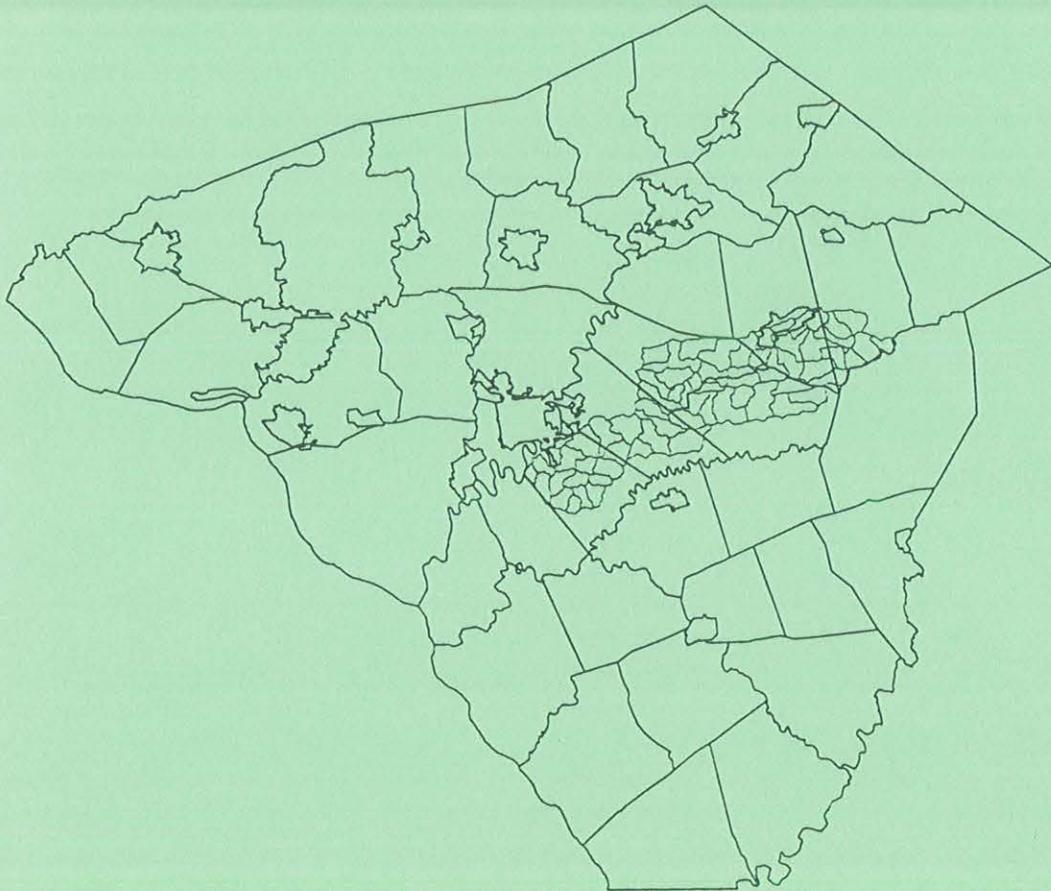


**ACT 167  
WATERSHED STORM WATER  
MANAGEMENT PLAN**

**VOLUME 1 - EXECUTIVE SUMMARY**

**MILL CREEK WATERSHED**



LANCASTER COUNTY, PENNSYLVANIA  
FILE NO. SWMP (193:36)  
PROJECT NO. 92428

DECEMBER 1996

PREPARED FOR:

LANCASTER COUNTY COMMISSIONERS  
50 NORTH DUKE STREET  
LANCASTER, PA 17602

Act 167  
Watershed Storm Water Management Plan  
Phase II  
Mill Creek

Agreement No. SWMP 193:36  
Project No. 92428

**VOLUME 1**  
**EXECUTIVE SUMMARY**

Prepared by:

*Lancaster County Engineer's Office*  
50 North Duke Street  
Lancaster, PA 17602

# VOLUME I - EXECUTIVE SUMMARY

## TABLE OF CONTENTS

	<u>Page</u>
I. BACKGROUND INFORMATION	1
A. INTRODUCTION	1
B. STORM WATER RUNOFF - ITS PROBLEMS & SOLUTIONS	1
C. STORM WATER MANAGEMENT	2
D. STORM WATER MANAGEMENT ACT	2
E. PURPOSE OF THE STUDY	3
F. PLAN FORMAT	4
II. PLAN PREPARATION PROCESS	4
A. PHYSICAL WATERSHED CHARACTERISTICS	4
B. DEVELOPMENT AND CALIBRATION OF A MODEL	5
C. RUNOFF CONTROL STRATEGY	5
III. WATERSHED LEVEL STORM WATER MANAGEMENT	6
A. DESCRIPTION OF PERFORMANCE STANDARD DISTRICTS	6
B. SUBREGIONAL (COMBINED SITE) STORAGE	8
C. "NO HARM OPTION"	9
D. "HARDSHIP OPTION"	10
E. "MATCH PRE-EXISTING HYDROGRAPH"	10

### APPENDICES

#### A. SUBAREA PEAK FLOW TABLES

### PLATES

#### I. SUBWATERSHED BOUNDARY MAP

## VOLUME I - EXECUTIVE SUMMARY

### I. BACKGROUND INFORMATION

#### A. INTRODUCTION

The Mill Creek watershed is located in the eastern portion of Lancaster County adjacent to the Conestoga River.

Large portions of this watershed are undeveloped with a potential for extensive growth. The effect of this growth and development on drainage, flooding, and erosion problems is a major concern for County and Township officials, as well as affected property owners. Extensive commercial and industrial growth along Routes 30, 340, and 23 could result in accelerated storm water runoff which has the potential of causing flooding and erosion problems for property owners along Mill Creek and its tributaries. Stream water quality can also become degraded as impervious areas grow throughout the watershed.

#### B. STORM WATER RUNOFF - ITS PROBLEMS AND ITS SOLUTIONS

The water that runs off the land into surface waters during and immediately following a rainfall event is referred to as storm water. In any watershed in which development occurs, the volume of storm water resulting from a particular rainfall event increases because of the increase in impervious land area (i.e., pavement, concrete, or buildings). That is, the alteration of natural 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 pressures increase, so will the problems of dealing with the increased quantity of storm water runoff. Failure to properly manage this runoff will result 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 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 the 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 damage 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 (i.e., watershed-level) approach must be taken if a reasonable and practical management and implementation approach and/or strategy is to be successful.

C. STORM WATER MANAGEMENT

The broad perspective of storm water management deals with bringing surface runoff caused by precipitation events under control. In former years, storm water control was viewed only on a site-specific basis. Recently, local perspectives and policies have changed, realizing 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 involves cooperation between state, county and local officials and involves proper planning, engineering, construction, operation and maintenance. This entails educating the public and local officials, and requires program development, financing, revising policy, and development of workable criteria and adoption of ordinances. The Mill Creek Watershed Storm Water Management Plan, under the Storm Water Management Act, will enable the Mill Creek watershed to develop in a controlled, systematic fashion utilizing both structural and non-structural measures to properly manage storm water runoff in the watershed.

D. 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, municipalities and counties, and provides for enforcement and appropriations. The Act requires the Department 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). The Act specifies that each county will 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 each 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, timing and direction of resulting storm water runoff in a manner which adequately protects health and property from possible injury, and must implement such measures that are consistent with the provisions of the watershed plan and the Act. It also provides for civil remedies for those aggrieved by inadequate management of accelerated storm water runoff.

#### **E. PURPOSE OF THE STUDY**

There is an increased sentiment state-wide, as well as local recognition, that a sound and effective storm water management 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 peak flows throughout the watershed equal to or less than existing conditions as the watershed becomes developed.

By developing the Mill Creek Watershed Storm Water Management Plan, reasonable regulation of development activities can be administered to control accelerated runoff 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 Mill Creek and its tributaries.

## F. PLAN FORMAT

The Plan format of the Mill Creek Storm Water-Management Plan consists of Volume I, Executive Summary, Volume II, Plan Content, and the Technical Appendices. 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 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.

The Technical Appendices provide all of the supporting data, procedures, parameters and watershed modeling.

In order to provide for planning consistency in computational methods utilized for storm water calculations in the Mill Creek watershed, standards and criteria had to be established. Thus, standards were established for runoff curve numbers, rational "C" values, rainfall depths and intensities, and time of concentrations.

## II. PLAN PREPARATION PROCESS

The detailed process involved in the preparation of the Mill Creek Watershed Act 167 Plan included the documentation of the physical watershed characteristics, development of a computer runoff simulation model based upon the documented watershed characteristics, "calibration" of the computer model to reflect runoff conditions used for the Flood Insurance Studies and analysis of computer results to devise the watershed runoff control strategy. A brief description of the basic steps involved is presented below.

### A. DOCUMENTATION OF THE PHYSICAL WATERSHED CHARACTERISTICS

Existing physical characteristics of the watershed were obtained from field surveys, published data, aerial photography and topographic map interpretation. Data acquired from the County Geographic Information System included existing land use, soils, land slopes, water impoundments and flow obstructions. A future condition land use was developed utilizing existing zoning in the municipalities. The County has proposed Urban Growth Boundaries which were devised to allow sufficient areas of growth in each municipality for the next 20 years. Moreover, the existing zoning provides

significantly more area for growth than the proposed Urban Growth Boundaries. The Plan can then be assumed to meet the storm water requirements for this basin for more than the next 20 years assuming the zoning does not change.

**B. DEVELOPMENT AND CALIBRATION OF A COMPUTER RUNOFF SIMULATION MODEL FOR THE MILL CREEK WATERSHED**

The 57 square mile Mill Creek watershed was subdivided into 62 subareas for computer modeling purposes. With the assistance of a Geographic Information System (GIS), the physical watershed characteristics were aggregated by subarea for use as model input. The computer model used was TR-20, a river analysis program written by the US Soil Conservation Service, which generates runoff for each subarea and accumulates the runoff as flow proceeds downstream. "Calibration" of the model involves adjustment of certain model parameters within generally accepted limitations so that the model produces events consistent with other published storm water data. The calibrated model was run for design storm conditions to generate runoff events which could be analyzed to develop an appropriate runoff control strategy for the watershed. A "design storm" is an event that should produce the maximum reasonable runoff for a given rainfall depth due to an optimized rain pattern.

In the modeling analysis of the Mill Creek watershed the 2, 5, 10, 25, 50 and 100-year SCS Type II storms were analyzed for 24-hour durations. General acceptance of the 24-hour SCS Type II storm for design purposes prompted its use as the design duration for use in the obstruction capacity analysis. The determination of the storm frequency for standards and criteria development was not as simple. Act 167 does not address what storm frequency should be utilized. The intent, however, would not be to allow any increase in flows for any storm frequency. Since the Federal Flood Insurance Studies are based upon the 100-year flood elevations, and these elevations would increase if the peak flow increased (assuming the same channel dimensions), it would not make sense to ignore controlling runoff from the 100-year storm. Control or management measures for the 100-year storm can, however, increase cost. On the other hand, controlling the first flush of storm events entraps sediment and improves water quality. Thus, controlling a high frequency (i.e. one or two year storms) storm would promote infiltration and groundwater recharge and improve stream baseflow and water quality.

**C. RUNOFF CONTROL STRATEGY DEVELOPMENT**

An analysis was performed to find a combination of design storms which would provide protection over the entire range of design storm frequencies, yet not impose economic difficulties on the developer. In addition, capacities

of obstructions and locations of problem areas all had to be evaluated in determining which design storms should be managed.

The basic runoff control strategy employed for the Mill Creek watershed is to not increase peak runoff rates throughout the watershed even after development activities take place. Whereas conventional site design would only consider the runoff impact of development at the downstream end of the site itself, the comprehensive approach requires analysis of site runoff at points further downstream. An assumption of the comprehensive control concept is that the total volume of runoff will increase with development of a site (true for the vast majority of developments). With the increase in impervious area which accompanies site development, storm water volumes inevitably increase, unless of course the increase in runoff volume is recharged to the ground water. The timing of the watershed subareas must be thoroughly analyzed to determine storm water management criteria (or performance standard districts) to account for this increase on runoff volume and subarea timing. Thus, these districts will have varying degrees of storm water control criteria to achieve the goal of no net increase in flood flows within the watershed as shown on the subwatershed boundary map included with this Executive Summary. The conclusion from the comprehensive approach is that, in exchange for the increase in runoff volume with development, the rate of runoff leaving a site will have to be decreased. The magnitude of the required decrease in peak rate for a given site is determined from the computer model.

### III. WATERSHED LEVEL STORM WATER MANAGEMENT

#### A. DESCRIPTION OF PERFORMANCE STANDARD DISTRICTS

In performing the tasks for the Mill Creek Watershed Plan under Act 167, a major goal was to determine where in the watershed storm water detention was appropriate for new development and, just as importantly, where detention was not appropriate. It was also important to determine to what extent storm water detention would be required in individual subareas. Individual subareas would fall into one of three districts:

##### a. One Hundred Percent Pre-development Release Rate:

In these subareas it was determined to be advantageous not to over detain the runoff volume. Development areas which can be discharged directly to the main channel of the Mill Creek may do so if the discharge will not cause an erosion problem. Other areas in these basins may discharge 100% of the pre-development runoff rate. This is an effort to direct the storm flows

from these subareas to the Mill Creek before the peak flow rate arrives at that point on the stream.

b. **Seventy-five Percent Pre-development Release Rate:**

In these subareas it was determined to be advantageous not to over detain the runoff volume; however, 100 percent release rates could not be permitted without causing increased peak flow rates which could cause damage to the tributary streams before reaching the Mill Creek.

c. **Fifty Percent Pre-development Release Rate:**

In these subareas it was determined to be advantageous to over detain the storm water flows to reduce the peak flows seen by the Mill Creek. Most of these subareas contribute to the peak flows.

Development in the 100% pre-development release rate subareas designated on the subwatershed boundary map included in this Executive Summary must be able to convey the generated storm water runoff to a stream or watercourse in a safe non-erosive manner. The conveyance facilities must manage the quantity, velocity and direction of resulting storm water runoff in a manner which otherwise adequately protects health and property from possible injury pursuant to Act 167, does not overtax existing drainage facilities and does not cause erosion or sedimentation. Anyone who proposes no detention for greater than the 2-year storm must show that the downstream natural or man-made channel or watercourse has the capacity within its banks to convey the 2-year design storm at velocities which are not erosive. Acceptable velocities shall be based upon criteria contained in the PADER "Erosion and Sediment Pollution Control Program Manual." The 100-year design storm must also be safely conveyed by the stream and over its banks without causing erosion or sedimentation, or creating any damage, safety or property hazard. The post-development flow greater than pre-development flow can only be released if it does not aggravate a significant obstruction or existing problem area as identified on Plate IV of Volume II. If it would, proper storm water management, obstruction replacement or standard detention would be required. Any flow from the 100-year storm not carried by downstream drainage facilities must be addressed and, where necessary, additional controls installed to assure upstream collection of this water by control facilities where required by the storm water design.

Proper analysis of channel capacity downstream of a development site for the purpose of discharging greater than pre-development peak flow rates is essential for insuring that the goal of not creating any new problem areas or

aggravating existing drainage problem areas is achieved. The analysis must include the assumption of complete build-out of the tributary areas to the channel being evaluated based upon the Future Land Use Map (Plate III, Volume II) or the latest zoning revision after Plan adoption. Also, storm water control measures consistent with the Plan must be assumed in analyzing projected development tributary to the point of evaluation.

Culverts, bridges, stream enclosures or any other facilities proposed within an area where no detention is required must pass flows for the 50-year design storm without causing a backwater which would act as a "detention basin" or meet more stringent PADER criteria. Such facilities shall allow an unimpeded flow to be conveyed.

Stream channels, water courses or other conveyance facilities may be improved to meet the above requirements and alleviate existing capacity deficiencies as long as local, state, and federal requirements are met and permits obtained.

Any facilities that constitute stream enclosures or dams, as regulated in PADER Chapter 105 regulations (as amended or replaced from time to time by PADER), shall be designed in accordance with Chapter 105 and will require a permit from PADER. The definition of dam is defined in Chapter 105 regulations. Any roadway crossing including pipes, bridges, storm sewers or any other drainage conveyance facilities or any work involving wetlands as described in PADER Chapter 105 regulations shall be designed in accordance with Chapter 105 regulations and may require a permit from the Department. Any roadway crossing or any facility located within a PADOT right-of-way must meet PADOT minimum design standards and permit submission requirements.

#### **B. 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 improve the capability and flexibility of land developers and communities to control runoff consistent with the Mill Creek Watershed Storm Water 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 the property(s) in question. There could be publicly owned detention, retention, lake, pond or other physical facilities to serve multiple developments. The design would need to be consistent with the Plan.

### C. "NO HARM OPTION"

For any proposed development site not located in a provisional no detention district, the developer has the option of using a less restrictive runoff control (including, no detention) 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:

1. The peak flow values to be used for downstream areas for the design return period storms (2, 5, 10, 25, 50, 100 year) shall be the values from the calibrated TR-20 Model for the Mill Creek watershed. These flow values would be supplied to the developer by the municipality or County upon request.
2. Any available capacity in the downstream conveyance system as documented by a developer may be used by the developer only in proportion to his development site acreage relative to the total upstream undeveloped acreage from the identified capacity (i.e. if his site is 10% of the upstream undeveloped acreage, he may use up to 10% of the documented downstream available capacity).
3. 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 303.1.

Any "no harm" justifications shall be submitted by the developer as part of the Drainage Plan submission per Article IV of the Model Ordinance.

D. "HARDSHIP OPTION"

The development of the Plan and its standards and criteria was designed to maintain existing peak flows throughout the Mill Creek watershed as the watershed becomes developed. There may be certain instances, however, where the standards and criteria established are too restrictive for a particular landowner or developer. The existing drainage network in some areas may be capable of safely transporting slight increases in flows without causing a problem or increasing flows elsewhere. If a developer or homeowner cannot reasonably meet the storm water standards due to lot conditions or if conformance would become a hardship to an owner and the developer/homeowner can demonstrate "no harm" if the hardship waiver is granted, the hardship option may be applied. The landowner would have to plead their case to the Township Supervisors with the final determination made by the township. Any landowners pleading the "hardship option" will assume all liabilities that may arise due to exercising this option. In cases where the hardship option is requested, it will be the applicant's responsibility to notify adjacent and/or affected property owners and municipalities and provide written proof of the notification. Financial obligations are not considered a hardship.

E. "Match Pre-existing Hydrograph"

Developers and/or landowners will have the option to provide infiltration facilities allowing the post-development hydrograph to match the pre-existing hydrograph for the site. This will be most useable for small subdivisions in the 50% pre-development runoff rate areas.

## **APPENDIX A**

### **SUBAREA PEAK FLOW TABLES**

(CFS)

2 Year Storm of 24 hour duration

Subarea Number	Present Conditions	Future with No Control	Future with SWM Control
1	598.6	754.2	703.0
2	606.5	763.0	708.8
3	609.7	767.1	709.4
4	603.3	758.5	700.7
5	606.0	763.3	701.5
6	617.6	780.4	705.9
7	96.2	128.3	72.1
8	49.8	70.4	35.3
9	23.5	23.5	23.5
10	89.8	121.7	67.3
11	39.6	68.2	20.5
12	17.2	29.3	8.6
13	579.5	732.9	652.3
14	593.8	746.5	656.1
15	24.8	36.2	28.6
16	16.0	16.0	16.0
17	586.6	738.2	646.7
18	579.9	731.6	640.1
19	577.8	728.8	628.7
20	130.0	250.4	86.9
21	53.4	148.1	40.0
22	530.6	674.1	560.4
23	530.7	670.2	563.5
24	459.5	576.1	467.9
25	176.1	315.8	193.8
26	554.0	697.8	591.8
27	471.6	595.0	473.3
28	542.5	687.2	578.8
29	573.9	721.8	616.0
30	568.1	714.9	607.4
31	470.5	599.1	466.2
32	83.5	103.1	79.3
33	74.6	96.9	68.6
34	382.3	489.6	382.2
35	384.0	495.1	378.9
36	345.5	463.1	337.9
37	403.3	523.8	382.0
38	42.8	42.8	42.8
39	151.1	275.3	75.6
40	356.2	457.8	268.7
41	176.4	225.4	88.3
42	373.0	508.6	339.1
43	452.9	632.6	343.2
44	328.7	422.6	251.1
45	67.8	94.2	62.5
46	54.5	54.5	54.5
47	22.7	22.7	22.7
48	This Subarea Number was not used		
49	15.2	15.2	15.2
50	10.6	10.6	10.6
51	362.8	464.5	271.8
52	90.7	133.0	97.4
53	115.7	199.2	111.5
54	111.8	196.6	98.2
55	12.7	22.5	6.4
56	30.0	31.0	29.9
57	9.6	9.6	9.6
58	6.5	6.5	6.5
59	2.3	2.3	2.3
60	576.8	724.9	618.6
61	547.1	691.1	586.0
62	393.0	442.5	348.3
63	177.3	267.6	103.8

5 Year Storm of 24 hour duration

Subarea Number	Present Conditions	Future with No Control	Future with SWM Control
1	1876.8	2190.7	2052.0
2	1901.3	2216.2	2069.5
3	1916.2	2229.8	2078.7
4	1901.4	2211.2	2060.5
5	1913.8	2226.6	2069.2
6	1956.5	2273.3	2092.1
7	374.2	444.0	308.5
8	143.0	177.9	124.0
9	97.0	97.0	97.0
10	345.7	416.0	280.2
11	191.6	256.0	95.7
12	79.4	106.6	39.7
13	1857.7	2158.4	1957.0
14	1904.2	2204.2	1977.7
15	127.6	159.3	151.6
16	89.3	89.3	89.3
17	1895.3	2192.8	1959.6
18	1878.3	2175.6	1942.8
19	1885.5	2178.1	1928.6
20	410.9	625.2	263.2
21	180.8	347.8	135.6
22	1801.7	2082.0	1788.6
23	1782.5	2058.2	1786.5
24	1607.4	1841.3	1531.2
25	604.1	871.8	620.3
26	1838.7	2122.2	1853.3
27	1642.8	1884.3	1546.4
28	1811.5	2095.8	1819.4
29	1880.4	2169.0	1907.1
30	1872.5	2161.0	1891.3
31	1656.2	1915.3	1539.4
32	351.8	408.4	328.7
33	330.3	393.7	305.9
34	1284.2	1489.8	1195.5
35	1287.3	1497.4	1188.3
36	1139.3	1358.9	1058.1
37	1329.7	1552.9	1190.8
38	158.9	158.9	158.9
39	322.9	488.8	161.5
40	957.7	1116.1	723.1
41	378.0	446.1	189.0
42	1215.4	1461.4	1056.8
43	1381.3	1680.8	1030.1
44	1070.0	1224.0	831.3
45	309.2	383.1	288.0
46	250.9	250.9	250.9
47	108.6	108.6	100.6
48	This Subarea Number was not used		
49	85.2	85.2	85.2
50	62.8	62.8	62.8
51	1062.1	1220.5	799.9
52	402.8	498.1	378.9
53	520.6	689.2	409.1
54	423.6	589.9	304.6
55	73.8	105.4	36.9
56	212.8	214.2	211.9
57	73.1	73.1	73.1
58	51.1	51.1	51.1
59	19.6	19.6	19.6
60	1889.9	2178.5	1915.7
61	1822.6	2106.2	1836.9
62	854.3	925.0	717.3
63	586.7	711.9	399.4

10 Year Storm of 24 hour duration

Subarea Number	Present Conditions	Future with No Control	Future with SWM Control
1	3697.4	4163.3	3958.3
2	3737.9	4206.1	3992.0
3	3766.9	4236.3	4015.0
4	3744.1	4208.1	3988.4
5	3772.8	4239.8	4012.1
6	3844.7	4315.9	4063.5
7	863.5	973.0	692.5
8	264.4	305.6	251.3
9	196.6	196.6	196.6
10	771.4	880.1	598.9
11	401.6	493.1	200.9
12	167.3	205.5	83.7
13	3673.0	4130.7	3826.1
14	3771.2	4242.0	3887.9
15	297.3	344.6	345.4
16	204.1	204.1	204.1
17	3759.9	4224.7	3865.5
18	3729.7	4194.5	3837.1
19	3741.4	4201.7	3823.7
20	755.8	1048.5	480.8
21	345.9	568.7	259.4
22	3623.1	4065.6	3628.2
23	3580.9	4017.2	3613.0
24	3280.0	3649.9	3154.8
25	1168.0	1545.7	1149.8
26	3681.1	4130.1	3721.6
27	3335.3	3715.6	3184.7
28	3632.6	4082.4	3669.7
29	3745.1	4204.1	3799.8
30	3739.1	4195.6	3781.7
31	3410.1	3811.5	3210.6
32	771.9	864.9	714.7
33	730.6	833.7	672.8
34	2601.7	2917.0	2461.5
35	2605.1	2926.7	2446.8
36	2294.7	2623.2	2158.6
37	2666.4	3005.0	2449.6
38	314.6	314.6	314.6
39	503.1	698.4	251.6
40	1707.5	1962.9	1447.3
41	587.5	668.8	293.8
42	2425.3	2788.7	2162.2
43	2617.0	3025.3	2138.6
44	2075.6	2326.5	1785.7
45	689.9	803.1	639.4
46	538.8	538.8	538.8
47	234.2	234.2	234.2
48	This Subarea Number was not used		
49	195.9	195.9	195.9
50	150.0	150.0	150.0
51	1972.9	2227.7	1673.6
52	938.3	1085.6	856.9
53	1200.8	1417.8	937.6
54	871.7	1088.7	608.8
55	176.2	227.0	95.9
56	459.6	463.7	457.1
57	209.7	209.7	209.7
58	150.8	150.8	150.8
59	57.5	57.5	57.5
60	3761.2	4220.6	3815.8
61	3654.8	4103.4	3696.7
62	1378.6	1450.9	1230.0
63	1074.9	1230.3	766.2

25 Year Storm of 24 hour duration

Subarea Number	Present Conditions	Future with No Control	Future with SWM Control
1	4983.9	5551.7	5311.8
2	5037.1	5607.1	5356.7
3	5077.2	5648.2	5387.6
4	5047.0	5611.6	5352.9
5	5085.7	5652.0	5382.2
6	5186.7	5758.2	5453.8
7	1180.6	1307.6	948.0
8	348.4	390.0	338.4
9	260.4	260.4	260.4
10	1040.0	1166.2	811.0
11	540.2	645.2	270.3
12	225.2	269.1	112.7
13	4965.8	5516.4	5150.9
14	5126.2	5685.1	5262.9
15	417.6	473.3	480.5
16	283.5	283.5	283.5
17	5112.6	5668.4	5231.7
18	5075.8	5631.5	5195.0
19	5096.4	5646.2	5182.1
20	976.9	1307.3	612.5
21	453.1	702.9	339.8
22	4943.9	5465.4	4928.4
23	4895.9	5414.1	4913.2
24	4492.0	4922.4	4294.1
25	1535.1	1965.8	1503.0
26	5026.9	5561.2	5057.7
27	4563.1	5006.8	4332.5
28	4965.4	5500.5	4987.9
29	5109.6	5655.1	5159.8
30	5100.1	5642.3	5135.3
31	4654.8	5114.7	4362.7
32	1079.9	1196.2	992.1
33	1024.3	1148.9	935.9
34	3528.2	3878.7	3323.6
35	3531.9	3888.4	3304.0
36	3104.3	3458.3	2899.7
37	3604.1	3973.2	3307.7
38	417.0	417.0	417.0
39	610.4	819.5	305.2
40	2234.0	2531.8	1939.8
41	712.0	799.7	356.5
42	3265.7	3644.1	2912.0
43	3447.3	3863.6	2864.8
44	2774.4	3064.1	2422.2
45	970.7	1103.3	891.8
46	744.2	744.2	744.2
47	319.7	319.7	319.7
48	This Subarea Number was not used		
49	272.5	272.5	272.5
50	211.9	211.9	211.9
51	2612.4	2910.2	2264.2
52	1318.8	1495.6	1199.3
53	1653.6	1898.9	1306.0
54	1157.4	1402.5	811.7
55	249.1	309.7	124.6
56	621.2	627.8	617.5
57	314.1	314.1	314.1
58	229.0	229.0	229.0
59	86.8	86.8	86.8
60	5131.3	5677.5	5180.3
61	4995.1	5530.3	5026.1
62	1710.2	1904.3	1666.3
63	1382.1	1553.4	1000.1

50 Year Storm of 24 hour duration

Subarea Number	Present Conditions	Future with No Control	Future with SWM Control
1	7152.5	7831.3	7454.5
2	7228.3	7909.7	7515.4
3	7285.9	7968.1	7556.4
4	7247.5	7923.4	7512.2
5	7304.8	7985.6	7552.3
6	7451.5	8136.0	7657.7
7	1680.3	1829.8	1359.2
8	477.1	524.4	474.5
9	358.1	358.1	358.1
10	1469.5	1618.7	1140.1
11	755.1	876.8	377.7
12	315.0	365.9	157.5
13	7156.8	7824.9	7252.1
14	7400.9	8072.3	7412.1
15	614.2	678.9	685.7
16	409.8	409.8	409.8
17	7395.4	8063.2	7379.1
18	7348.1	8015.1	7332.4
19	7382.8	8040.7	7321.1
20	1315.0	1691.2	809.2
21	617.9	901.0	463.4
22	7206.5	7841.1	6985.8
23	7125.6	7742.4	6962.4
24	6572.9	7094.4	6115.1
25	2100.8	2596.6	2048.5
26	7305.5	7944.0	7162.4
27	6682.1	7218.7	6168.6
28	7223.7	7860.7	7066.7
29	7413.4	8065.9	7297.2
30	7402.3	8051.2	7262.9
31	6785.7	7337.8	6187.2
32	1632.5	1782.2	1473.8
33	1546.2	1703.8	1384.9
34	5095.3	5508.5	4648.7
35	5099.9	5519.0	4619.3
36	4485.5	4899.3	4030.4
37	5195.4	5628.6	4618.2
38	575.7	575.7	575.7
39	767.2	993.0	383.6
40	3227.2	3583.0	2678.1
41	893.8	989.3	446.9
42	4707.6	5145.6	4041.4
43	4885.9	5360.3	3930.9
44	4015.6	4365.1	3364.2
45	1476.4	1633.4	1320.9
46	1111.0	1111.0	1111.0
47	455.6	455.6	455.6
48	This Subarea Number was not used		
49	395.6	395.6	395.6
50	311.9	311.9	311.9
51	3790.4	4148.7	3146.3
52	1984.8	2185.3	1734.3
53	2366.2	2654.7	1915.5
54	1596.2	1885.5	1140.9
55	366.6	440.4	183.3
56	871.8	883.4	867.2
57	491.7	491.7	491.7
58	362.3	362.3	362.3
59	136.1	136.1	136.1
60	7443.0	8095.6	7326.3
61	7267.1	7904.7	7122.0
62	2528.6	2753.0	2312.5
63	1847.6	2040.8	1358.2

100 Year Storm of 24 hour duration			
Subarea Number	Present Conditions	Future with No Control	Future with SWM Control
1	10051.0	10852.6	10325.4
2	10152.9	10955.0	10401.8
3	10231.3	11031.3	10454.2
4	10181.7	10973.5	10398.9
5	10263.9	11056.8	10456.5
6	10455.7	11248.1	10588.0
7	2309.2	2477.0	1868.0
8	644.3	690.2	633.7
9	478.9	478.9	478.9
10	2003.1	2173.6	1541.1
11	1024.1	1162.6	511.0
12	427.5	485.5	213.0
13	10078.4	10848.5	10068.9
14	10413.0	11210.2	10287.7
15	868.3	943.5	978.5
16	572.0	572.0	572.0
17	10417.1	11212.5	10257.9
18	10354.1	11148.2	10196.9
19	10399.1	11182.5	10187.7
20	1733.2	2154.4	1047.0
21	822.6	1139.3	617.0
22	10160.2	10893.7	9778.4
23	10045.6	10776.6	9730.3
24	9292.6	9895.0	8641.2
25	2806.1	3366.6	2641.6
26	10300.7	11059.5	9998.4
27	9446.7	10065.4	8722.7
28	10181.7	10937.4	9873.6
29	10447.5	11224.7	10170.1
30	10431.8	11203.3	10130.6
31	9555.5	10190.2	8736.6
32	2356.7	2538.5	2106.9
33	2212.9	2399.7	1960.7
34	7124.4	7597.4	6537.2
35	7123.2	7602.7	6500.2
36	6207.9	6693.6	5619.6
37	7234.1	7725.8	6507.6
38	774.3	774.3	774.3
39	953.7	1203.3	476.9
40	4397.3	4810.3	3722.5
41	1109.9	1212.9	555.0
42	6463.8	6974.9	5650.8
43	6618.1	7209.1	5478.6
44	5548.0	5960.4	4736.5
45	2104.1	2287.4	1865.3
46	1557.5	1557.5	1557.5
47	627.8	627.8	627.8
48	This Subarea Number was not used		
49	553.0	553.0	553.0
50	442.0	442.0	442.0
51	5199.7	5616.3	4411.7
52	2826.3	3064.2	2524.8
53	3330.4	3672.6	2720.3
54	2182.3	2525.9	1567.8
55	519.6	607.1	259.9
56	1189.4	1208.8	1185.2
57	735.1	735.1	735.1
58	544.3	544.3	544.3
59	202.8	202.8	202.8
60	10486.1	11263.8	10208.2
61	10245.8	11002.6	9945.1
62	3499.6	3768.1	3248.8
63	2423.5	2641.2	1806.4

