corridor that parallels Route 222 that includes Brownstown, Akron, Ephrata, Denver and Adamstown is currently under heavy development pressure due to its proximity to Route 222 and the Pennsylvania Turnpike. The development is residential, commercial and industrial. This corridor is expected to continue to grow rapidly.

Agriculture is expected to remain a predominant land use in this watershed. However, it is expected that most of the agricultural land along the Route 222 corridor will change to other uses in the future.

C. Topography and Stream Bed Profile

The watershed topography ranges from the moderate hills ringing the northern part of the watershed to the undulating valleys comprising the southern part. There is also a broad, flat valley in Lebanon County that is part of the headwaters of the watershed. The highest point in the watershed is on South Mountain in Millcreek Township, Lebanon County at 1360 feet. The lowest point is at the confluence with the Conestoga River below Brownstown at 275 feet. Cocalico Creek flows for a distance of approximately 26.3 miles with an average slope of about 0.8%. The lower reaches are characterized by bed slopes of about 0.1%, with meandering of the streambed and numerous horseshoe bends.

D. Soils and Geology

Soil properties influence the process of runoff generation and are therefore classified into four hydrologic soil groups, A through D. The A soils have the lowest runoff potential and are typically sands and gravels whereas the D soils have a high runoff potential and are typically clay soils. The majority of the soils in the watershed are of the B and C hydrologic soil group. The watershed consists of 71.3% B soils, 23.3% C soils, and 5.4% D soils. There do not appear to be any A type soils in the watershed, although there may be small, isolated locations where A soils do exist in the watershed.

The major soil types in the watershed are as follows:

- The Ungers - Bucks - Lansdale soil type accounts for the majority of soils in the watershed. These soils are nearly level to steep well-drained soils formed in residuum of siltstone, conglomerate, shale, and sandstone.
- The Duffield-Hagerstown soil type is formed from limestone. This soil type is found in the top, middle, and bottom of the watershed, corresponding to the areas underlain by carbonate bedrock. These areas are also typified by sinkholes and closed depressions which absorb much of the rain which would otherwise appear as runoff.
- A relatively small area of Manor-Chester-Glenelg soils are located at the North (upslope) end of the watershed. These soils are nearly level to very steep well-drained soils on broad ridge tops and side slopes; formed in residuum from mica schist, schist, gneiss and quartzite.
- There is a small area of Bedington on the ridge tops in Penn and Warwick Townships, and at the South (bottom) end of the watershed. Bedington is a nearly level to moderately sloped well drained soil, on dissected ridgetops and side slopes; formed in residuum from acid shale.

Approximately 32% of the Cocalico Creek Watershed is underlain by carbonate rock, namely limestone and dolomite. Sinkhole activity is common in these areas. Rapid infiltration of storm water runoff into the groundwater system at sinkholes and sinking streams can cause a significant reduction in streamflow and flood peaks at downstream locations. The three main areas underlain by carbonate bedrock are located in Lebanon County at the headwaters of Hammer and Middle Creeks, in an area bounded roughly by Denver and Ephrata Boroughs and extending North and West, and a small area at the very bottom (South end) of the watershed.

E. Climate

Lancaster County is generally cool and humid. The average annual precipitation is about 45 inches.

Major rain producing storms, other than hurricanes, tend to have the same general characteristics. They are slow moving storms from the south or southwest with an abundance of moisture that has been transported from the Gulf of Mexico and resupplied with Atlantic Ocean moisture by a strong, nearly stationary, Bermuda High. At the same time, there is frequently a blocking high pressure area to the northeast of Pennsylvania.

Intense local flash floods are most likely to occur in squall lines just to the east of a slow moving north-south oriented cold front. These are usually warm weather phenomena where afternoon heating adds to the instability of the already unstable, moist air mass.

Large floods occurred in June 1972 and September 1975. Lesser floods occurred in September 1987 (Nissly Acres development), November and December 1993 and January 1996.

F. Description of Data Collection

The base data came mostly from the Lancaster County GIS database. The information for Berks and Lebanon Counties came from the Berks and Lebanon County GIS databases, and USGS information for Pennsylvania obtained from the Internet.

1. **Topography:** The base map was developed using two sources. Lancaster County GIS data at a vertical interval of 5 feet was used inside Lancaster County. In Berks and Lebanon Counties, the data used was USGS 30 meter DEMs. The subwatersheds were made into a GIS coverage.
2. **Geology:** Geology plays a major role in this study. Thirty two percent of the basin has underlying carbonate geology. This was taken into consideration when the modeling process was completed.
3. **Soils:** Soils derived from the underlying bedrock (residual soils) have various drainage properties depending upon the type of bedrock from which they evolved. Soils derived from limestone shales and siltstones may be fairly well-drained. S.C.S has nationally classified soils into four hydrologic soil groups, A through D. Hydrologic soil group A is the most pervious with the least amount of natural runoff while soils in hydrologic group D are tight, low permeable soils with high runoff rates. The soil data was from Lancaster, Berks, and Lebanon County GIS coverages. There do not appear to be any A type soils in the watershed, although there may be small, isolated locations where A soils do exist in the watershed.
4. **Land Cover/Land Use and Hydrology:** Existing land use, streams, lakes, etc. was determined from 1993 Lancaster County GIS data inside Lancaster County. USGS information was used in Lebanon and Berks Counties. Future Land use was based on Lancaster County GIS zoning boundaries inside Lancaster County, and from scanned and digitized zoning maps in Berks and Lebanon Counties.

G. Significant Obstructions

Four structures were included in the watershed computer model - Rexmont #2 dam in South Lebanon Township (formerly Lebanon Reservoir), Speedwell Forge dam, Middle Creek dam, and Blue Lake dam. Physical data on the storage behind these dams was obtained from USGS Quads and Lancaster County GIS topography. Information on the dam dimensions and configuration was obtained from various State agencies which oversee the dams. We field verified the information for Blue Lake dam since the information available from the State was limited.

H. Projected/Alternative Land Development Patterns in the Watershed

1. Projected Land Development Patterns

Most of the townships within the watershed are predominantly suburban in nature and largely undeveloped. A majority of suitable land in the Boroughs has been developed. Overall, potential development pressures will be significant based on existing zoning.

Future development within the Cocalico Creek Watershed will most likely occur where public facilities are available. Commercial and industrial development will most likely be confined to industrial parks or areas where public water and sewer are or will soon be available.

2. Impact of Runoff From Future Development

A Future Land Use Map was developed using existing zoning in conjunction with physical limitations (wetlands, floodplain, topography). The potential impact of additional runoff was then evaluated by placing the future land use conditions into the computer model and re-running the model. Appendix A shows a comparison of the existing flows, future flows without control of runoff, and future flows with control of runoff (as proposed by this plan). The design storm used for the comparison is the 100-year, 24-hour SCS storm.

SECTION IV

WATERSHED TECHNICAL ANALYSIS - MODELING

A. Watershed Modeling

An initial step in the preparation of this Storm Water Management Plan was the identification of the storm water runoff simulation model to be utilized. A number of widely accepted computer models are available each of which has its own forte; however, for this study, it was necessary to select a model which:

- Could model design storms of various durations and frequencies to produce routable hydrographs which could be combined.
- Was adaptable to the size of subwatersheds in this study.
- Could evaluate specific physical characteristics of the rainfall-runoff process.
- Was capable of utilizing GIS coverages to provide model input.

The model comparison yielded the decision that TR-20 would be utilized for the following reasons:

- TR-20 was developed by the hydrology branch of the Soil Conservation Service (SCS) specifically for the analysis of the timing of surface flow contributions to peak rates at various locations in a watershed.
- The data requirements make it easily adaptable for GIS input.
- Input parameters provide a flexible calibration process.
- It has the ability to analyze reservoir or detention basin routing effects and location on the watershed.
- It is accepted by the Pennsylvania Department of Environmental Protection.

B. Calibration Process

In order to model a watershed with confidence and reliability, the chosen computer model should be calibrated against actual field data or actual storm events. We used several sources to check the model, as follows;

- Using a Pa. Fish and Boat Commission report for Speedwell Forge Dam, we found that the peak flow over the spillway for Hurricane Agnes was **6,740** cfs. This closely matched our model flow of **6,998** cfs from an 8.46" rainfall (the same as Agnes' rainfall). This is a difference of only 4%. The 8.46" of rain was obtained from the Millersville University web site for 6/22/72.
- Using a Pa. Bureau of Land Management report for Middle Creek Dam, we found that the peak flow for Hurricane Agnes was **1,615** cfs. Using 8.46" of rain in our model resulted in a flow of **2,018** cfs. Although this is a relatively large difference of 25%, it is still fairly close in the context of watershed modeling.
- A stream gauge located in Reamstown, which only captures 3.75 square miles of the 140 square mile watershed. Since the stream gauge doesn't include a rain gauge, we obtained the rainfall amounts for various storms from newspaper reports. The resulting flow versus rainfall plotting showed that all of the storms fell between the average and wet conditions TR20 model runs, as expected (the area is not underlain by carbonate geology).
- Lastly, we obtained a high water mark from Hurricane Agnes on one of the County's covered bridges that survived the storm. The bridge is located on Log Cabin Road, which is at the bottom of the watershed. Using the high water mark, County GIS topo, and estimated channel roughness values, we calculated a flow of **36,030** cfs. We next ran our model using a rainfall of 8.46" and obtained a flow of **36,474** cfs. The difference is only 1.2%.

Since we obtained good results for four different sub-watersheds, we feel confident that we have an acceptably accurate model of the Cocalico Creek watershed. As with any study involving stormwater runoff, there is as much art involved as science, and we can never expect to get completely accurate results when dealing with something as variable as rainfall and runoff characteristics in a large watershed.

We also looked at how the calibrated TR20 flows matched the FEMA Flood Insurance Study flows from approximately 1980, as follows;

Return Period	10 Year	50 Year	100 Year
Calibrated TR20	10,117	18,132	24,513
FEMA FIS	8,270	13,850	16,690
% Difference	22%	31%	47%

This shows that the FEMA flows, about 20 years old, appear to be too low. This is mainly due to the large amount of development that has taken place in the last 20 years, and the accompanying increase in runoff volume and coincident peaks due to watershed timing issues.

C. Modeling Process

The Cocalico Creek Watershed was subdivided into 107 subwatersheds for modeling purposes. Considerations in the subdivision process were: location of obstructions, known flooding, drainage or erosion problems, zoning, and tributary confluences. The most downstream point of each of these areas was considered a “point of interest” in which increased runoff was analyzed for its potential impact.

The watershed was modeled to determine the hydrologic response for the 2, 5, 10, 25, 50 and 100-year storm events for the 24-hour storm..

The modeling process addressed:

- peak discharge values at 107 locations along the stream and its tributaries;
- time to peak for the above discharges;
- runoff contributions of individual subareas at all downstream locations;
- flow values contained in the channel and overflow values; and
- overall watershed timing.

The modeling process assumed the future 100 year floodplains to be in the same condition as today. Lancaster County has a history of significant flooding. This is a result of the low slope meandering streams which exist in the County. It is imperative that the floodplains be kept free and clear, as assumed in this model, in the future to alleviate increased flooding of the existing development. The plan strongly supports a policy of no encroachment into the 100 year floodplain.

The potential for future development of this watershed required a model approach which could analyze the effects of different levels of development. The County has developed a "tool" (actually a computer program) which allows the modification of the hydrological model for this watershed to be adjusted between existing and future development by subwatershed and to adjust the model beyond the existing zoning and look at a total build out scenario. This tool allows the hydrologist to change the percentage release rates for each individual subwatershed and allows the results to be evaluated in a few minutes. In essence, this tool allowed the County to look at many different scenarios to develop this plan. The WPAC decided that an "across the board" 50% release rate would be the easiest to implement and control and was the most equitable for this basin. The computer program is available on the Lancaster County Website, and can be used by the Municipal Engineers and others for use in complying with this plan.

After adoption of the plan, this program will allow the County to determine the effects of zoning changes, when requested, and provide solutions if the proposed zoning change will have an adverse impact on the watershed. Since all zoning changes are reviewed by the Lancaster County Planning Commission, the need to reevaluate the plan can occur as each change is requested and not every five years as suggested by the Act. Changes to the plan may be required if large areas are rezoned from existing lower density zoning to higher density zoning.

SECTION V

STANDARDS AND CRITERIA FOR THE CONTROL OF STORM WATER RUNOFF

A. Performance Standards

1. “Match Pre-existing Hydrograph”

Developers and/or landowners are encouraged to provide infiltration facilities or utilize other techniques so that the post-development hydrograph will match the pre-existing hydrograph for the site. This option is most feasible for small subdivisions in areas of non-carbonate geology. “Groundwater Recharge” and “Water Quality” volumes will be a part of this option.

2. Groundwater Recharge Standard

Recharging rainfall into the ground replenishes the groundwater that, in turn, provides baseflow to streams, a process that keeps streams flowing during the dryer summer months and maintains groundwater for drinking purposes. Storm water management measures such as porous pavement with underground infiltration beds and infiltration/recharge structures or Best Management Practices (BMPs) can be designed to promote groundwater recharge. Infiltration BMPs shall meet the following minimum requirements:

- Infiltration BMPs intended to receive runoff from developed areas shall be selected based on suitability of soils and site conditions and shall be constructed on soils that have the following characteristics:
 - A minimum depth of 48 inches between the bottom of the facility and the seasonal high water table and/or bedrock (limiting zones)
 - An infiltration and/or percolation rate sufficient to accept the

- additional storm water load and drain completely as determined by field tests conducted by the Owner's professional designer.
- Infiltration BMPs receiving only roof runoff may be placed in soils having a minimum depth of 24 inches between the bottom of the facility and the limiting zone.
 - The size of the recharge facility shall be based upon the following equation:

$$Re_v = [(S) (R_v)(A)] / 12$$

Re_v = Recharge volume in acre-feet

A = Area of watershed in acres

$R_v = 0.05 + 0.9(I)$ where *I* is the new impervious area / Area of watershed (A)

S = Soil Specific Recharge factor and varies according to soil type, as follows:

<u>Hydrologic Soil Group</u>	<u>Soil Specific Recharge Factor (S):</u>
A	0.32
B	0.22
C	0.10
D	0.05

- If more than one hydrologic soil group (HSG) is present at a site, a composite recharge volume shall be computed based upon the proportion of total site area within each HSG.
- The recharge volume provided at the site shall be directed to the most permeable HSG available.
- The recharge facility shall be capable of completely infiltrating the impounded water within 48 hours.
- Watersheds where the post developed impervious area is equal to or less than the pre developed impervious area shall not be required to provide Ground Water Recharge volume.

- The general process for designing the infiltration BMP shall be:
 1. Analyze the hydrologic soil groups as well as natural and man-made features within the watershed to determine general areas of suitability for infiltration practices.
 2. Provide a field test to determine appropriate percolation rate and/or hydraulic conductivity.
 3. Design the infiltration structure for the required storm volume based on field determined capacity at the level of the proposed infiltration surface.

Extreme caution shall be exercised where infiltration is proposed in geologically susceptible areas such as limestone areas. Extreme caution shall also be exercised where salt or chloride would be a pollutant since soils do little to filter this pollutant and it may contaminate the groundwater. A detailed hydrogeologic investigation may be required.

It is extremely important that strict erosion and sedimentation control measures be applied surrounding infiltration structures during installation to prevent the infiltrative surfaces from becoming clogged. It is also extremely important that the design professional evaluate the possibility of groundwater contamination from the proposed infiltration/recharge facility and recommend a hydrogeologic justification study be performed if necessary. Recharge/infiltration facilities may be used in conjunction with other innovative or traditional BMPs, storm water control facilities, and nonstructural storm water management alternatives.

Structural Storm water management facilities which provide treatment and recharge of the required Recharge Volume will be designed as part of a storm water management facility which incorporates groundwater recharge BMPs as a primary benefit of using that facility, in accordance with design specifications contained in "Pennsylvania Handbook of Best management Practices for Developing Areas", 1998.

3. Water Quality Standard

Pollutants accumulate on impervious surfaces between rainfall events or during dry weather. Pollutant concentrations in runoff from developed land tends to be greatest at the beginning of the storm event, or the "first flush" of runoff. It has been found that eighty to ninety percent of rainfall events are 1.2" or less, storms that essentially simulate this "first flush". The majority of the nonpoint source pollutants, therefore, are being washed into streams during the smaller storms. Capturing this first flush and/or smaller storms will allow the storm water to be detained and will allow pollutants to settle, thus allowing a "cleaner" outflow.

To achieve this goal, the following criteria is established:

Determine the volume of runoff from the first 1.2" of rainfall and detain this amount from each storm, releasing the runoff slowly over a minimum of 24 hours. The design of the facility shall consider and minimize the chances of clogging and sedimentation potential.

Calculation of Water Quality Volume: The Water Quality Volume (WQ_v) is the storage capacity needed to treat storm water runoff equivalent to a minimum of the first 1.2" of runoff from the developed areas of the site. The following calculation is used to determine the storage volume, WQ_v , in acre-feet of storage:

$$WQ_v = [(1.2) (R_v)(A)] / 12$$

WQ_v = Water Quality volume in acre-feet

A = Area of watershed in acres

R_v = $0.05 + 0.9(I)$ where I is the new impervious area / Area of watershed (A)

WQ_v shall be designed as part of a storm water management facility which incorporates water quality BMPs as a primary benefit of using that facility, in accordance with design specifications contained in "Pennsylvania Handbook of Best Management Practices for Developing Areas", 1998. The facility must take a minimum of 24 hours after the end of the design storm to drain. Watersheds where the post developed impervious area is equal to or less than the pre developed impervious area shall not be required to provide Ground Water Recharge volume.

4. Description of Performance Standard Districts

In performing the tasks for the Cocalico Creek Watershed Plan under Act 167, the goal was to provide a runoff control strategy which could be implemented so as not to increase storm water runoff anywhere in the Cocalico Creek basin. It was also important to determine to what extent storm water detention would be required in individual subareas. Specific goals were to try to have no increase in storm water flows at any point of interest and to maintain as few different release rate areas as possible. It was found during the watershed study that a release rate of 50 percent of the pre-existing flow rates in all areas provided results which were not significantly different (5 percent) than any variable release rate scenario. The variable release rate scenarios evaluated for this basin indicated that most of the development potential of the basin exists around the edges of the watershed. A release rate of fifty percent of the pre-existing runoff rate was required so the tributaries and the main branch were not impacted. The rural area lends itself to infiltration control measures which would allow proposed development to meet the pre-existing hydrograph by infiltration and not be required to provide reduced discharge rates. "Groundwater Recharge" and "Water Quality" volumes as described in Sections 302.C and 302.D of the model ordinance will be a part of this option.

5. Sub-Regional (Combined Site) Storage

Traditionally, the approach to storm water management has been to control the runoff on an individual site basis. However, there is a growing commitment to finding cost-effective comprehensive control techniques which both preserve and protect the natural drainage system. In other words, two developers developing sites adjacent to each other could pool their capital resources to provide for a community storm water storage facility in the most hydrologic advantageous location.

The goal should be the development and use of the most cost-effective and environmentally-sensitive storm water runoff controls which significantly improves the capability and flexibility of land developers and communities to control runoff consistent with the Cocalico Creek Management Plan.

An advantage to combining efforts is to increase the opportunity to utilize storm water control facilities to meet other community needs. For example, certain storm water control facilities could be designed so that recreational facilities such as ball fields, open space, volleyball, etc. could be incorporated. Natural or artificial ponds and lakes could serve both recreational and storm water management objectives.

To take this concept a step further, there is also the possibility that the storm water could be managed "off-site;" that is, in a location off of the property(s) in question. There could be publicly owned detention, retention, lake, pond or other physical facilities to serve multiple developments. The design and release rate would need to be consistent with the Plan. "Groundwater Recharge" and "Water Quality" volumes as described in Sections 302.C and 302.D of the model ordinance will be a part of this option.

6. “No Harm Option”

The “No Harm” option does not apply to the water quality requirement described in item number 2 above. The “No Harm” option does not apply to the groundwater recharge requirement described in item number 3 above, unless it can be shown that the site is underlain by carbonate geology and infiltration can not be safely accomplished.

For any proposed development, the developer has the option of using a less restrictive runoff control if the developer can prove that “no harm” would be caused by discharging at a higher runoff rate than that specified by the Plan. Proof of “no harm” would have to be shown from the development site through the remainder of the downstream drainage network until there is no additional flow increase. Proof of “no harm” must be shown using the capacity criteria specified in Section 303.C of the Model Ordinance if downstream capacity analysis is a part of the “no harm” justification.

Attempts to prove “no harm” based upon downstream peak flow versus capacity analysis shall be governed by the following provisions:

- a. The peak flow values to be used for downstream areas for the design return period storms (2-, 5-, 10-, 25-, 50-, and 100-year) shall be the values from the calibrated TR-20 Model for the Cocalico Creek Watershed. These flow values would be supplied to the developer by the County upon request.
- b. At peak flow, any available capacity in the downstream conveyance system (as documented by a developer) may be used only in proportion to the proposed development site acreage relative to the total upstream undeveloped acreage (i.e. if the site is 10% of the upstream undeveloped acreage, the developer may use up to 10% of the documented downstream available capacity at peak flow).

- c. Developer-proposed runoff controls which would generate increased peak flow rates at documented storm drainage problem areas would, by definition, be precluded from successful attempts to prove "no harm," except in conjunction with proposed capacity improvements for the problem areas consistent with Section 303.C. of the Model Ordinance.

Appendix A

TABLE III-3
PRESENT VERSUS FUTURE FLOWS
100 Year Storm of 24-hour Duration

Sub-area Number	Area (sq. mi.)	Present Flow (cfs)	Cumulative Area (sq. mi.)	Cumulative Present Flow (cfs)	Cum. Future Flow w/ 100% Release Rate in Developable Areas (cfs)	Cum. Future Flow w/ 50% Release Rate in Developable Areas (cfs)
1	0.58	249.0	0.58	249.0	249.0	249.0
2	1.09	617.0	1.09	401.0	401.0	401.0
3	2.05	411.0	3.72	863.0	863.0	863.0
4	2.30	376.0	6.02	1195.0	1195.0	1007.0
5	1.32	674.0	7.34	1501.0	1524.0	1337.0
6	0.75	274.0	0.75	274.0	274.0	137.0
7	0.83	452.0	0.83	452.0	452.0	226.0
8	0.68	325.0	1.51	733.0	766.0	390.0
9	1.30	300.0	2.05	553.0	572.0	287.0
10	1.38	297.0	1.38	297.0	297.0	149.0
11	1.04	512.0	5.98	1885.0	**2,010.0	1223.0
12	1.25	512.0	14.57	3473.0	**3,674.0	2744.0
13	1.03	466.0	15.60	3486.0	**3,694.0	2793.0
14	0.80	350.0	0.80	350.0	350.0	350.0
15	1.28	588.0	0.80	888.0	888.0	888.0
16	0.94	446.0	2.08	3952.0	4140.0	3279.0
17	1.51	936.0	18.62	4114.0	4297.0	3461.0
18	1.60	841.0	20.13	841.0	844.0	844.0
19	0.75	512.0	1.60	512.0	527.0	527.0
20	1.61	1,366.0	0.75	4787.0	4953.0	4755.0
21	0.70	727.0	24.09	4503.0	4686.0	4274.0
22	1.19	710.0	24.79	710.0	710.0	710.0
23	1.24	335.0	1.19	335.0	335.0	335.0
24	1.51	904.0	1.24	4577.0	4760.0	4328.0
25	1.34	430.0	28.73	430.0	430.0	430.0
26	1.08	399.0	1.34	4606.0	4788.0	4365.0
27	1.87	567.0	31.15	4612.0	4808.0	4569.0
28	2.23	646.0	33.02	4634.0	4832.0	4601.0
29	0.75	647.0	35.25	647.0	647.0	324.0
30	0.59	280.0	0.75	280.0	287.0	287.0
31	1.55	591.0	0.59	787.0	814.0	519.0
32	1.67	926.0	2.14	1354.0	1414.0	1230.0
33	1.62	709.0	3.81	709.0	726.0	726.0
34	1.41	531.0	1.62	644.0	648.0	648.0
35	1.32	827.0	3.03	2329.0	**2,704.0	2117.0
36	1.34	357.0	8.16	357.0	357.0	179.0

Sub-area Number	Area (sq. mi.)	Present Flow (cfs)	Cumulative Area (sq. mi.)	Cumulative Present Flow (cfs)	Cum. Future Flow w/ 100% Release Rate in Developable Areas (cfs)	Cum. Future Flow w/ 50% Release Rate in Developable Areas (cfs)
37	0.86	455.0	1.34	455.0	455.0	228.0
38	2.26	1,460.0	0.86	1812.0	**1,931.0	1704.0
39	0.86	442.0	4.46	442.0	442.0	442.0
40	0.75	318.0	0.86	318.0	318.0	318.0
41	1.79	1,325.0	0.75	1374.0	1369.0	1276.0
42	1.51	618.0	7.86	1503.0	1497.0	1399.0
43	0.66	304.0	9.37	304.0	304.0	304.0
44	2.20	995.0	0.66	1673.0	1663.0	1639.0
45	1.20	648.0	12.23	1957.0	1968.0	1948.0
46	1.55	446.0	13.43	4529.0	**4,972.0	4266.0
47	0.84	267.0	23.14	4439.0	**4,785.0	4206.0
48	1.00	277.0	23.98	277.0	277.0	277.0
49	1.41	477.0	1.00	723.0	726.0	726.0
50	0.59	313.0	2.41	841.0	**903.0	819.0
51	0.95	292.0	3.00	292.0	292.0	146.0
52	1.07	387.0	0.95	387.0	387.0	194.0
53	0.77	238.0	1.07	832.0	**925.0	591.0
54	1.62	400.0	2.79	5262.0	**5,827.0	5037.0
55	1.34	422.0	31.39	5308.0	**5,869.0	5104.0
56	0.77	423.0	32.73	423.0	423.0	423.0
57	1.87	1,023.0	0.77	1327.0	1335.0	1335.0
58	1.69	833.0	2.64	1950.0	1985.0	1985.0
59	1.70	355.0	4.33	2209.0	2248.0	2248.0
60	1.15	610.0	6.03	610.0	**644.0	**644.0
61	1.01	334.0	1.15	778.0	**819.0	**819.0
62	0.27	114.0	2.16	810.0	849.0	849.0
63	0.60	230.0	2.43	230.0	230.0	115.0
64	1.06	517.0	0.60	698.0	**747.0	373.0
65	1.50	480.0	1.66	3416.0	**3,704.0	3391.0
(MC1) *66	1.28	568.0	11.62	568.0	568.0	284.0
(MC2) *67	2.77	1,397.0	1.28	1595.0	**1,724.0	1567.0
(MC3) *68	2.31	1,139.0	4.05	2468.0	**2,621.0	2491.0
69	1.48	963.0	6.36	963.0	967.0	967.0
70	1.28	1,104.0	1.48	1104.0	1108.0	1108.0
71	2.00	1,175.0	1.28	1175.0	1175.0	588.0
72	0.98	543.0	2.00	1644.0	1695.0	1121.0
73	1.00	802.0	2.98	802.0	802.0	401.0
(MC4) *74	1.29	736.0	1.00	5108.0	**5,365.0	4890.0
75	1.29	632.0	13.39	632.0	640.0	640.0
(MC5) *76	2.01	933.0	1.29	6045.0	6318.0	5858.0
(MC6) *77	1.10	817.0	17.69	5844.0	6108.0	5708.0

Sub-area Number	Area (sq. mi.)	Present Flow (cfs)	Cumulative Area (sq. mi.)	Cumulative Present Flow (cfs)	Cum. Future Flow w/ 100% Release Rate in Developable Areas (cfs)	Cum. Future Flow w/ 50% Release Rate in Developable Areas (cfs)
(MC7) *78	1.06	346.0	18.79	5939.0	6218.0	5837.0
79	0.93	506.0	19.85	506.0	506.0	253.0
80	0.78	456.0	0.93	928.0	**984.0	481.0
81	0.92	431.0	1.71	431.0	431.0	431.0
82	1.74	939.0	0.92	1233.0	1288.0	819.0
83	0.93	605.0	2.66	2544.0	**2,830.0	1582.0
84	0.51	380.0	5.30	380.0	380.0	190.0
85	2.17	1,040.0	0.51	3718.0	**4,166.0	2263.0
86	1.06	577.0	7.98	577.0	577.0	289.0
87	0.64	378.0	1.06	881.0	918.0	659.0
88	2.02	968.0	1.70	1559.0	**1,660.0	1000.0
89	1.60	923.0	3.72	1810.0	**2,145.0	1416.0
90	0.97	524.0	5.32	5512.0	**6,637.0	3919.0
(MC8) *91	1.43	377.0	14.27	10829.0	**12,359.0	9885.0
92	1.83	973.0	35.55	973.0	973.0	487.0
93	1.52	848.0	1.83	1681.0	**1,824.0	910.0
94	0.73	643.0	3.35	643.0	643.0	322.0
(MC9) *95	1.71	331.0	0.73	11768.0	**14,099.0	11040.0
96	0.75	233.0	41.34	233.0	233.0	233.0
97	1.29	326.0	0.75	513.0	516.0	353.0
98	1.30	658.0	2.04	658.0	658.0	329.0
(MC10) *99	1.79	432.0	1.30	11632.0	**13,906.0	11254.0
(MC11)*100	1.60	936.0	44.43	11857.0	**14,143.0	11722.0
101	1.19	1,100.0	48.07	1100.0	1100.0	550.0
(MC12)*102	0.98	535.0	1.19	14345.0	**16,937.0	14053.0
(MC13)*103	1.46	1,509.0	61.86	14349.0	**16,915.0	14067.0
(MC14)*104	3.32	2,281.0	63.32	14596.0	**17,144.0	15177.0
(MC15)*105	1.47	849.0	66.64	23307.0	**26,490.0	24116.0
(MC16)*106	2.33	1,668.0	136.84	23197.0	**26,323.0	23942.0
(MC17)*107	1.02	200.0	139.17	23223.0	**26,354.0	24032.0

Note: These flows were developed for storm water planning purposes and are not considered regulatory under DEP, Chapter 105 for permitting of structures

* MC denotes those Subareas on the Main Channel of the Cocalico Creek. The accompanying number signifies the position on the Main Channel that the Subarea occupies, with 1 being at the top of the watershed, and 17 being at the bottom.

** Future flow more than 5% in excess of present flow.

Appendix B

STORM-WATER RUNOFF PROBLEM SITES

MUNICIPALITY QUESTIONNAIRE RESULTS

No Problem Areas in the Cocalico Creek watershed

CORNWALL BORO., LEBANON COUNTY
MILLCREEK TWP., LEBANON COUNTY
PENN TWP., LANCASTER COUNTY
SPRING TWP., BERKS COUNTY
WARWICK TWP., LANCASTER COUNTY

General Problems

ADAMSTOWN BORO., LANCASTER COUNTY

General stream and street flooding, conveyance problems, and impacts on threatened species (Big Turtles), also small lot sizes near flood plain that are too small to be developed or expanded with storm water detention facilities. Possible impact due to Route 222 project. Caused by too large an increase in uncontrolled runoff, uncontrolled runoff from upstream municipalities, lack of maintenance of drainage ways, drainage system is too small and has obstructions that need to be removed.

CLAY TWP., LANCASTER COUNTY

Flooding of farmland around bridges in major events

ELIZABETH TWP., LANCASTER COUNTY
 General soil washoff and stormwater pollution problems more than one time per year, caused by undersized drainage system(s)

EPHRATA TWP., LANCASTER COUNTY

General minor roadway/gutter damage - occurs more than 1 time per year, due to uncontrolled flow from upstream municipalities and undersized drainage system(s)

MANHEIM TWP., LANCASTER COUNTY

General flooding of farm crossings in major events, caused by obstructions, lack of maintenance of drainage ways, increase in uncontrolled runoff, drainage from upstream municipalities, and undersized drainage system(s)

WEST EARL TWP., LANCASTER COUNTY

General stream and street flooding, soil washoff and stormwater pollution problems more than 10 times per year. Trash and debris wash into the Township during major events. Caused by too large an increase in uncontrolled runoff, uncontrolled runoff from upstream municipalities, and lack of maintenance of drainage ways. Also, not enough Erosion and Sedimentation control in the farming Community. Not enough terraces and waterways built.

Specific Problems

AKRON BORO., LANCASTER COUNTY

1. Heritage development along Cocalico Creek - minor property damage, infiltration into sewer system

DENVER BORO., LANCASTER COUNTY

2. 300 and 400 blocks of Locust Street - basement flooding, vehicle and road surface deterioration - occurs more than 10 times per year, caused by lack of underground drainage
 3. N. 3rd and Main Street - basement flooding, vehicle and road surface deterioration - occurs more than 1 time per year, caused by lack of underground drainage East Cocalico Twp., Lancaster County

EAST COCALICO TWP., LANCASTER COUNTY

4. Little Cocalico Creek and Ridge Road - Stream flooding, Soil washoff, Bridge opening
 5. Intersections of Smokestown, Mill, and Roshols Road at confluence of Little Cocalico Creek and Fry's Run - Stream flooding, Bridge opening
 6. Fry's Run at Dogwood Drive - Stream flooding, Bridge opening
 7. Fry's Run at White Oak Road - Stream flooding, Street flooding, Bridge opening
 8. Fry's Run at Smokestown Road - Stream flooding, Street flooding, Bridge opening
 9. Stony Run at Hill Road - Stream flooding, Bridge opening
 10. Cocalico Creek in vicinity of West Church Street - Stream flooding
 11. Stony Run at Bunker Hill Road - Stream flooding, Bridge opening
 12. Stony Run at West Church Street - Stream flooding, Bridge opening
 13. Cocalico Creek at Cocalico Creek Road - Stream flooding
 14. Haldemans Mobile Home Park (Justh Circle and Wabash Road) - Stream flooding
 * Stormwater pollution at High Concrete Yard (not shown on map)

EPHRATA BORO., LANCASTER COUNTY

15. Nisley Acres (Niss, Bellevue, and James Avenues) flooding occurs during major events, caused by too large an increase in uncontrolled runoff and uncontrolled runoff from upstream municipalities
 16. GOO Block of W. Main Street - occurs during major events, caused by undersized drainage system and lack of maintenance of drainage ways
 17. Walnut Street East - occurs during more than 10 times per year, caused by undersized drainage system (problem is being corrected)

HEIDELBERG TWP., LEBANON COUNTY

18. Stream flooding on Hammer Creek - occurs in major events, caused by natural constriction of drainage way - causes minor road damage

SOUTH HEIDELBERG TWP., BERKS COUNTY

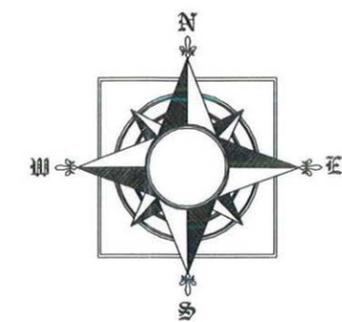
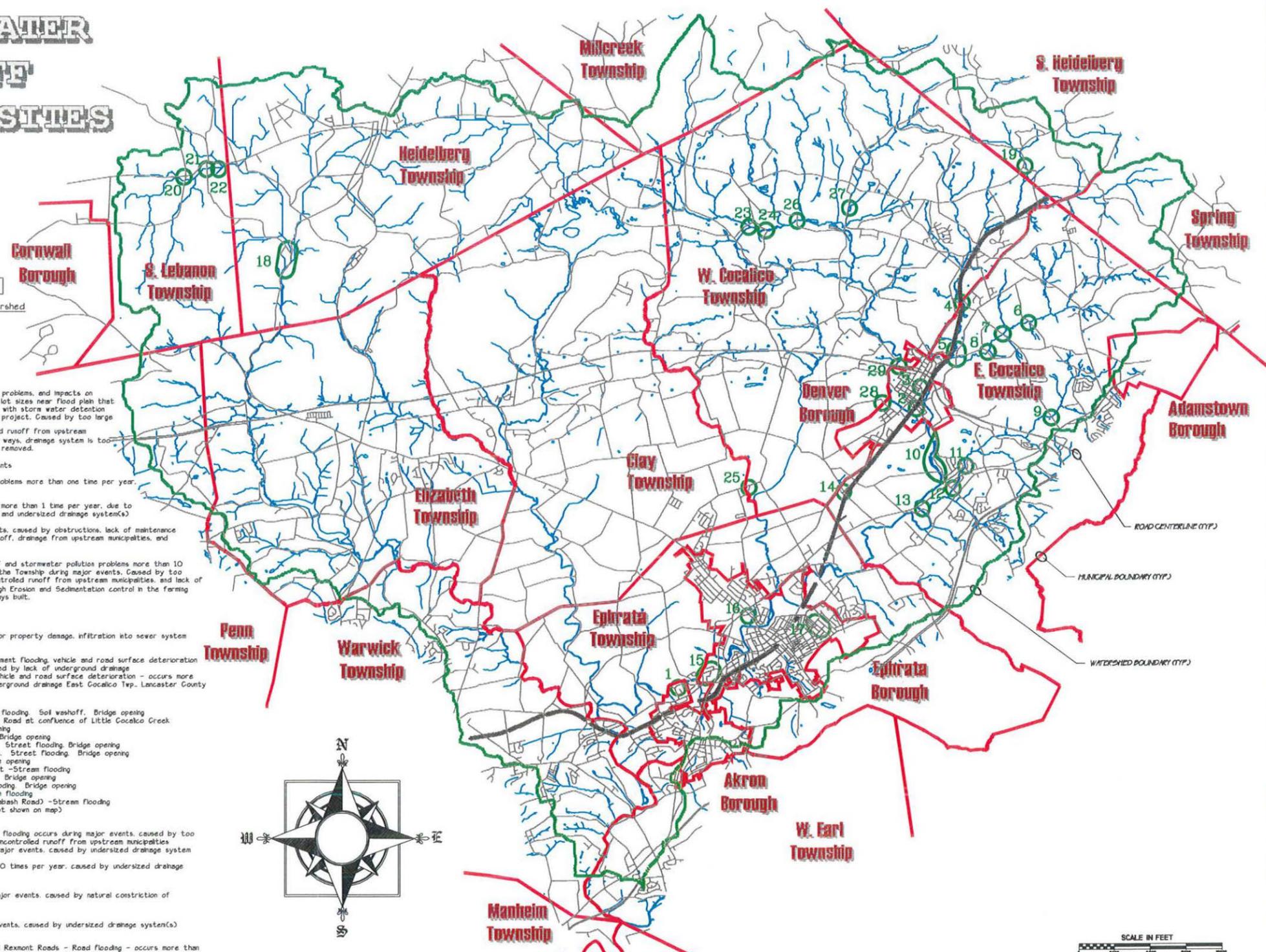
19. Stream flooding on Mill Road - occurs in major events, caused by undersized drainage system(s)

SOUTH LEBANON TWP., LEBANON COUNTY

20. Hammer Creek at intersection of Schaeffer and Rexmont Roads - Road flooding - occurs more than once per year, caused by too large an increase in uncontrolled runoff
 21. Hammer Creek and Obie Road - Road flooding - occurs more than once per year, caused by too large an increase in uncontrolled runoff
 22. Hammer Creek between Obie Road and Heidelberg Twp. line - Stream flooding - occurs more than once per year, caused by too large an increase in uncontrolled runoff

WEST COCALICO TWP., LANCASTER COUNTY

23. Confluence of Cocalico Creek and Hickory Road - flooding occurs more than 10 times per year, caused by undersized drainage system, obstructions in system, and lack of maintenance of drainage ways - road is too low in relation to the pipe under the road
 24. Confluence of Cocalico Creek and bridge over Preview Drive - flooding occurs during major events, caused by undersized drainage system - bridge approach is low
 25. Confluence of Trout Run Creek and Heckman Road - flooding occurs during major events, caused by too large an increase in uncontrolled runoff - dangerous in major events
 26. Sportsman Road and Cocalico Creek
 No other information provided
 27. Pearltown Road South of Rt. 897
 No other information provided
 28. Long Lane at Denver Borough line
 No other information provided
 29. Cocalico Creek at Greenville Road and Leisley Road - potentially dangerous during major events - no other information provided



PROBLEM SITES
COCALICO CREEK
 LANCASTER COUNTY ACT 167
 STORM WATER MANAGEMENT PLAN
 PHASE II AGREEMENT # ME 359242

L ANCASTER
 C COUNTY
 E ENGINEER'S
 O OFFICE

DATE: JAN. 11, 2001 SCALE: 1" = 5,000' DRAWN BY: ACW.