been the participation (100%) of every community in the study area in the Federal Flood Insurance Program. It appears that advantages of making flood insurance available at subsidized rates has not gone unnoticed by the flood plain communities. Consequently, it is assumed that these communities are complying with flood plain land use regulations as is required by the Federal Flood Insurance Program.

74. Next to the flood insurance program, the most popular measure is flood warning. Of the 58 municipalities in the study area, 19 (approximately 33%) have some form of flood warning. This low percentage is surprising in light of the fact that flood warning systems are usually economically feasible. In addition to the saving of lives, the warning time afforded by an accurate forecast gives the entire community the time needed to carry out its evacuation and contingency plans. Some of the commercial and industrial activities which depend on warning are located within municipalities which, themselves, do not have a flood warning system. Most of the municipalities which have a system do not have corresponding evacuation plans for their community. Existing plans are usually limited to plans of action for their personnel and departments.

75. Of the 58 municipalties, 18, or 31 percent, have bought up flood plain lands giving them direct control over their use. Land use shifted from residential - commercial - industrial to recreational parks or open spaces. For the most part, damage potential has been substantially reduced, or essentially eliminated by these lesser land uses. In 14 communities, or 24 percent of the municipalities, areas damaged in 1955 have been redeveloped. This usually occurred in communities which had portions of their river front devastated by the flood. In most cases, a large portion of the areas were converted to open spaces and parking lots, with new structures being either flood-proofed or built above the 1955 flood stage. Only seven percent or four communities permanently evacuated (purchased and demolished) flood plain structures. Once again, they were ones which were severely damaged in 1955.

PROBLEM IDENTIFICATION

76. The Delaware River Basin periodically experiences large floods from heavy rains and spring thaws. Tropical hurricanes, northeasters, and localized thunderstorms have all resulted in record flows and significant flooding. Some streams have fairly frequent and severe flooding from summer storms, hurricanes and continental storms. Some natural detention is provided by undeveloped lowlands, but narrow, constricted channels downstream and generally flat slopes result in considerable channel overflow.

77. The aftermath of a flood causes suffering and inflicts damages, losses and other related costs. These consist of physical damages or costs directly due to floods; expenditures for flood fighting, rescue work, emergency measures and preventive maintenance; losses to business, production, profits, and wages; and losses due to interruption of traffic, communications and normal activities in the flooded area. Also, intangible costs occur which cannot be assigned a monetary value. Such costs include loss of human life; illness resulting from epidemics caused by unsanitary conditions; mental and emotional stress; inconvenience to both directly and indirectly affected parties; the detrimental effect on national production when flooded industrial plants are involved; and possible impact on national defense. In fully identifying the problem, all current and future flood related impacts had to be assessed.

78. The purpose of assessing the magnitude and character of flood related losses was to define them in detail in order to establish a set of detailed planning objectives. These objectives were then used to develop and evaluate solutions. During the initial reconnaissance, all available publications, reports, pertinent correspondence and other literature were reviewed with input from key contacts in the study area. Local public input was obtained by using the public participation program already developed by the Delaware River Basin Commission for its ongoing "Level B Study". This identified "preliminary" problems and needs which were sufficient for a reconnaissance; however, a more complete and detailed effort followed.

79. A study area of this size required a methodical approach for identification, collection of data and analysis of flood prone units. A basic schematic of the approach which was adopted is presented in Figure 5. This process was initiated with the identification of the extent of the problem areas in order to define its general scope. Next, the entire study area was divided into damage reaches which would be the basic units for cataloging and building economic models for estimating inundation damages. A system for collecting, assimilating, and managing the data was developed. This was followed with an inventory of the entire flood plain including an aerial mapping of the study area. Those aerial photographs which delineate the Standard Project Flood* (SPF) plain and the damage reaches are available upon request. Data collected in the inventory was supplemented by follow up mail questionnaires, phone calls, and selected interviews, as required. All this information was prepared and processed for input to the damage inundation models. As the data was being collected and processed, methodologies were being developed for maximizing the use of attainable data. Adaptation of standardized models and development of new ones translated these methodologies into working procedures. Finally, flood damage potential could be analyzed in order to define current and future flood water and flood plain management problems and needs.

FLOOD PLAINS

80. Three distinct areas are subject to flooding along the entire main stem of the Delaware River. The upper or nontidal area, which includes the main stem and tributaries of the Delaware River above Trenton, New Jersey, is subject to floods caused by storms which traverse the basin. The lower or tidal area below Burlington is subject to floods caused by three factors acting singly or in combination: high spring tides caused by tidal fluctuations, wind tides produced by hurricanes or storm action, or either of these in combination with flows from the upper river. The reach between Trenton and Burlington is subject to tidal, nontidal, and combination influences. The Burlington limit for tidal influence was determined from a study of high water profiles, flood frequencies and flood damage field surveys.

81. The flood plain area in the reach of the river from Hancock, New York to Port Jervis, New York, consists of an extremely narrow valley with little development along the banks of the stream. The reach from Port Jervis to the Delaware Water Gap flows through a wider valley which has a flood plain that

*A hypothetical flood representing the critical flood runoff volume and peak discharge that may be expected from the most severe combination of meteorologic and hydrologic conditions that is considered reasonably characteristic for the hydrologic region involved, excluding extremely rare combinations.

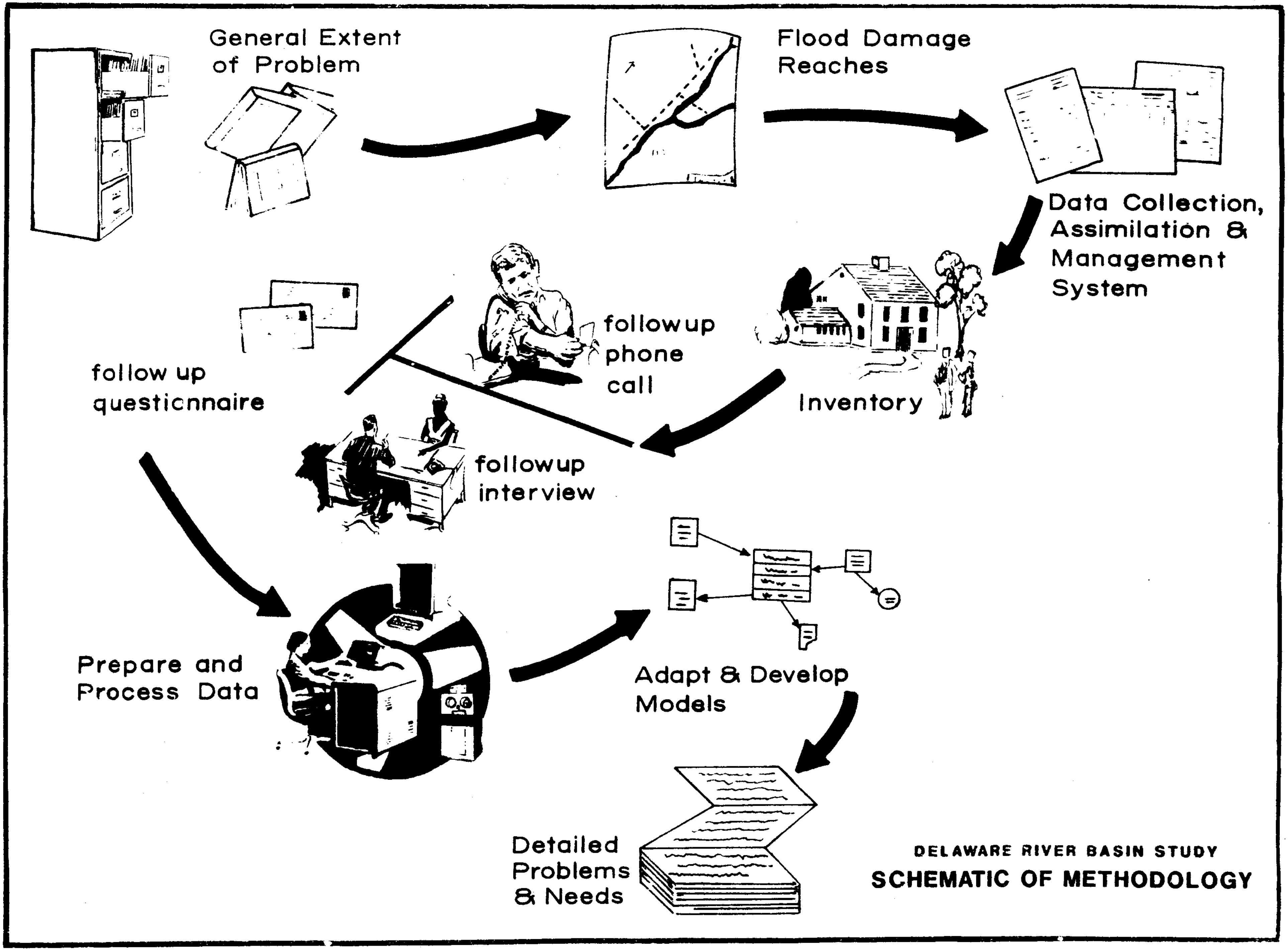

General Extent of Problem
Flood Damage Reaches
Data Collection, Assimilation & Management System
Inventory
follow up questionnaire
followup phone call
followup interview
Prepare and Process Data
Adapt & Develop Models
Detailed Problems & Needs
DELAWARE RIVER BASIN STUDY
SCHEMATIC OF METHODOLOGY

FIGURE 5

averages 1,200 feet in width. Flooding in this reach is confined to scattered residences and summer cottages on both banks and to several small communities. The remainder of the nontidal section from Delaware Water Gap to Trenton, New Jersey, has a flood plain that averages 1,600 feet in width. This section of the Delaware River is more highly urbanized containing the major population and industrial centers of the study area.

HYDROLOGY AND HYDRAULICS

82. To facilitate accurate problem identification and subsequent formulation, a complete investigation of the hydrology and hydraulics of the main stem Delaware River was performed using existing data which was supplemented and updated as necessary. For details of this investigation see Appendix C. A discharge-frequency analysis at five selected main stem gaging stations was conducted initially involving separate hurricane and non-hurricane series analyses with the subsequent development of composite annual frequency curves. These curves were then coordinated with data formulated by other agencies, notably the U.S. Geologic Survey. The effects of regulation by existing flood control structures were included in these discharge-frequency curves.

83. Using these curves, hydraulic and hydrologic models for the main stem Delaware River were developed. The HEC-2 model was the basis for the hydraulic modeling of the Tocks Island to Trenton section of the study area. This model produces water surface elevation-frequency data. A separate hydraulic evaluation was required to generate similar data for the tidal portion of the study area (Trenton to Burlington). The HEC-1 model was the basis for the hydrologic modeling of the main stem Delaware River. The hydrologic model which includes the SPF development, was complete only after thorough unit hydrograph, base flow, and recession characteristic analysis.

HISTORY AND CHARACTER OF FLOODING

84. As throughout all of the northeastern portion of the United States, early settlements developed along major rivers as they were the natural avenues of travel and commerce to the interior. Communities grew primarily at the confluence with major tributaries. Indians warned the early settlers that great floods occurred on the Delaware River at regular intervals. These warnings apparently went unheeded. The Delaware, as well as its tributaries, have been subject to both local and widespread damage caused by excessive rainfall leading to the flooding of lands and property adjacent to its streams. Since the mid-1880's twelve "major basin-wide" floods have been recorded.

85. Fluvial floods are usually caused by storms which traverse the basin. These storms are of two general types, namely, storms of tropical origin (hurricanes) and storms of extra-tropical origin such as thunderstorms and northeasters. Storms occur separately and together, with the most intense precipitation resulting from a combination of both types. Movement of warm moist air into contact with surrounding air of lower temperature produces the violent thunderstorms and intense precipitation of the summer months and the northeasters of the cool months. The latter are of coastal origin and are accompanied by severe winds and possible flood-producing precipitation.

86. Other floods are caused by combinations of storms, snow melt, ice jams and tidal action. The lower reach of the study area, below Burlington, New Jersey, is subject to floods caused by several factors, acting singlely or in combination: flows from the upper river, high spring tides resulting from tidal fluctuations, and wind tides produced by hurricanes or storm action.

87. The most significant and widespread flood producing storms which have occurred in the Delaware River Basin are listed in Table 3. Very little is known about the storm of March, 1902 other than the magnitude of damages. Detailed discussions of each of the other storms that have affected the main stem of the Delaware River follows.

88. STORM AND FLOOD OF 7-11 OCTOBER 1903. A tropical barometric low joining a stagnating extra-tropical cyclone located off the coast of North Carolina resulted in heavy rainfall over New Jersey, New York and Pennsylvania. The heaviest rainfall center in the basin occurred in the upper reaches of the Delaware. A total of 10.2 inches of precipitation was recorded at Port Jervis, New York. As a result of this hurricane associated storm, most of the basin above Trenton, New Jersey, experienced severe flooding, and records were established that remained upbroken for 52 years. Flood flows in the upper basin were exceedingly high and flood stages reached on the east and west branches of the Delaware River at Fishs Eddy and Hale Eddy, respectively, still remain the maximum recorded.

89. STORM AND FLOOD OF 16-19 MARCH 1936. During the period 9 to 22 March, four distinct storm centers passed over the northeastern part of the United States. Two of those major disturbances, on 11-12 and 17-18 March, caused floods in the Delaware River. On 10 March, a Gulf disturbance which centered off the Georgia coast moved northeastwards with increasing intensity. By 12 March this disturbance had crossed Virginia, Pennsylvania and New York and was accompanied by heavy precipitation. With regard to the amount and extent of precipitation, this storm was notable but not extraordinary; in general, it stands out only as a major contributing factor to the flood that was to follow. An outstanding low pressure area emanating from the Gulf States passed over Pennsylvania and New Jersey on 19 March accompanied by generally heavy precipitation. This second storm was of sufficient magnitude and extent to rank with the great northern storms and together with the antecedent precipitation, caused major flooding throughout the entire Delaware River Basin. The heaviest rainfall center in the basin occurred in the Pocono Mountains where 7.58 inches were recorded at Stroudsburg, Pennsylvania. Runoff from the second storm was greater than that from the first storm on the main stem. On the tributaries in the southern part of the basin in Pennsylvania and New Jersey, the runoff from the first storm was the greater of the two. At a few places in the central part of the basin there was approximately the same runoff from each major storm.

90. FLOOD OF RECORD, 18-19 AUGUST 1955. The greatest flood recorded for the main stem of the Delaware River was Hurricane Diane in 1955. The 1955 flood is best classified as a "flash flood". Flood warnings came late or not at all, and those which were received were not acted upon quickly enough to prevent loss of life.

91. On 13 August 1955, Hurricane Connie, coming up the Atlantic Coast from the south, had not proved to be a very destructive storm as predicted, but it did dump from 10 to 12 inches of rain in the mountains of eastern Pennsylvania before expiring in Canada. Hurricane Diane, erratically following five days behind Connie, seemed even less of a threat. The Washington weather bureau,

TABLE 3

RECORDED MAJOR FLOODS
DELAWARE RIVER BASIN
1841 THROUGH 1983 1/

Storm Period	Storm Type	Main Stem Only Recorded Damages 2/ 3/	Entire Basin Recorded Damages 3/
Jan 1841	5/	4/	4/
Jan 1862	5/	4/	4/
Dec 1901	5/	0	$ 72,261,000
Mar 1902	5/	$ 2,829,834	16,708,608
Oct 1903	Tropical Storm	722,610	7,715,610
Aug 1933	Tropical Storm	0	57,021,300
Jul 1935	Thunderstorms	0	37,148,436
Mar 1936	Northeasters	21,315,505	52,874,810
Sep 1938	Tropical Storm	0 5/	634,088 5/
May 1942	Northeasters	0	174,858,600
Aug 1955	Tropical Storm	157,184,252	520,438,250
Jun 1972	Tropical Storm	0	414,780,000

1/ Major floods which have been recorded to have had widespread consequences. Does not include localized events.

2/ Major flood damages recorded for the main stem from Stroudsburg, Pennsylvania, to Burlington, New Jersey.

3/ Dollar damages are presented in terms of March 1983 price level. However, to truly compare the magnitude of specific events, allowance must be made for changes in both the level of urban development in the areas flooded and any projects which may have been constructed to prevent damages.

4/ The flood events were recorded but the magnitude of monetary losses were not documented.

5/ Complete data not available.

after tracking Diane up the eastern coast for four days, announced at 11 p.m. Wednesday, 17 August: "This will be the final bulletin issued on this storm." On 18 August, a low pressure trough developed over the foothills of Pennsylvania and southern New England which pulled the nearly windspent Diane inland. In collision with a cooler air mass there, Diane began to drop her heavy moisture load throughout eastern Pennsylvania, parts of New York State, New Jersey and eastern New England.

92. Rain fell in torrents that afternoon and into the night of 18 August. About 8 inches of rain fell between 2 p.m. and 6 p.m. The ground in the area, already saturated by Hurricane Connie a few days earlier, simply would not absorb any more water. Small streams were flowing over their banks within a few hours and soon all tributaries of the Delaware were pouring enormous quantities of water downstream as high tides abetted and prolonged flood waters. New records in flood stages were established throughout the basin including communities along the main stem.

93. The result was the worst and most destructive flood experienced to date in the Delaware River Basin. Although some portions of the basin have since experienced greater events, the 1955 event is still the most destructive flood along the main stem. The devastation did not become totally evident until Saturday morning, 20 August 1955, when the sun "... fell on an unparalleled picture of carnage and death...". The first to be hit were the Pocono Mountain resort and camping communities in the upper reaches. At one camp, near East Stroudsburg, 37 women and children were swept away by flood waters. Communities along the Delaware were wiped out entirely or in part or were left completely isolated. The ability to conduct massive air rescues was instrumental in keeping the death toll from climbing above the 99 deaths officially recorded.

94. As stated in the preceding discussion, the flood of August 1955 was the greatest recorded flood event along the main stem of the Delaware River. Table 4 illustrates the magnitude of precipitation at selected precipitation gages (see Figure 6) in August 1955 which produced these record damages.

MAJOR DAMAGE CENTERS

95. As can be seen from Table 3, the greatest recorded flood damages along the main stem were caused by the event of August 1955. The postflood survey for that event reported that almost 57 percent of reported flood damages along the main stem of the Delaware River occurred at eight urban centers: Easton, Riegelsville, New Hope and Yardley in Pennsylvania and Belvidere, Philipsburg, Trenton, and Burlington in New Jersey. These centers are shown in Figure 7. More than 2,400 structures were inundated in these major damage centers (See Table 5).

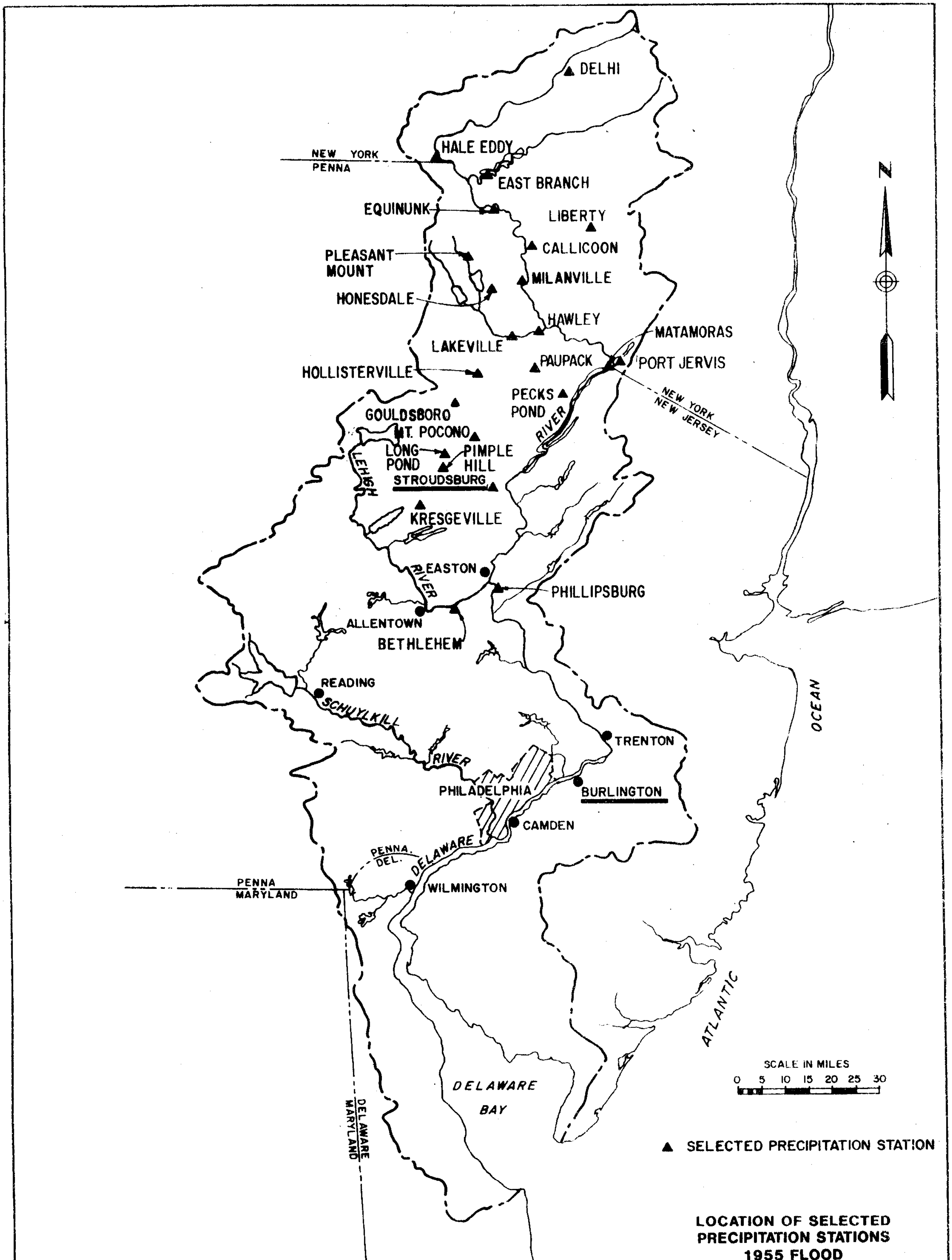
96. A discussion of these damage centers is presented in the following paragraphs. This discussion includes a generalization of what has occurred since the 1955 flood which may have changed flood protection needs. Changes did not necessarily occur because of the flood threat.

TABLE 4

FLOOD OF RECORD PRECIPITATION
SELECTED PRECIPITATION STATIONS
1955 FLOOD
DELAWARE RIVER BASIN

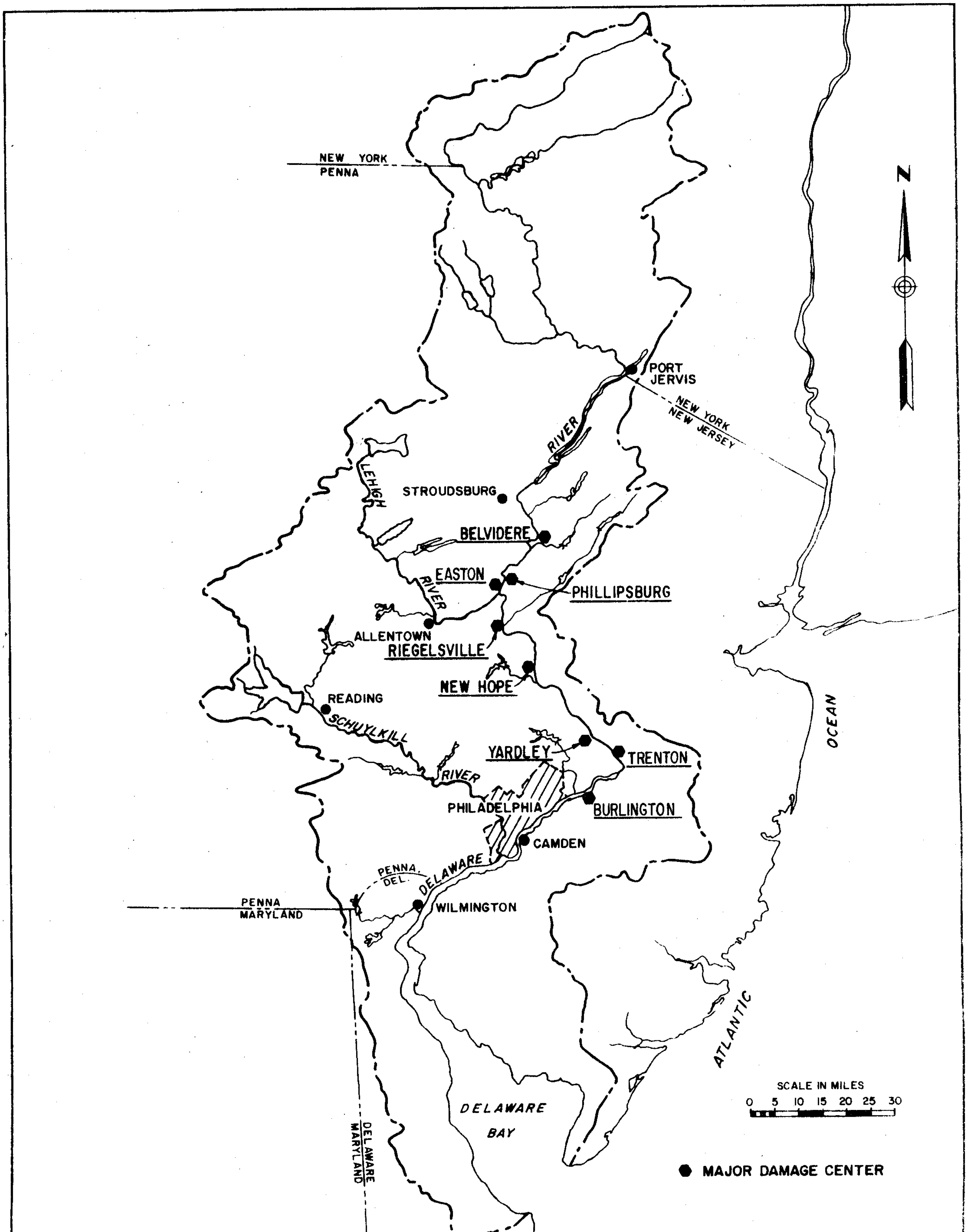
STATION	HURRICANE CONNIE 11-16 Aug Total Inches	HURRICANE DIANE 17 Aug Inches	18 Aug Inches	19 Aug Inches	20 Aug Inches	TOTAL Inches	TOTAL 11-20 Aug Inches
Bethlehem, PA	7.71		.68	2.20		2.88	10.59
Callicoon, NY	4.60	.01	3.00	1.88		4.89	9.49
Delhi, NY	4.11		.93	4.81		5.74	9.85
East Branch, NY	8.94		1.38	4.75	.20	6.33	15.27
Equinunk, PA	4.41		1.17	4.51	.03	5.71	10.12
Gouldsboro, PA	7.99		1.39	8.68		10.07	18.06
Hale Eddy, NY	3.84		1.10	1.18		2.28	6.12
Hawley, PA	6.22		1.58	8.70		10.28	16.50
Hollisterville, PA	6.62		1.13	7.22		8.35	14.97
Honesdale, PA	6.46		3.64	4.35		7.99	14.45
Kresgeville, PA	9.64		1.35	4.57		5.92	15.56
Lakeville, PA	5.72		2.24	8.67		10.91	16.63
Liberty, NY	9.45		2.45	5.03	.03	7.51	16.96
Long Pond, PA	9.94	.05	1.50	4.91		6.46	16.40
Matamoras, PA	6.70		2.39	5.83		8.22	14.92
Milanville, PA	4.52		.85	5.65		6.50	11.02
Mt. Pocono, PA	9.84	.12	1/	10.63		10.75	20.59
Paupack, PA	7.16		1.18	9.07	.01	10.26	17.42
Pecks Pond, PA	8.04		2.11	9.00		11.11	18.15
Phillipsburg, NJ	7.28	.05	1.92	4.09		6.06	13.34
Pimple Hill, PA	9.86		2.03	4.45		6.48	16.34
Pleasant Mt., PA	6.48		1.57	2.48		4.05	10.53
Port Jervis, NY	7.68		5.77	2.53		8.30	15.98
Stroudsburg, PA	6.82		1.90	4.25		6.15	12.97
Tannersville, PA	9.95		.69	3.58		4.27	14.22

1/ Precipitation included in following measurement.



LOCATION OF SELECTED PRECIPITATION STATIONS 1955 FLOOD

FIGURE 6



1955 FLOOD
MAJOR DAMAGE CENTERS

FIGURE 7

TABLE 5
Structures Damaged
1955 Flood of Record

Major Damage Centers	Number of Structures Damaged		
	Residential	Commercial	Industrial
Burlington, NJ	875	77	4
Trenton, NJ	358	46	9
Yardley, PA	223	26	0
New Hope, PA	146	0	0
Riegelsville, PA	134	25	1
Easton, PA	237	117	12
Philipsburg, NJ	32	17	3
Belvidere, NJ	58	20	0
TOTAL	2,063	328	29

97. BURLINGTON, NEW JERSEY. The 1955 flood left more structures inundated in Burlington than any other community along the Delaware River. As a direct result of the flood, the city constructed 5,800 linear feet of earthen dikes along both banks of the Assicunk Creek. In addition, the city developed an open space park area and a retention pond with pumping station to collect interior drainage from an improved storm drainage system. However, some of the levee is in disrepair and the project no longer provides the intended level of protection. In 1972, construction of a steel bulkhead along the Delaware River was completed along with landfill behind the bulkhead to an elevation one foot above the stated 100-year flood elevation. Under an urban renewal project funded by HUD, some of the old structures in the flood plain were condemned and removed. All new development adheres to strict zoning and building standards of the urban renewal plan concerning floodproofing, setbacks, insurance coverage and housing density.

98. TRENTON, NEW JERSEY. Although the 1955 flood inundated fewer structures in Trenton than in Burlington, the extent of physical damages was far more severe. Residential damages were the highest for any community along the Delaware River and total damages were second only to Easton, Pennsylvania. In response to the 1955 flood, a retaining wall was built on the south side of the Delaware - Raritan Canal to prevent erosion of the banks.

99. Many of the structures severely damaged in the 1955 flood have been replaced with a recreational area (Stacy Park) bordered by an improved four-lane highway. Although Trenton has not initiated a local program of flood plain management, city officials have made an effort to restrict development and intensive land use from the riverfront area. Flood proofing and flood insurance have been implemented to reduce the risk of physical damages to flood plain structures.

100. EASTON, PENNSYLVANIA. In terms of physical damage no community suffered more than Easton as a result of the 1955 flood. The major damage area occurred at the confluence of the Delaware and Lehigh Rivers. Many of the damaged structures were removed and the area has been converted under a HUD urban renewal project to a public park with recreational facilities. In addition, city officials instituted setback requirements, right of way restriction and zoning ordinances which will ensure that all future development will take place above the immediate flood plain. Easton has experienced a net decrease in total number of structures within the 1955 flood plain.

101. PHILLIPSBURG, NEW JERSEY. This city, like Easton, is one of the few areas to experience a net decrease in the number of structures within the 1955 flood plain. This decrease was mainly due to a realignment of a four-lane highway.

102. YARDLEY, PENNSYLVANIA. Following the 1955 flood, the drainage gates were replaced on the Delaware Division of the Pennsylvania Canal which reduced the flood potential to homes north of the canal. In addition, in the commercial district, roads have been raised in low lying areas to reduce the flood potential. With the assistance of the County Department of Natural Resources, flood plain zoning and building code regulations have been developed.

103. NEW HOPE, PENNSYLVANIA. Since 1955, the Borough has evolved from an artisan's colony to a highly commercial and tourist oriented community. The flood plain has actually been transformed to a higher land use. Since the Borough is very conscious about maintaining a highly aesthetic environment, it has not promoted any structural or nonstructural measures which would detract from the surroundings. Characteristically, the Borough has enacted only measures to mitigate the flood threat such as flood insurance, building code restrictions and a flood warning system.

104. RIEGLESVILLE, PENNSYLVANIA. The total number of structures in the flood plain has increased but there has been a net decline in the number of commercial activities. Floodplain lands have been acquired for recreational purposes.

105. BELVIDERE, NEW JERSEY. This community has experienced a large increase in residential structures but commercial activities have declined.

FLOOD PRONE UNITS

106. Based on the flood plain inventory conducted for this study, the number of units in the 100-year flood, 1955 flood and Standard Project Flood (SPF) area were summarized for each municipality by each type of land use in Tables 6 through 8. There are a total of 5007, 5632 and 9700 units for each respective flood plain. The 1955 flood and SPF flood plains include, respectively, 13 percent and 94 percent more units than the 100-year flood plain. They are approximately 84 percent residential (RES), 13 percent commercial (COM), 2 percent service (SER), and 1 percent or less of other land use types: industrial (IND), public (PUB), utility (UTL), historical (HIS), and Not Elsewhere Classified (NEC). The only application of NEC in the Basin are several cemeteries and a Boy Scout Camp on Treasure Island.

TABLE 6

NUMBER AND TYPE STRUCTURES
100 YEAR
FLOOD PLAIN

	RES	COM	IND	SER	PUB	UTL	HIS	NEC	TOTAL
PENNSYLVANIA									
Bensalem Twp	19	3	3	-	5	-	-	-	30
Bristol Twp	53	10	1	-	2	-	-	-	66
Bristol Boro	40	2	-	1	-	-	-	-	43
Tullytown Twp	1	6	-	-	-	-	-	-	7
Falls Twp	1	-	1	-	-	-	-	-	2
Morrisville Boro	13	-	1	-	-	-	-	-	14
Lower Makefield Twp	374	1	-	-	-	1	-	1	377
Yardley Boro	240	26	-	3	-	2	-	-	271
Upper Makefield Twp	104	3	-	1	4	-	3	1	116
Solebury Twp	50	8	-	1	1	1	-	-	61
New Hope Boro	91	73	-	3	-	-	-	-	167
Plumstead Twp	8	1	-	1	-	-	-	-	10
Tinicum Twp	92	18	-	1	2	-	2	6	121
Bridgeton Twp	104	8	-	2	-	-	-	-	114
Nockamixon Twp	1	3	-	1	-	-	-	-	5
Durham Twp	15	5	-	-	-	-	-	-	20
Reigelsville Boro	112	12	-	2	1	-	-	-	127
Williams Twp	56	5	-	1	-	-	1	-	63
Easton	50	48	10	7	1	3	-	1	120
Forks Twp	41	-	-	-	-	-	-	-	41
Lower Mount Bethel Twp	70	7	2	-	-	-	-	-	79
Upper Mount Bethel Twp	76	3	-	-	-	-	-	-	79
Portland Boro	4	15	-	2	-	-	-	-	21
Delaware Water Gap Twp	-	6	1	-	-	-	-	-	7
Smithfield Twp	17	5	2	-	-	-	-	-	24
NEW JERSEY									
Delran Twp	24	1	-	-	-	-	-	-	25
Riverside Twp	79	7	-	-	-	1	-	-	87
Delanco Twp	30	2	-	-	-	-	-	-	32
Beverly	-	-	-	-	-	-	-	-	-
Edgewater Park Twp	-	-	-	-	-	-	-	-	-
Burlington Twp	3	-	1	-	-	-	-	-	4

TABLE 6 (Cont'd)

NUMBER AND TYPE STRUCTURES
100 YEAR
FLOOD PLAIN

	RES	COM	IND	SER	PUB	UTL	HIS	NEC	TOTAL
Burlington	1471	209	8	55	6	2	4	2	1757
Florence Twp	-	-	-	-	-	-	-	-	-
Mansfield Twp	-	-	2	-	-	-	-	-	2
Bordentown Twp	-	-	-	-	2	-	-	-	2
Fieldsboro Boro	-	-	-	-	-	-	-	-	-
Bordentown	-	-	-	-	-	-	-	-	-
Hamilton Twp	-	6	3	-	-	-	-	-	9
Trenton	284	9	1	2	1	-	-	1	298
Ewing Twp	66	10	-	-	-	-	-	-	76
Hopewell Twp	12	3	-	-	1	-	1	-	17
West Amwell Twp	-	-	-	-	-	-	-	-	-
Lambertville	102	18	4	3	3	3	-	-	133
Delaware Twp	6	-	-	-	-	-	-	-	6
Stockton Boro	46	12	-	4	1	-	1	-	64
Kingwood Twp	39	3	-	-	-	-	-	26	68
Frenchtown Boro	39	8	2	1	-	1	-	-	51
Alexandria Twp	19	-	-	-	-	-	-	1	20
Milford Boro	4	4	-	-	-	-	-	1	9
Holland Twp	28	-	1	-	-	-	-	-	29
Pohatcong Twp	46	2	1	-	-	-	-	-	49
Phillipsburg	11	4	-	2	-	2	-	-	19
Lopatcong Twp	-	-	-	-	-	-	-	-	-
Harmony Twp	84	2	-	-	-	-	-	-	86
White Twp	57	2	-	-	-	-	-	-	59
Belvidere	71	4	-	-	-	-	-	-	75
Knowlton Twp	41	3	-	-	1	-	-	-	45
Pahaquarry Twp	-	-	-	-	-	-	-	-	-
TOTALS	4194	577	44	93	31	16	12	40	5007

TABLE 7

NUMBER AND TYPE STRUCTURES
1955 FLOOD OF RECORD
FLOOD PLAIN

	RES	COM	IND	SER	PUB	UTL	HIS	NEC	TOTAL
PENNSYLVANIA									
Bensalem Twp	6	1	-	-	-	-	-	-	7
Bristol Twp	22	2	-	-	2	-	-	-	26
Bristol Boro	40	-	-	1	-	-	-	-	41
Tullytown Boro	1	8	4	-	-	-	-	-	13
Falls Twp	-	-	1	-	-	-	-	-	1
Morrisville Boro	5	-	1	-	-	-	-	-	6
Lower Makefield Twp	468	1	-	-	-	1	-	1	471
Yardley Boro	274	27	-	3	-	2	-	-	306
Upper Makefield Twp	196	24	-	3	10	1	11	1	246
Solebury Twp	58	9	-	2	1	1	-	-	71
New Hope Boro	106	109	-	4	-	-	-	-	219
Plumstead Twp	12	2	-	1	-	-	-	-	15
Tinicum Twp	127	20	-	1	2	-	2	6	158
Bridgeton Twp	126	9	-	2	-	-	-	-	137
Nockamixon Twp	1	4	-	1	-	-	-	-	6
Durham Twp	17	8	-	-	-	-	-	-	25
Reigelsville Boro	155	21	-	2	1	-	-	-	179
Williams Twp	70	9	-	3	-	-	1	-	83
Easton	80	64	12	11	2	3	-	1	173
Forks Twp	61	6	-	-	-	-	-	-	67
Lower Mount Bethel Twp	125	10	2	1	-	-	-	-	138
Upper Mount Bethel Twp	90	5	-	-	-	-	-	1	96
Portland Boro	7	26	-	4	-	-	-	-	37
Delaware Water Gap Twp	5	7	1	-	-	-	-	-	13
Smithfield Twp	20	12	2	1	1	-	1	-	37
NEW JERSEY									
Delran Twp	10	-	-	-	-	-	-	-	10
Riverside Twp	7	-	-	-	-	-	-	-	7
Delanco Twp	13	2	-	-	-	-	-	-	15
Beverly	-	-	-	-	-	-	-	-	-
Edgewater Park Twp	-	-	-	-	-	-	-	-	-

TABLE 7 (Cont'd)

NUMBER AND TYPE STRUCTURES
1955 FLOOD OF RECORD
FLOOD PLAIN

	RES	COM	IND	SER	PUB	UTL	HIS	NEC	TOTAL
Burlington Twp	3	-	-	-	-	-	-	-	3
Burlington	1100	180	8	46	6	2	3	2	1347
Florence Twp	-	-	-	-	-	-	-	-	-
Mansfield Twp	-	-	2	-	-	-	-	-	2
Bordentown Twp	-	-	-	-	-	-	-	-	-
Fieldsboro Boro	-	-	-	-	-	-	-	-	-
Bordentown	-	-	-	-	2	-	-	-	2
Hamilton Twp	-	6	3	-	-	-	-	-	9
Trenton	381	9	1	2	2	-	-	1	396
Ewing Twp	130	11	-	-	-	-	-	-	141
Hopewell Twp	54	4	-	-	1	-	1	-	60
West Amwell Twp	-	1	-	-	-	-	-	-	1
Lambertville	176	44	6	3	3	3	-	-	235
Delaware Twp	12	-	-	-	-	-	-	-	12
Stockton Boro	69	12	-	5	1	-	1	-	88
Kingwood Twp	39	3	-	-	-	-	-	26	68
Frenchtown Boro	58	12	2	1	-	1	-	-	74
Alexandria Twp	35	-	-	-	-	-	-	1	36
Milford Boro	9	6	-	-	-	-	-	1	16
Holland Twp	31	-	1	-	-	1	-	-	33
Pohatcong Twp	61	2	1	-	-	-	-	-	64
Phillipsburg	19	25	-	2	-	2	-	-	48
Lopatcong Twp	-	-	-	-	-	-	-	-	-
Harmony Twp	149	2	-	-	-	-	-	-	151
White Twp	57	3	-	-	-	-	-	-	60
Belvidere	109	16	-	1	-	-	-	-	126
Knowlton Twp	49	6	-	1	1	-	-	-	57
Pahaquarry	-	-	-	-	-	-	-	-	-
	4643	728	47	101	35	17	20	41	5632

TABLE 8

NUMBER AND TYPE STRUCTURE
STANDARD PROJECT FLOOD
FLOOD PLAIN

	RES	COM	IND	SER	PUB	UTL	HIS	NEC	TOTAL
PENNSYLVANIA									
Bensalem Twp	87	20	8	-	5	1	-	-	121
Bristol Twp	113	18	1	-	2	1	-	1	136
Bristol Boro	40	20	-	1	3	1	1	-	66
Tullytown Boro	1	11	4	1	-	-	-	-	17
Falls Twp	3	-	1	-	-	-	-	-	4
Morrisville Boro	32	-	1	-	-	-	-	-	33
Lower Makefield Twp	633	3	-	-	1	1	-	1	639
Yardley Boro	289	34	-	3	-	2	-	-	328
Upper Makefield Twp	233	44	-	3	10	2	11	1	304
Solebury Twp	82	11	2	1	1	-	-	-	97
New Hope Boro	122	147	-	5	-	2	2	-	278
Plumstead Twp	12	3	-	1	-	-	-	-	16
Tinicum Twp	178	22	-	1	2	-	2	6	211
Bridgeton Twp	141	9	-	2	-	-	-	-	152
Nockamixon Twp	1	4	-	1	-	-	-	-	6
Durham Twp	17	8	-	-	-	-	-	-	25
Reigelsville Boro	169	25	-	2	1	-	-	-	197
Williams Twp	102	10	-	4	-	-	1	-	117
Easton	118	108	12	15	3	3	-	1	260
Forks Twp	65	6	-	-	-	-	-	-	71
Lower Mount Bethel Twp	186	11	2	2	-	1	-	-	202
Upper Mount Bethel Twp	109	10	-	-	1	1	-	1	122
Portland Boro	7	26	-	4	-	-	-	-	37
Delaware Water Gap Twp	26	7	2	-	-	-	-	-	35
Smithfield Twp	123	12	2	2	1	-	1	-	141
NEW JERSEY									
Delran Twp	69	4	-	-	-	-	-	-	73
Riverside Twp	143	17	-	2	-	1	-	-	163
Delanco Twp	43	2	-	-	-	-	-	-	45
Beverly	-	-	-	-	-	-	-	-	-
Edgewater Park Twp	-	-	-	-	-	-	-	-	-
Burlington Twp	11	1	1	-	-	-	-	-	13

TABLE 8 (Cont'd)

NUMBER AND TYPE STRUCTURE
STANDARD PROJECT FLOOD
FLOOD PLAIN

	RES	COM	IND	SER	PUB	UTL	HIS	NEC	TOTAL
Burlington	2525	335	14	74	6	3	7	2	2966
Florence Twp	-	1	-	-	-	-	-	-	1
Mansfield Twp	-	-	2	-	-	-	-	-	2
Bordentown Twp	-	-	-	-	-	-	-	-	-
Fieldsboro Boro	-	-	2	-	-	-	-	-	2
Bordentown	-	-	-	-	2	-	-	-	2
Hamilton Twp	-	6	3	-	-	1	-	-	10
Trenton	621	14	3	5	2	-	-	1	646
Ewing Twp	183	11	-	6	-	-	-	-	200
Hopewell Twp	88	6	2	1	-	1	-	-	98
West Amwell Twp	-	4	-	-	-	-	-	-	4
Lambertville	360	70	7	7	3	3	-	-	450
Delaware Twp	20	-	-	-	-	-	-	-	20
Stockton Boro	108	22	-	7	2	-	1	-	140
Kingwood Twp	41	3	-	-	-	-	-	26	70
Frenchtown Boro	163	38	3	1	-	1	-	-	206
Alexandria Twp	42	4	-	-	-	-	-	1	47
Milford Boro	68	14	1	4	-	-	-	3	90
Holland Twp	35	-	1	-	-	1	-	-	37
Pohatcong Twp	110	2	1	-	-	-	-	-	113
Phillipsburg	75	35	2	3	1	2	-	-	118
Lopatcong Twp	-	1	-	-	-	-	-	-	1
Harmony Twp	171	3	1	-	-	-	-	-	175
White Twp	57	3	-	-	-	-	-	-	60
Belvidere	151	38	-	2	-	-	-	-	191
Knowlton Twp	128	10	-	1	1	-	-	-	140
Pahaquarry	-	-	-	-	2	-	-	-	2
TOTALS	8101	1213	78	161	49	28	26	44	9700

107. A comparison with the inventory that was conducted following the 1955 flood is presented in Table 9. For this comparison the attempt was made to duplicate coverage of the same area included in the 1955 postflood damage survey. With the number of structures which were demolished and removed since the 1955 flood, a sharp decrease was expected. Instead, the 1981 inventory documented 2,704 structures compared with 2,422 from the 1955 survey. This is an increase of 12 percent. The differences result from new construction in the flood plain between the limits of the 100-year and 1955 floods and units which were not included in the 1955 counts or which were combined with another unit.

POTENTIAL DAMAGES

108. Potential flood damages by damage category that are associated with the occurence of a particular event (1.05 year, 10 year, 20 year, 30 year, 100 year, 1955 flood of record, and 500 year) were calculated for the main stem and its component segments by the Structural Inventory of Damages (SID) computer program. For a detailed discussion of this program and its role in flood damage analysis refer to the Benefit/Cost Analysis Appendix.

109. A 10-year flood along the main stem would cause well over $4 million in damages (See Table 10). This is relatively minor for 100 miles of river. This is because of relatively high zero damage stages for much of the development in the flood plain communities. Major damages do not occur until closer to a 50-year flood event ($79 million). However, the damage potential increases considerably to $171 million, $275 million, and $689 million for the 100-year, 1955 flood and SPF events, respectively.

110. This frequency or stage versus damage pattern is a testimony to local efforts to reduce their flooding threat through better management. Understandably, the emphasis has been placed on the more frequently flooded areas near the river. In some communities the 1955 flood outline has been set as a goal, but in most the 100-year flood plain provides their total security. This has obscured the actual flood threat and the potential for disaster.

This has also led to intensification of development on lands immediately beyond the 100-year flood plain which has resulted in the following increases in potential damages for that portion between the limits of the 100-year and 1955 flood plains.

Bucks County	34%	
Northampton County		114%
Monroe County	54%	
Burlington County		19%
Mercer County	36%	
Hunterdon County		188%
Warren County	93%	

AVERAGE ANNUAL DAMAGES

111. The recurrent or equivalent average annual damages (AAD) are presented in Table 11 for each municipality by each land use type. The AAD's are produced by the Equivalent Annual Damage (EAD) Computer Model which is discussed in detail in the Damage and Benefit Analysis Appendix. Residential structures (RES) and content (RESCON) damages were aggregated separately as were commercial structures (COM) and contents (COMCON). This was done in

TABLE 9

COMPARISON
1955 FLOOD PLAIN STRUCTURES
MAJOR DAMAGE CENTERS
(1955 and 1981)

	Structures					
	Residential		Commercial		Industrial	
Damage Centers 1/	1955 2/	1981 3/	1955 2/	1981 3/	1955 2/	1981 3/
Belvidere, NJ	58	108	20	14	0	1
Easton, PA	237	75	119	54	12	12
Phillipsburg, NJ	32	19	17	25	3	0
Riegelsville, PA	134	157	25	19	1	1
New Hope, PA	146	105	0	109	0	0
Yardley, PA	223	272	26	27	0	0
Trenton, NJ	358	403	46	4	9	2
Burlington, NJ	875	1106	77	181	4	10
	2063	2245	330	433	29	26

1/ Major damage centers identified and documented in 1955.
2/ Source: HD 522, 87th Congress, 2nd Session, Table 1, Sheet 1.
3/ Source: Philadelphia District field inventory 1980-81.

TABLE 10

FLOOD DAMAGES
SELECTED SINGLE EVENTS
MUNICIPALITIES, COUNTIES, STUDY AREA
($000)
(March 1983 Dollars and Conditions

Municipality	10 Yr	50 Yr	100 Yr	1955	S. P. F. (500 Yr.)
BUCKS COUNTY, PA					
Bensalem Twp	57	280	1,842	100	12,629
Bristol Twp	117	414	1,216	381	6,657
Bristol Boro	64	294	675	464	1,628
Tullytown Boro	11	35	130	625	1,417
Falls Twp	25	95	1,361	741	8,393
Morrisville Boro	27	1,981	2,944	2,427	56,674
Lower Makefield Twp	122	3,426	7,779	11,598	22,450
Yardley Boro	156	3,942	8,308	11,509	15,696
Upper Makefield Twp	260	1,702	3,728	8,134	15,565
Solebury Twp	165	1,451	2,691	3,905	5,690
New Hope Boro	67	2,589	5,929	10,932	18,424
Plumstead Twp	77	242	428	714	969
Tinicum Twp	385	2,198	3,949	5,693	8,855
Bridgeton Twp	190	1,486	2,855	4,201	5,891
Nockamixon Twp	102	334	497	762	770
Durham Twp	12	598	1,049	1,800	2,080
Reigelsville Boro	7	210	1,518	4,009	7,202
Sub-total	1,844	21,277	46,899	67,995	190,990
NORTHAMPTON CO., PA					
Williams Twp	28	483	1,054	1,771	4,212
Easton City	25	7,984	24,762	55,603	77,675
Forks Twp	11	389	940	1,818	3,270
Lower Mt. Bethel Twp	148	955	1,898	4,734	11,966
Upper Mt. Bethel Twp	32	457	1,144	2,216	56,727
Portland Boro	-	78	870	3,403	4,979
Sub-total	244	10,346	30,668	69,545	158,829
MONROE CO., PA					
Delaware Water Gap	-	32	241	567	17,999
Smithfield Twp	547	2,143	4,992	7,683	15,300
Sub-total	547	2175	5233	8250	33,299
BURLINGTON COUNTY, NJ					
Delran Twp	42	160	301	78	2,172
Riverside Twp	41	263	738	54	3,216
Delanco Twp	58	206	317	85	667
Beverly City	2	3	4	3	5
Edgewater Park Twp	-	-	-	-	-
Burlington Twp	12	30	370	34	1,814
Burlington City	618	28,211	43,993	40,000	115,515
Florence Twp	-	1	203	163	284
Mansfield Twp	31	139	445	445	762

TABLE 10 (Cont'd)

FLOOD DAMAGES
SELECTED SINGLE EVENTS
MUNICIPALITIES, COUNTIES, STUDY AREA
($000)
(March 1983 Dollars and Conditions)

Municipality	10 Yr	50 Yr	100 Yr	1955	S. P. F. (500 Yr.)
Bordentown Twp	13	32	39	44	68
Fieldsboro Boro	13	26	33	34	109
Bordentown City	4	63	90	107	145
Sub-total	834	29,134	46,533	41,047	124,757
MERCER CO., NJ					
Hamilton Twp	410	954	1,107	1,075	13,367
Trenton City	41	3,943	10,316	13,312	29,152
Ewing Twp	4	479	1,563	3,077	7,825
Hopewell Twp	62	417	905	1,767	3,808
Subtotal	517	5,793	13,891	19,231	54,152
HUNTERDON CO., NJ					
West Amwell Twp	-	58	98	176	310
Lambertville City	1	3,557	10,168	16,214	27,956
Delaware Twp	20	79	198	410	704
Stockton Boro	24	559	1,270	2,179	4,371
Kingwood Twp	29	895	1,632	2,240	2,991
Frenchtown Boro	37	669	1,691	2,760	11,691
Alexandria Twp	148	252	440	697	1,506
Milford Boro	185	417	538	668	12,807
Holland Twp	44	286	1,548	25,466	28,967
Sub-total	488	6,772	17,583	50,810	91,303
WARREN COUNTY, NJ					
Pohatcong Twp	5	2,269	4,952	6,737	9,505
Phillipsburg	2	115	640	2,410	4,605
Lopatcong	-	-	-	24	103
Harmony Twp	174	1,021	1,898	3,306	6,092
White Twp.	29	470	1,013	1,503	2,889
Belvidere Town	-	150	782	2,112	6,406
Knowlton Twp	6	278	855	2,028	6,359
Pahaquarry Twp	-	2	5	8	60
Sub-total	216	4,305	10,145	18,128	36,019
Grand-total	4690	78,802	170,952	275,006	689,349

TABLE 11

SUMMARY
AVERAGE ANNUAL DAMAGES
BY COMMUNITY
(March 1983 Dollars & Conditions)

COMMUNITY	RES	COM	IND	SER	PUB	UTL	TRN	AGR	HIS	RESCON [1]	COMCON [1]	NEC	EMR	TOTAL
PENNSYLVANIA														
Bensalem Twp	9.73	3.25	42.24	-	3.63	0.15	25.21	-	-	6.37	7.74	-	-	98.32
Bristol Twp	33.46	4.77	6.30	-	0.76	2.20	24.63	-	-	18.12	13.24	0.05	1.94	105.47
Bristol Boro	10.76	0.60	-	5.95	0.19	0.01	8.83	-	0.02	12.41	0.87	-	2.28	41.92
Tullytown Boro	3.01	1.50	3.00	0.03	-	-	1.79	-	-	2.05	2.50	-	-	13.88
Falls Twp	0.06	-	63.96	-	-	-	15.58	-	-	0.03	-	-	-	79.63
Morrisville Boro	3.42	-	371.54	-	-	-	12.67	-	-	2.59	-	-	-	390.22
Lower Makefield Twp	162.85	0.92	-	-	0.05	0.09	24.28	0.05	-	127.37	1.66	0.61	9.80	327.68
Yardley Boro	143.17	12.15	-	7.10	-	8.09	7.69	-	-	99.11	18.95	-	32.48	328.74 [2]
Upper Makefield Twp	87.14	2.77	-	0.55	15.63	0.07	38.56	0.55	4.92	60.00	4.09	0.81	1.85	216.94
Solebury Twp	46.83	28.74	-	2.97	0.06	0.02	13.92	-	-	28.78	6.76	-	3.71	131.79
New Hope Boro	38.08	75.03	-	1.10	-	1.14	4.56	-	0.27	26.91	81.31	-	14.86	243.26 [2]
Plumstead Twp	26.78	0.50	-	1.85	-	-	0.61	-	-	22.27	0.86	-	0.93	53.80
Tinicum Twp	110.53	13.84	-	6.05	3.62	-	20.37	0.52	8.27	74.76	26.45	4.94	-	269.35
Bridgeton Twp	75.52	3.32	-	1.40	-	-	8.13	0.02	-	42.51	2.56	-	6.07	139.53
Nockamixon Twp	0.86	9.93	-	0.73	-	-	2.59	-	-	0.52	21.85	-	0.02	36.50
Durham Twp	13.11	7.76	-	-	-	-	3.78	0.09	-	8.49	7.01	-	1.89	42.13
Reigelsville Boro	23.54	5.54	-	0.46	0.53	-	1.07	0.06	-	14.09	7.21	-	4.71	57.21 [2]
Williams Twp	21.81	2.21	-	1.00	-	-	9.12	0.01	0.20	12.61	1.84	-	0.80	49.60
City of Easton	29.90	73.50	508.69	16.67	6.03	1.62	9.15	-	-	16.32	70.18	0.40	59.42	791.88 [2]
Forks Twp	21.15	1.83	-	-	-	-	1.16	-	-	13.34	1.05	-	-	38.53
Lower Mount Bethel Twp	65.82	5.65	8.56	0.63	-	10.84	7.39	-	-	39.64	4.35	-	2.00	144.88
Upper Mount Bethel Twp	23.94	3.76	-	-	0.11	113.80	5.47	0.12	-	13.34	2.07	0.19	-	162.80
Portland Boro	4.91	9.53	-	3.72	-	-	0.27	-	-	3.90	12.73	-	-	35.06
Delaware Water Gap Twp	1.92	0.42	41.91	-	-	-	1.68	-	-	1.12	0.64	-	13.32	61.01
Smithfield Twp	15.82	9.93	183.57	0.40	0.26	-	2.93	-	0.49	9.48	7.54	-	12.24	242.66
NEW JERSEY														
Delran Twp	9.67	9.09	-	-	-	-	6.75	-	-	6.17	0.64	-	-	32.32
Riverside Twp	27.90	3.12	-	0.11	-	0.80	-	-	-	16.29	6.40	-	-	54.62
Delanco Twp	16.65	6.89	-	-	-	-	9.77	-	-	8.43	6.45	-	-	48.19
Beverly	-	-	-	-	-	-	1.54	-	-	-	-	-	-	1.54
Edgewater Park Twp	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 11 (Cont'd)

SUMMARY
AVERAGE ANNUAL DAMAGES
BY COMMUNITY
(March 1983 Dollars & Conditions)

COMMUNITY	RES	COM	IND	SER	PUB	UTL	TRN	AGR	HIS	RESCON 1/	COMCON 1/	NEC	EMR	TOTAL
Burlington Twp.	1.14	-	10.05	-	-	-	6.23	-	-	0.77	0.01	-	0.61	18.18
Burlington	602.70	151.26	124.12	251.94	2.33	49.13	1.21	-	0.92	185.89	266.56	3.27	91.85	1731.18 2/
Florence Twp.	-	0.01	-	-	-	-	0.06	-	-	-	-	-	3.06	3.13
Mansfield Twp.	-	-	8.63	-	-	-	19.10	-	-	-	-	-	-	27.73
Bordentown Twp.	-	-	-	-	-	-	3.82	-	-	-	-	-	-	3.82
Fieldsboro Boro	-	-	0.19	-	-	-	8.31	-	-	-	-	-	-	8.50
Bordentown	-	-	-	-	3.17	-	0.31	-	-	-	-	-	-	3.48
Hamilton Twp.	-	5.07	85.57	-	-	93.17	9.36	-	-	-	7.95	-	-	201.12
Trenton	108.19	2.46	41.27	14.81	0.38	-	4.40	-	-	68.61	2.67	0.04	79.41	322.24 2/
Ewing Twp.	27.48	6.32	-	4.03	-	-	2.77	-	-	18.88	4.83	-	0.52	64.83
Hopewell Twp.	8.93	3.93	-	0.33	0.14	-	23.72	0.01	5.96	5.36	4.59	-	-	52.97
West Amwell Twp.	-	0.36	-	-	-	-	3.26	-	-	-	0.10	-	-	3.72
Lambertville	34.14	12.24	172.08	1.51	3.36	0.67	2.90	0.02	-	23.35	18.44	-	16.08	284.79
Delaware Twp.	4.90	-	-	-	-	-	2.95	-	-	3.07	-	-	0.86	4.90
Stockton Boro	16.95	2.82	-	5.00	0.35	-	3.82	-	11.44	11.12	3.71	-	0.59	55.80
Kingwood Twp.	15.44	2.89	-	-	-	-	8.70	-	-	8.55	4.92	25.09	0.10	65.69
Frenchtown Boro	12.47	15.02	32.98	0.36	-	0.23	3.63	-	-	8.45	9.59	-	0.23	82.96
Alexandria Twp.	4.17	0.24	-	-	-	-	3.35	0.01	-	2.60	0.41	31.33	-	42.11
Milford Boro	1.37	3.29	51.59	0.23	-	-	0.94	-	-	0.84	6.65	76.16	-	141.07
Holland Twp.	20.19	-	30.23	-	-	117.73	5.19	0.01	-	11.86	-	-	1.63	186.84
Pohatcong Twp.	17.82	0.49	98.34	-	-	-	1.35	0.13	-	10.32	0.51	-	10.25	139.21
Phillipsburg	3.33	3.96	0.12	1.52	0.24	0.19	0.23	-	-	1.99	4.07	-	9.55	25.20 2/
Lopatcong Twp.	-	-	-	-	-	-	0.22	-	-	-	-	-	0.08	0.30
Harmony Twp.	66.00	4.53	0.43	-	-	-	2.92	-	-	37.12	12.33	-	3.28	126.61
White Twp.	19.09	2.98	-	-	-	-	1.72	-	-	10.89	1.58	-	4.05	40.31
Belvidere.	16.56	4.32	-	0.50	-	-	0.39	-	-	9.83	5.37	-	2.78	39.75 2/
Knowlton Twp.	14.69	0.92	-	0.04	1.11	-	2.01	0.49	-	8.13	0.93	-	13.44	41.76
Pahaquarry Twp.	-	-	-	-	-	-	0.37	-	-	-	-	-	-	0.37
TOTALS	2023.90	519.66	1885.37	330.99	41.95	399.95	392.74	2.09	32.49	1114.65	672.17	142.89	406.69	7965.54

1/ Residential and commercial contents were aggregated separately in anticipation that a growth factor such as affluence may have to be applied. Affluence was only applied to RESCON.

2/ Reported major damage centers for the 1955 flood.

order to allow separate computations of affluence and other growth in contents, if desired. The major portion of the AAD would occur to (RES) residential (39%), (IND) industrial (24%) and (COM) commercial (15%) land uses. The other land use types Historic (HIST), Agricultrual (AGR), Service (SER), Public (PUB), Utility (UTL), Transportation (TRN), Emergency (EMR), and Not Elsewhere Classified (NEC) each account for five percent or less.

112. A comparison of the portion of the potential problem that each type land use contributes is presented below. The number indicates the percent of the total population of flood plain structures and AAD indicates the percent of the total recurrent damages. An asterisk (*) indicates less than one percent of the total.

	RES	COM	IND	SER	PUB	UTL	TRN	AGR	HIS	NEC	EMR
Number(%)	83	12	1	2	1	*	N/A	N/A	*	1	N/A
AAD(%)	39	15	24	4	1	5	5	*	*	2	5

FORMULATION PROCESS

113. As shown conceptually in Figure 8, the formulation process was structured basically as a review of previous proposals and an introduction of new ones. It began with a check of the previous investigations to determine if changes have occurred which would affect the stated conclusions and recommendations. Those changes could be physical or analytical in nature and result from changes primarily in the proposed project site; hydrology and hydraulics; improved base data; economics, to include new sources of benefits; design requirements; or construction techniques. The level of detail of those reviews varied with the outlook for changing previous recommendations.

114. Flood protection measures suggested but never investigated and new concepts for providing protection were then screened for their applicability. Those investigations were initially conducted (conceptually) at a low level of detail. Measures were eliminated from further consideration as being impractical (if they lacked measurable physical performance); technically infeasible; or, obviously, too costly.

115. The major portion of the formulation effort was expended in performing the following steps. Potential flood protection measures were evaluated for physical and economic performance with consideration of critical environmental, cultural and social impacts. Physical performance was measured by decreases in discharges, decreases in stages and increases in levels of protection. Economic performance was measured by the amount of benefits to be derived, level of residual damages, and the ability to achieve the benefits for an equal or lower cost. In order not to prematurely eliminate a measure or plan, alternatives were retained for further consideration if they had a benefit to cost ratio (BCR) of 0.80 or greater. Assessments were conducted of the likely major or critical impacts of each plan. Major or critical impacts were defined as those which: make a plan unacceptable; result in substantial benefits which were not included in the economic analysis such as conservation, fish and wildlife enhancement or aesthetics; change primary components of the plan; or require mitigation costs which would obviously render the plan economically infeasible.