DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO

DELAWARE RIVER BASIN STUDY
SURVEY REPORT

MAIN REPORT

AUGUST 1984

DELAWARE RIVER BASIN STUDY
MAIN REPORT

Table of Contents

Table of Contents (Continued)

List of Tables

List of Figures

List of Plates

Exhibits

List of Appendices

List of Supplemental Data

SYLLABUS

This survey report presents the results of the analysis of flooding along the main stem Delaware River. This analysis was authorized by Congress at the request of the Delaware River Basin Commission (DRBC) in response to the deferment of the Tocks Island Lake Project. This study examined flood damage reduction alternatives for the section of the Delaware River from Stroudsburg, Pennsylvania to Burlington, New Jersey, which would have received flood protection from the Tocks Island Lake Project.

The Madigan-Praeger Report, The Comprehensive Study of the Tocks Island Lake Project and Alternatives, served as a point of departure for the comprehensive analysis by this study of localized structural and nonstructural alternative measures for flood damage reduction along the main stem Delaware. The Madigan-Praeger Report determined that with a repetition of the flood of record in 1955, catastrophic losses would result despite the construction of some flood control facilities and some floodplain management programs established since 1955. It was concluded by the Madigan-Praeger Report that only a mix of nonstructural measures could be economically justified as an alternative to the Tocks Island Lake Project.

This survey investigation determined the potential for flood damage along the main stem Delaware River (Stroudsburg to Burlington) by first updating hydrologic and hydraulic data and conducting a comprehensive damage survey of all structures subject to flooding. All practicable localized structural and nonstructural flood damage reduction alternatives were then investigated.

This investigation concluded that local structural protective works could not be justified. This is because high zero damage elevations and the older, complex infrastructure that characterize the main stem result in high project costs relative to flood damages reduced.

Although 12 study area communities were identified as justified for nonstructural protection based on the survey-level analysis, only a small percentage (approximately 2%) of the total structures (approximately 12,000) subject to flooding along the main stem are justified for nonstructural application. In addition, these structures are widely distributed throughout those 12 communities. These could be pursued further under the Continuing Authorities Program if non-Federal sponsorship is available.

The investigation does confirm that there is the potential for a major disaster should there be an occurrence of an event equal to the 1955 flood. This should be addressed both directly and indirectly at the local level. In addition, direct action should be taken by all the main stem communities in strict enforcement of flood plain ordinances and codes and in the improvement and maintenance of flood warning and preparedness plans.

The Corps of Engineers could provide technical assistance, as requested, through the provision of data for floodplain management and aid in preparedness planning.

Indirect action should also be taken at the local level. This involves a flood consciousness in all decisions made in land use and urban planning. Individual communities can minimize potential flood problems by including the benefits of reducing or eliminating flood related problems in making long range decisions on growth, development, and associated public policy.

INTRODUCTION

1. The Corps of Engineers' role in water resources planning for the Delaware River Basin dates back to 1823 when the Corps formulated plans for a breakwater at the mouth of the Delaware River for protection of shipping from storms and ice. In 1933 the Corps conducted a study of our nation's water resources which was known as the "308" report. A preliminary study of the Delaware River Basin was part of that study. The Delaware River Basin portion of the study dealt with navigation, hydroelectric power, flood control, irrigation, and water supply.

2. Seventeen years later (April 1950), as a result of extensive changes in the region's population and economy, Congress, acting at the request of local citizens, asked for a review of the "308" report. Limited review was in progress in August 1955 when two tropical storms (Hurricanes Connie and Diane) moved up the eastern coast of the continental United States about a week apart. The flood damage and other destruction resulting from those storms dramatically emphasized the need for a full appraisal of the water problems of the Delaware River Basin. Subsequently, as a result of additional Congressional action, the Comprehensive Survey of the Water Resources of the Delaware River Basin was undertaken.

3. That comprehensive study was completed by the Corps in 1962 and recommended a plan for adoption as a guide to the timed and balanced development of the water resources of the basin. Also, as a result of that study, the Delaware River Basin Commission (DRBC) was established and charged with the responsibility to oversee the planning, development, management and protection of the water resources of the four state river system, including all of its tributaries.

4. Another significant step in the development of comprehensive planning came in 1972, with Section 209 of the Federal Water Pollution Control Act Amendments Legislation (Public Law 92-500). Section 209 directed that so-called "Level B" plans be prepared for all regions or river basins in the United States. This represented an acceleration of the Federal government's comprehensive planning program. Within the Delaware River Basin, the DRBC was charged with the responsibility to develop the "Level B" plan.

5. The original Comprehensive Survey of the Delaware Basin, completed by the Corps (1962), recommended that 19 major water reservoir projects and 39 smaller reservoir projects be included in a plan for the long-range development of the basin's water resources. The largest project recommended for construction was the Tocks Island Lake project. The Tocks Island project would have reduced recurrent flooding along the main stem of the Delaware River. In response to public controversy surrounding the project, Congress directed the Corps, in cooperation with the DRBC, to conduct a comprehensive and impartial review of the project and its alternatives.

6. On 31 July 1975, based on the results of that review, DRBC, by majority vote, recommended that construction funds for the project not be appropriated by Congress. This prohibited its construction. Nevertheless, DRBC has retained the authorized project in its comprehensive plan for possible development after the year 2000.

7. Subsequent to the denial of construction funding for the Tocks Island project, thirty-seven miles of the Middle Delaware River within the Delaware Water Gap National Recreation Area were assigned "recreational" status in an amendment (Public Law 95-625) to the Wild and Scenic Rivers Act (Public Law 90-542). This designation includes this section of the main stem Delaware River in the National Wild and Scenic River System.

The Wild and Scenic Rivers Act Section 7(b) declares that

> ".... no department or agency of the United States shall assist by loan, grant, license, or otherwise in the construction of any water resources project that would have a direct and adverse effect on the values of which the river might be designated as determined by the Secretary for its study."

In this case the "recreational" designation is defined as

> "Those rivers or sections of rivers that are readily accessible by road or railroad that may have some development along their shoreline and that may have undergone some impoundment or diversion in the past."

8. The implications for any future construction of the Tocks Island project are that this stretch of the Delaware River would require the removal of this designation which, although not totally improbable, would at the minimum constitute a major planning impediment.

9. Recognizing that without the Tocks Island project, existing properties within the main stem area are without the realistic prospect of receiving protection from flooding, DRBC expressed an interest in the development of a flood damage reduction program for that area. Acting on this interest, several Congressional representatives, in November 1975, made a request to the chairman of the House Committee on Public Works and Transportation for Congressional authorization of such a flood control study. The result is the subject Delaware River Basin Study (DRBS).

STUDY AUTHORITY

10. This study was authorized by a resolution adopted 23 September 1976, by the House Committee on Public Works and Transportation. The resolution is as follows:

> "Resolved by the Committee on Public Works and Transportation of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors is hereby requested to review the reports of the Chief of Engineers on the Delaware River and Tributaries, New York, New Jersey, Pennsylvania, and Delaware, printed in House Document No. 522, 87th Congress, 2nd Session, and other pertinent reports, with a view to determining the need for modification of the recommendations contained therein with particular reference to the advisability of adopting improvements for flood control and allied purposes in the Delaware River Basin, including but not limited to a flood protection program consisting of non-structural measures, in coordination with the Delaware River Basin Commission."

SCOPE OF STUDY

11. Flooding problems in the Delaware River Basin were addressed in the Comprehensive Plan of the Corps of Engineers for development of water resources in the Delaware River Basin as contained in House Document No. 87-522 (HD 522). Flooding problems exist throughout the basin. Their causes are complex and their solutions difficult. Since the authorization of HD 522 in 1962, many local and area-wide detailed flood control studies have been conducted. The larger efforts addressed portions of tributaries in New York, the Schuylkill River Basin, the Lehigh River Basin, the Lackawaxen River Basin, the Christina River Basin, the Rancocas Creek Basin, the Chester Creek Watershed, the tri-county region of New Jersey including Burlington, Camden, and Gloucester counties, and the reach along the New Jersey side of the Delaware River south of Gloucester County. However, since the proposed Tocks Island project was to provide protection, flooding problems along a major portion of the main stem of the Delaware River were not addressed further.

12. Taking into consideration flood control measures constructed by others, the main stem is where residual damage potential (i.e. damages that might occur despite the presence of flood control measures) is currently the greatest. Other water resource problems and needs in the Delaware River Basin, such as those related to navigation, water supply, recreation, and hydroelectric power, are adequately addressed by other ongoing or completed study efforts by the Federal and state governments and regional agencies including those listed in Table 1. Therefore, in accord with the wishes of the study sponsor, the Delaware River Basin Commission, the major purposes of this study are to determine more precisely the potential for flood damage and potential for solutions along the Delaware River below the Tocks Island site.

STUDY AREA

13. As shown in Plate 1, the physical boundaries of the Tocks Island flood control influence area and therefore, the study area considered in this report, covers approximately a 100 river mile portion of the Delaware River main stem from Stroudsburg, Pennsylvania, downstream to and including Burlington, New Jersey. This area includes portions of 58 municipalities in seven counties consisting of Monroe, Northampton, and Bucks in Pennsylvania and Warren, Hunterdon, Mercer and Burlington in New Jersey.

NATIONAL OBJECTIVE

14. This study was carried out by systematic preparation and evaluation of alternative ways to address the problems, needs, concerns, and opportunities under the "Principals and Guidelines" (P&G) of the Cabinet Council on Natural Resources and Environment. The P&G requires that Federal and Federally-assisted water resource planning be directed to achieve the National Economic Development (NED) objective. NED is to be achieved by increasing the value of the nation's output of goods and services and improving national economic efficiency. Each structural and nonstructural alternative plan's effect on environmental quality, regional development and other social effects were considered. This approach resulted in information that allowed effective choices to be made regarding resource management under existing projected conditions.

STUDY OBJECTIVES

15. There are two primary purposes for this study. The first is to determine more precisely the potential for flood damage in exisiting developed areas along the main stem Delaware River below the Tocks Island site. The second is to determine the costs, effectiveness, feasibility, and acceptability of nonstructural measures and local protection works for flood protection or damage reduction in that area.

16. Previous formulation and evaluation of structural and nonstructural local measures are considered approximate by current standards. This is because of the age and limited scope of the 1955/1958 basic data as well as the rapid advance of state-of-the-art evaluation techniques relative to previous methodologies employed. In addition, simplified procedures were often followed in past formulation and evaluation analyses which may have incorrectly grouped or bypassed potential solutions. The first part of the study develops new physical and economic data and tests its impact on benefits, costs and subsequently, on previous conclusions. Previous conclusions for not only structural projects but also nonstructural programs were often qualified to reflect the limited scope of the original data base. The second part of the study considers the nonstructural measures in light of more recent findings and state-of-the-art evaluation techniques.

PRIOR AND ON-GOING INVESTIGATIONS

17. Since the founding of this country, Congress has realized the importance of our natural resources as a basis for our national wealth. Consequently, development of these resources has always been of concern. Through the years, national policies have been established regarding their use. As the development of our nation's water resources began and progressed, the Federal Government, states, and local groups became concerned over the "best use" of our nation's water resources.

18. Since the "308" report mentioned previously, a number of investigations pertaining to the flood control and related water resource problems and needs of the Delaware River Basin have been made by the Corps of Engineers, the DRBC and others. These prior efforts have included post-flood studies, comprehensive water resources studies which included flood control, special project reports, multipurpose project studies, local or area-wide flood control studies and other general investigations. Table 1 presents 14 of the many prior investigations and reports which were used in varying degrees for this study. The prior investigations which are most pertinent to this study are discussed in the following paragraphs.

19. POST FLOOD REPORT, HURRICANES CONNIE AND DIANE. The August, 1955 storms produced the largest flood of record generally throughout the basin and provided an opportunity to secure data necessary to establish stage-damage relationships on a large number of streams not covered in earlier surveys. During, and immediately following, the 1955 flood, preliminary reconnaissance and aerial photographic surveys were made of the flooded areas in the basin. These were followed by a field survey made during the period October through December 1955. A supplemental survey of the August 1955 flood losses was conducted in August 1958 for the purpose of securing additional flood damage data throughout the basin in order to define more adequately the stage-damage relations for various river reaches and damage centers. That data was then used in the Comprehensive Basin Study described in the following paragraph.

20. COMPREHENSIVE BASIN STUDY (1962). As a result of extensive changes in the region's population and economy, Congress, in April 1950, asked for a

TABLE 1

PERTINENT STUDIES
DELAWARE RIVER BASIN

Study	Publication	Remarks
Delaware River Basin, NY, NJ, PA and DE	"308" Report by the Corps of Engineers, 1933	Preliminary study of water resources of the basin as part of a national survey.
Post-Flood Report, Hurricanes Connie and Diane	Report on Operation Noah by the Corps of Engineers, May 1957	Description of relief and emergency operations with estimate of flood damages.
Delaware River Basin, NY, NJ, PA and DE	Comprehensive Basin Study by the Corps of Engineers, House Document No. 522, 87th Congress, 2d Session, August 1962	Comprehensive plan for development of water resources of the Delaware River Basin. (Discussed in text.)
Delaware River Basin, NY, NJ, PA and DE	Report for Corps of Engineers by J. Mellan Co., Inc., March 1966	Update of 1955 flood damages utilizing aerial photography and sampling techniques.
Delaware River Basin, NY, NJ, PA and DE	Report for Delaware River Basin Commission by Tippetts, Abbett, McCarthy and Stratton, March 1972	Reviews potential impoundment sites for power and related water resources.
Delaware River Basin, PA and NJ	Report by Environmental Defense Fund, Inc., April 1973	Flood control study with emphasis on non-structural solutions.
State of Pennsylvania	Report prepared for the Commonwealth of Pennsylvania by Michael Baker, Jr., Inc., November 1974	Description of flood plain land use, population and damage estimates for flood prone communities in Pennsylvania aggregated by River Basin information plotted on USGS quads.

TABLE 1 (Cont'd)

Study	Publication	Remarks
Delaware River Basin, NY, NJ, PA and DE	Report by Delaware River Basin Electric Utilities Group, Reservoir Contingency Study Subcommittee, May 1975	Reviewed alternative water supplies for power or consumptive use.
Comprehensive Study of the Tocks Island Lake Project & Alternatives	Report prepared for the Corps of Engineers by URS/Madigan-Praeger, Inc. and Conklin & Rossant, June 1975.	Identified various viable technical alternatives to the Tocks Island Lake project. (Discussed in text.)
Delaware River Basin, NY, NJ, PA and DE	Report for Delaware River Basin Commission by Tippetts, Abbett, McCarthy and Stratton, August 1976	Investigated water supply for power use or consumptive use.
Camden Metropolitan Urban Study	Survey study completed by the Corps of Engineers, April 1980	Flood control, water quality, water supply of Burlington, Camden and Gloucester Counties, NJ.
Delaware River Basin Comprehensive Study (Level B Study)	Final report completed for the Delaware River Basin Commission (DRBC), May 1981	To provide a basis for updating comprehensive plan of DRBC for development of water resources. (Discussed in text)
Daily Flow Model of the Delaware River Basin	Report by Corps of Engineers in cooperation with DRBC and Commonwealth of PA, New York State and USGS, September 1981	Basin management - reservoir regulation model.
Delaware River Tributaries in New York State	Survey study by the Corps of Engineers, April 1981	Flood control, flood plain management.

review of the "308" report. A limited review was in progress in August 1955 when Hurricanes Connie and Diane moved up the eastern coast. The flood damage and other destruction resulting from these storms dramatically emphasized the need for a full appraisal of the water problems of the Delaware River Basin.

Subsequently, as a result of additional Congressional action, the Comprehensive Survey of the Water Resources of the Delaware River Basin was undertaken.

21. This comprehensive study was completed by the Corps in 1962, and recommended a plan for adoption as a guide to the timed and balanced development of the water resources of the basin. Throughout the study, it was apparent that the plan would require a program of participation by Federal and non-Federal interests. As a means for coordinating and integrating these interests, local agencies of the area were concurrently considering the nature and establishment of an appropriate lead organization. In 1961, an interstate Federal Compact was drawn up with concurrent legislation from Congress and the States of New York, New Jersey, Pennsylvania and Delaware. The Compact established the DRBC whose members are the governors of the four states and the Secretary of the Interior (the Federal Representative). The Commission was charged with the responsibility to oversee the planning, development, management and protection of the water resources of the four state river system, including all of its tributaries.

22. MADIGAN-PRAEGER REPORT. The largest project recommended by the 1962 Comprehensive Basin Study was the Tocks Island Lake project. Public controversy surrounding the project in the early 1970's, centered on the project's possible environmental, social, and economic impacts on the surrounding area. In response to the controversy, Congress directed the Corps, in cooperation with the DRBC, to conduct a comprehensive and impartial review of the project and its alternatives.

23. The resulting Comprehensive Review Study of the Tocks Island Lake Project and Alternatives did not make recommendations. It did, however, analyze the water related demands to be placed upon basin resources; investigate alternatives available to meet or modify those demands that would have been satisfied by the Tocks Island Lake project; and identify the potential impacts of both the Tocks Island project and its alternatives.

24. LEVEL B STUDY. The Level B Study did not devote much effort to flood control considerations since the basin states and DRBC are engaged in such studies under the National Flood Insurance Program grant assistance program.

25. DELAWARE RIVER BASIN ICE JAMS STUDY. This study was authorized by the Senate Committee on Environment and Public Works on March 26, 1982. Its purpose is to determine if improvements for those areas subjected to flooding from the formation and movement of ice along the main stem of Delaware River and its tributaries are warranted.

The study was initiated in October 1984 and is being conducted in two phases. The initial phase is the Reconnaissance Study which will be completed by October 1984. The Reconnaissance Study will establish the definition of the problems, present an array of potential solutions, update the estimated study cost and, if appropriate, establish a project cost sharing agreement

with the non-Federal sponsors. A portion of the Reconnaissance Study is being devoted to solving the ice related problems in the vicinity of Port Jervis, New York; Metamoras, Pennsylvania; and Westfall Township, Pennsylvania. These are the communities in the basin which have historically experienced the most severe ice related damages. The balance of the Reconnaissance Study considers other potential problem areas. In fiscal year 1985, the second phase, the Detailed Feasibility Study, will be initiated.

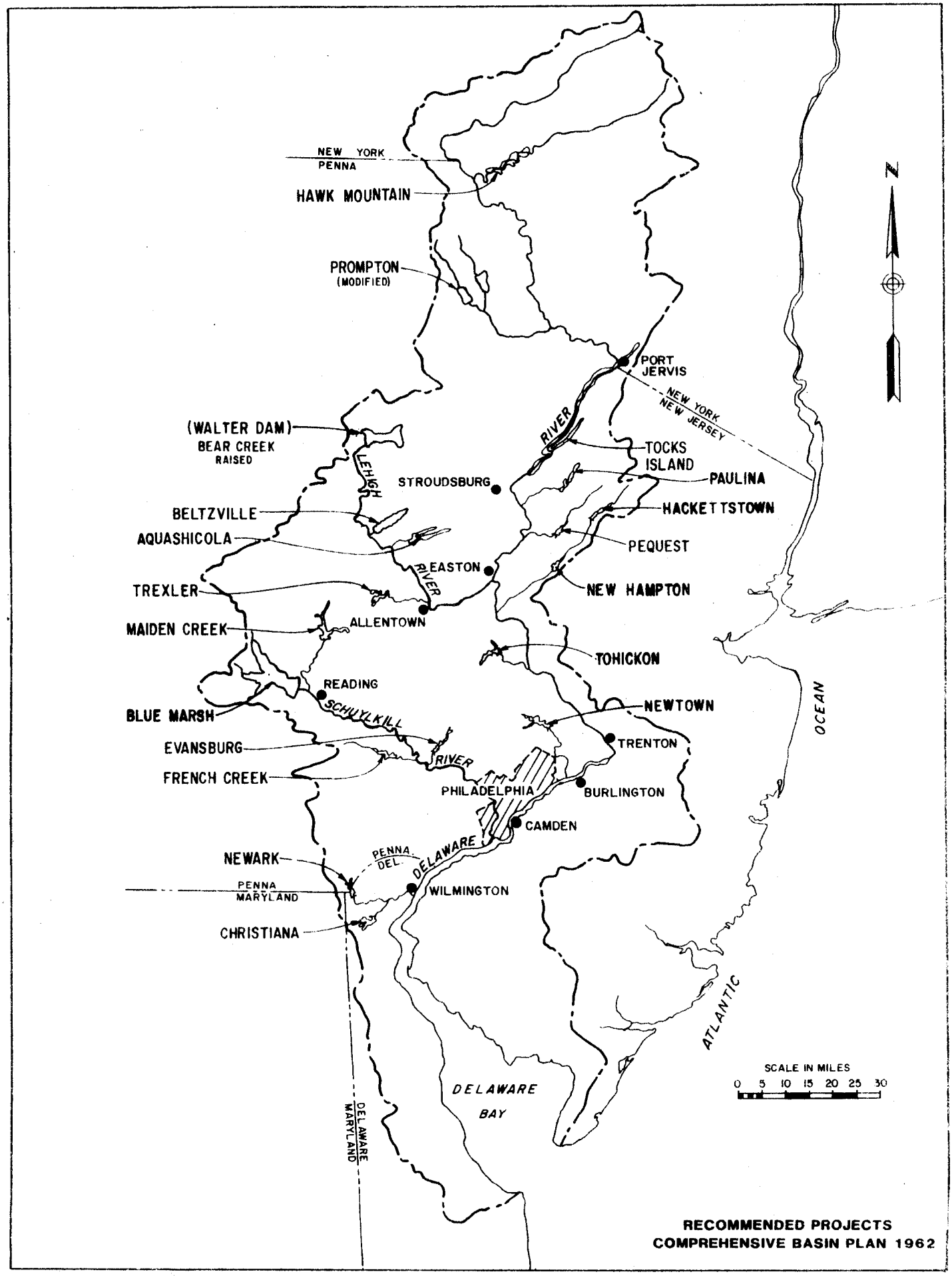
EXISTING PROJECTS AND PROGRAMS

26. This section presents a description of existing projects and programs used to prevent or limit flood damages in the study area. Basically, structural protective works are projects that prevent or protect against flooding. Nonstructural programs attempt to manage or control the level or type of development of flood plain areas in order to minimize property damages and human suffering when flooding occurs. The following discussion is limited to major projects and programs which have an impact on the main stem of the Delaware River between Stroudsburg, Pennsylvania and Burlington, New Jersey.

27. EXISTING FEDERAL FLOOD CONTROL PROJECTS. Construction of the flood control (impoundment) projects recommended in the Comprehensive Plan of the Corps of Engineers was authorized by the Flood Control Act of 1962 (Public Law 87-874). The locations of those projects are shown on Figure 1 and their current status is listed in Table 2. As shown in Table 2, this Comprehensive Plan has yet to be fully implemented with construction to date of only the Beltzville Lake and Blue Marsh Lake Projects. (Blue Marsh Lake is in the Schuylkill River Basin and does not impact the study area.) In addition to the projects recommended by the Comprehensive Plan for construction and modification, other projects for purposes of flood damage reduction have been authorized and constructed under earlier Flood Control Acts. Those projects impacting on the study area are the General E. Jadwin Dam and Prompton Reservoir projects in the Lackawaxen River Basin, and the Francis E. Walter Dam in the Lehigh River Basin. A description of each project and its current status is given in the following paragraphs.

. Beltzville Lake. Beltzville Lake project was placed in operation in February 1971. The project is located on Pohopoco Creek in Carbon County, Pennsylvania, about four miles upstream from the confluence of that stream with the Lehigh River, a major tributary to the Delaware River. This is a multipurpose development project to provide flood control, water supply, water quality and recreation. Its primary purpose is to reduce flood stages on the Lehigh River below the confluence of that river with Pohopoco Creek, and secondarily to the main stem Delaware River.

. General E. Jadwin Dam. The Jadwin Dam project authorized and completed prior to passage of Public Law 87-874 is located on Dyberry Creek, in Wayne County, northeastern Pennsylvania, about three miles above the confluence of that stream with the Lackawaxen River in Honesdale. Jadwin Dam is a single-purpose flood control reservoir which, during normal flow conditions, is a "dry dam" providing complete release of flows within the stream channel limits. The reservoir was designed with an uncontrolled outlet works for short term storage of water. Its primary purpose is to reduce flood stages in the Lackawaxen River at Honesdale and Hawley, Pennsylvania.



RECOMMENDED PROJECTS
COMPREHENSIVE BASIN PLAN 1962

FIGURE 1

TABLE 2

MAJOR PROJECTS AUTHORIZED BY
FEDERAL FLOOD CONTROL ACT OF 1962
(Public Law 87-874)

Project Name	Location	Purposes	Original Construction Schedule	Status
Hawk Mountain	E. Br. Delaware R. near Hancock, NY	S,P,R	2001	Development Precluded
Prompton* (modification)	Lackawaxen R. near Honesdale, PA	S,R,F	1974	Need confirmed by DRBC Level B Study
Tocks Island*	Delaware R. Near Del. Water Gap, PA	S,P,R,F	1974	Deferred
Walter* (modification)	Lehigh R. Near White Haven, PA	S,R,F	1989	AE & D Study Underway
Beltzville*	Pohopoco Cr. near Lehighton, PA	S,R,F	1965	Constructed
Aquashicola*	Aquashicola Cr. near Palmerton, PA	S,R,F	1981	Deferred
Trexler*	Jordan Cr. near Allentown, PA	S,R,F	1972	Inactive
Maiden Creek*	Maiden Cr. near Reading, PA	S,R,F	1982	Deferred
Blue Marsh*	Tulpehocken Cr. near Reading, PA	S,R,F	1969	Constructed
Newark	White Clay Cr. near Newark, DE	S,R	1975	Development Unlikely
Christiana	Christina R. near Christiana, DE	S,R	1980	Development Unlikely
Paulina	Paulina Kill Near Blairstown, NJ	S,R	**	Development Unlikely
Pequest	Pequest R. near Oxford, NJ	S,R	**	Development Unlikely
Hackettstown	Musconetcong R. near Hackettstown, NJ	S,R	**	Under Consideration by NJ
New Hampton	Musconetcong R. near Washington, NJ	S,R	**	Development Unlikely
Tohickon	Tohickon Cr. near Ottsville, PA	S,R	**	Constructed (Nockamixon)
Newtown	Neshaminy Cr. near Newtown, PA	S,R	**	Development Unlikely
French Creek	French Cr. near Phoenixville, PA	S,R	**	Development Unlikely
Evansburg	Skippack Cr. near Collegeville, PA	S,R	**	Inactive

* Recommended for Federal Development in House Document 522-87-2 and authorized for construction by PL 87-874

** 1st stage construction for recreation prior to 2010 with 2nd stage construction for other purposes after 2010.

S = Supplies of water to augment low flows
P = Hydroelectric power
R = Recreation
F = Flood control
AE & D = Advanced Engineering & Design

. Prompton Reservoir. The Prompton Reservoir project is located in Wayne County in northeastern Pennsylvania. The dam is located approximately 30 miles above the confluence of the Lackawaxen River with the Delaware River at Lackawaxen, Pennsylvania. Construction of the existing project was completed in November 1960, with incidental recreation facilities constructed at later dates. Prompton Dam is an earthfill structure with uncontrolled outlet works and was designed primarily for flood control purposes. The dam is designed to hold flood water for a short period after a flood. Its primary purpose is to reduce flood stages in the Lackawaxen River at Honesdale and Hawley.

Recreation was not an original project purpose and the existing facilities provide limited opportunities for swimming, fishing, boating and picnicking. These resources do not actually accommodate the recreational demand in the project area. Modification of the existing project was recommended in the Comprehensive Plan. The proposed modifications would convert the project to a multipurpose development providing long term storage for water supply and recreational use as well as maintain flood control protection. DRBC has recently confirmed the need for this modification in its Level B study and has recommended that construction be expedited.

. Francis E. Walter Dam. The Francis E. Walter project is located on the Lehigh River in Carbon and Luzerne Counties, approximately 75 river miles above its confluence with the Delaware River. Construction of the existing project was completed in 1961 with limited minor recreational facilities constructed at later dates. The dam is a rolled earthfill flood-control structure with gate controlled outlet works. The existing dam is operated primarily for flood control, and secondarily for recreation and water quality purposes. Its primary purpose is to provide flood control along the entire Lehigh River and secondarily along the main stem Delaware River. Recreation was not an original project purpose and the existing facilities provide limited opportunities for swimming, fishing, boating and picnicking. These resources do not actually accommodate the recreational demand in the project area. Modification of the existing project was recommended in the Comprehensive Plan. The proposed modification of the existing dam would convert the project to a multipurpose development providing long term storage for water supply and recreational use as well as maintain flood control protection. At the request of DRBC through Congress, advanced planning, engineering and design has been initiated for the modification by the Corps.

28. AUTHORIZED FEDERAL FLOOD CONTROL PROJECTS NOT CONSTRUCTED. As indicated in Table 2, in addition to the Tocks Island project, two other major projects recommended in the Comprehensive Plan which would provide some flood control were never funded for construction. These projects are Aquashicola Lake and Trexler Lake.

. Tocks Island Lake. Tocks Island Lake is the largest project recommended in the Comprehensive Plan. It is designed as a multi-purpose project for flood control, water supply, hydroelectric power and recreation. The damsite is located at the downstream end of Tocks Island in the main stem of the Delaware River about five miles upstream from the Delaware Water Gap. The project would reduce flooding on the main stem Delaware River in the reach from Tocks Island to Burlington, New Jersey. From a hydrologic point

of view, the Tocks Island site would have significance because of its strategic location within the basin relative to total drainage area intercepted (3,827 square miles) all of which is located upstream from the eight major damage centers and in that area of the basin which has historically produced the highest rates of runoff. The drainage area above the Tocks Island site represents better than 56 percent of the total drainage area above Trenton (6,780 square miles), and normally contributes better than 75 percent of the runoff passing Trenton.

. Aquashicola Lake. Aquashicola Lake is authorized as a multiple purpose development for flood control, water supply and recreation. The damsite is located on Aquashicola Creek in Carbon County, Pennsylvania, about four and a half miles from the confluence of that stream with the Lehigh River. Based on escalating old benefits and costs, the project has marginal economic justification and has been placed in a deferred category for restudy.

. Trexler Lake. Trexler Lake is authorized as a multipurpose project for flood control, water supply and recreation. The damsite is located on Jordan Creek in Lehigh County, Pennsylvania, about 12 miles above the confluence of that stream with the Lehigh River. Its primary flood control effects would be along the Jordan Creek and Lehigh River.

Strong local opposition to this project culminated with an expression by the voters of Lehigh County in November 1977, when they voted almost three to one on a nonbiding referendum against the project. This led to nonappropriation of funds by Congress and the subsequent supension of engineering and design. Resumption of construction planning and engineering is dependent upon Congressional appropriation of funds. The project has been retained in the Comprehensive Plan of the DRBC.

29. EXISTING LOCAL FLOOD CONTROL PROJECTS. The Commonwealth of Pennsylvania constructed local protective works consisting of levees and floodwalls in Stroudsburg and East Stroudsburg after the August 1955 flood. That flood event caused extensive damage in both areas. The local protective works are designed to protect against the recurrence of the damages resulting from a similar future event. These two projects are the only major state protective works affecting the study area.

30. The City of Burlington, New Jersey, also constructed levees. These were to have provided protection against approximately a 100 year event. The levees have fallen into disrepair, do not adequately tie into high ground, contain extensive breaches, and do not sufficiently provide for interior drainage.

31. EXISTING MANAGEMENT PROGRAMS. There are existing programs in the basin for properly managing flood plains and storm-water runoff. These programs involve participation at all levels of government; Federal, Interstate, state and local.

. Federal Programs. The most significant of these programs was created by the Federal Flood Disaster Protection Act of 1973. This act required every community identified by the Department of Housing and Urban Development (HUD) as having areas within a flood hazard zone to participate in the National Flood Insurance Program by 1 July 1975, or one year after identification. While participation in the program is not mandatory by law,

it is a prerequisite for Federal or Federally-related financial assistance for acquisition or construction of structures in these flood prone areas. Additionally, Federally regulated lending institutions must require flood insurance as a condition for a loan for property located in flood hazard areas. A major intent of the Act is to "Require states or local communities, as a condition of future Federal Financial Assistance,...to adopt adequate flood plain ordinances with effective enforcement provisions consistent with Federal standards to reduce or avoid future losses..."

Because of the strict sanctions associated with noncompliance, national, state and local officials feel that the Act is an effective instrument in controlling land use in floodplains. Almost all communities in the study area are participating to some extent. Some of the provisions of the Act are ambiguous and some are considered overly stringent by some communities. This has delayed or diluted proper implementation by a number of communities. Enforcement of adopted regulations remains to be proven.

. Interstate Program. The DRBC adopted its Flood Plain Regulations on November 10,1976, and they became effective on January 1, 1977. The standards of flood plain use contained in these regulations apply to the non-tidal portions of the Delaware River and its tributaries. They are utilized by the DRBC in reviewing certain categories of water-related projects. They are also designed as minimum compliance standards to be followed by local units of government in the promulgation of flood plain regulation ordinances.

Additional information concerning these regulations may be obtained from the Executive Director, Delaware River Basin Commission, P. O. Box 7360, West Trenton, New Jersey 08628.

. State Programs. State laws affecting flood plain development are in effect in both New Jersey and Pennsylvania. New Jersey State Act 58:16A-50 et seq. authorizes the State Department of Environmental Protection to delineate the state's flood hazard areas and after delineation, to adopt floodway land use regulations. It also directs the Department to delineate the flood fringe areas and to promulgate minimum standards for local rules and regulations governing uses and development in the area.

The implementation of these and similar laws in New Jersey has resulted in the general limitation of floodways for open-space uses, with the exception of needed bridges and utilities. The law accomplishes this by setting up a system requiring permits for all construction with the municipalities having jurisdiction over development of the flood fringe. New Jersey's program will serve to control land use in the future but has little impact on existing structures.

The potential of the New Jersey law is to greatly decrease future development in both the floodway and the flood fringe. Structures, both temporary and permanent, are required to obtain permits. These permits are intended to be given only if they do not have undue or significant effects on flood flows, velocities, or heights; local runoff; erosion or sedimentation; or ground water or surface water quality. Additionally, any structures in the floodway or flood fringe damaged beyond repair will need a permit to be replaced.

The stated purpose of the Pennsylvania Flood Plain Management Act is to: 1) encourage planning and development in flood plains which are consistent with sound land use practices, and 2) authorize a comprehensive and coordinated program of flood plain management. The Act gives the Department of Community Affairs and the Department of Environmental Resources the authority to review and process municipal flood plain management programs and, where municipal plans are inadequate, to implement the provisions of the Act. A major mechanism of control in the Act is the regulation of particular obstructions in the flood plain.

Section 301 of the Act states that no construction, enlargement, or expansion of certain obstructions listed in the Act can be undertaken unless a special permit has been issued. Section 205 requires the state to adopt regulations establishing criteria and standards for the coordination and uniform enforcement of municipal flood plain management regulations. Thus, the Act requires the state to develop minimum standards for land use management in floodways.

The intent of the Pennsylvania law is similar to that of the New Jersey law. That is, to regulate or prohibit structures in the "flood area". The enforcement of the law is given primarily to the local governments. The implementation of this law would result in a significant slowing of any growth in the "flood area" which would have otherwise occurred.

Another flood related program in Pennsylvania is for the management of storm water runoff. Pennsylvania has recently passed legislation requiring municipal and countywide storm water management planning, however, funding for this legislation has not yet been appropriated. This program would be critical in urbanizing areas on a scale from individual buildings to entire watersheds, to prevent increased future flood risks. Upstream development outside the flood plain often leads to increased flood damage potential downstream. Greater areas of impervious surface lead to less absorption, faster storm runoff, and sharper, more intense flood crests. Increased sedimentation and erosion associated with such development reduces stream channel capacity, resulting in more frequent local flooding; existing reservoirs downstream will suffer from increased siltation.

. Local Programs. In general, the local programs are the communities' implementation of, and compliance with, the Federal and state programs. The actual application and administration of the programs vary greatly. Some communities have truly established exemplary programs. In terms of local government control of flood plain management, some counties have taken a strong lead and, in other cases, strong municipalities overshadow their county and the rest of the communities. Local programs and activities will be further discussed later in this report.

EXISTING CONDITIONS

32. Contained in this section is a concise discussion of the existing natural and human-influenced conditions in the study area. For a more detailed discussion as well as projections of future conditions see Appendix A.

33. The Delaware River Basin extends approximately 265 miles southward from the western slopes of the Catskill Mountains in New York to the Atlantic Ocean at the mouth of Delaware Bay. The basin width varies from 40 miles to 80

miles. The total area of the basin, excluding Delaware Bay, is 12,765 square miles. It occupies a part of four states: New York, New Jersey, Pennsylvania and Delaware. Location of the basin is shown on Figure 2.

34. As shown on Plate 1, the East and West Branches of the Delaware River rise on the western slopes of the Catskill Mountains and flow southwesterly to make right angle turns in a valley descending southeasterly to Port Jervis, New York. In this valley, the West Branch is joined by the East Branch near Hancock, New York to form the main stem of the Delaware River. From its source to the mouth of Delaware Bay between Cape May, New Jersey and Cape Henlopen, Delaware, the flowing waters travel a distance of 350 miles.

PHYSIOGRAPHY

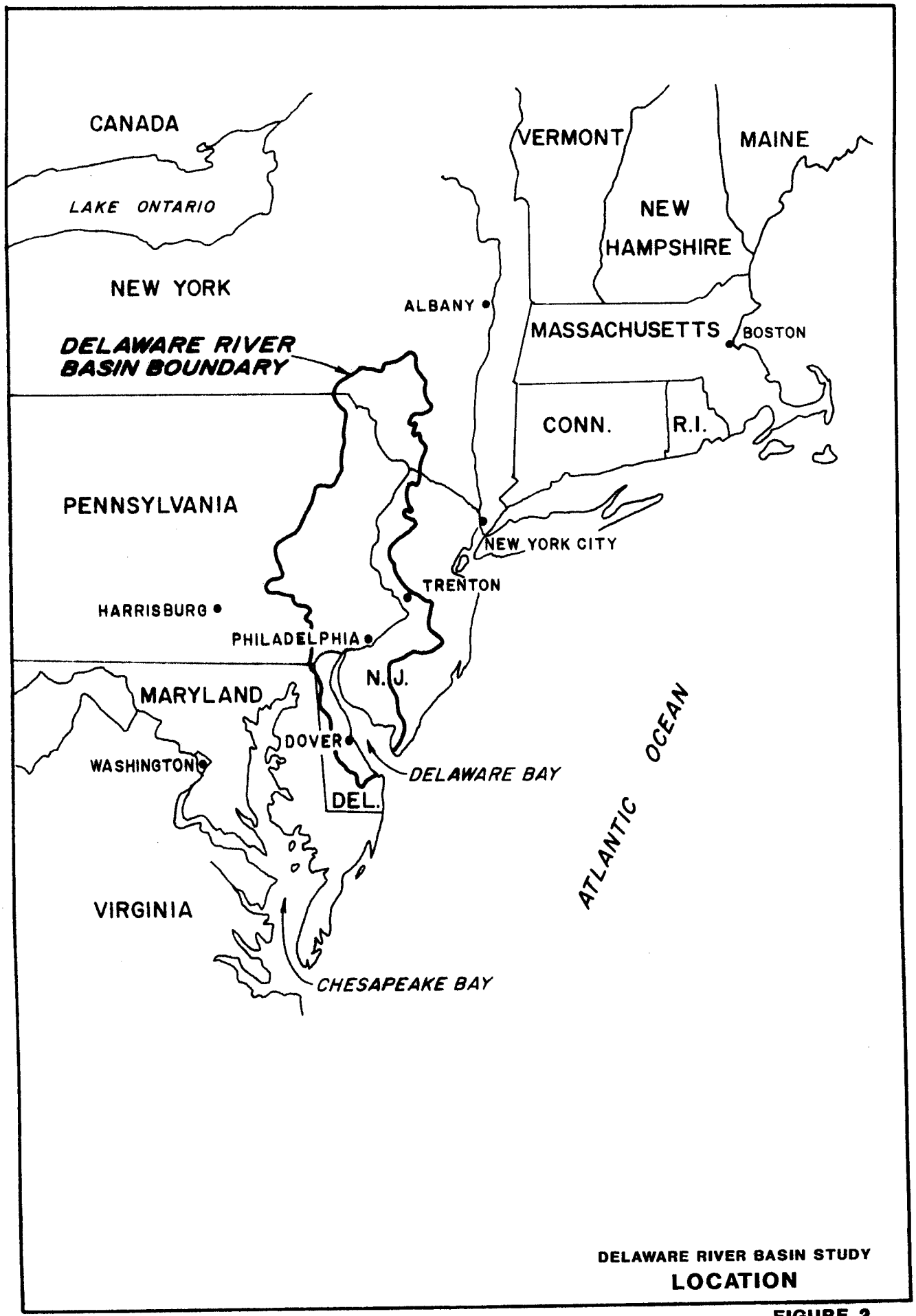
35. The Delaware River Basin lies across five of the major physiographic provinces of the eastern United States. These provinces, as shown on Figure 3, are the Catskill Mountains and the southern New York Section of the Appalachian Plateaus Province; the Great Valley and the valleys and ridges north of the Blue Mountain of the Valley and Ridge Province; the Reading prong of the New England Province; the Piedmont Upland and Piedmont Lowland sections of the Piedmont Province and the Coastal Plain Province. The natural characteristics of the basin including geology, soils, vegetation, ground water, regimen of streams and runoff lend themselves to three general physiographic definitions, namely, the Upper Region, the Central Region and the Lower Region. The upper limit of the Central Region is not distinctly defined; however, it may be considered as the Valley and Ridge physiographic province at Stroudsburg, Pennsylvania. The region is more clearly marked at its lower boundary by the fault line near Trenton, New Jersey, where there is a drop of about 250 feet to 350 feet in elevation to the Atlantic Coastal Plain. This Central Region includes the reach of the main stem Delaware River that is the subject of this report.

SOILS

36. The soils in the Delaware River Basin fall within three major divisions: the Mountainous and Upland Plateau; the Ridge and Valley and Piedmont Plateau Area, including the Triassic Basin and the Southern New England Upland and Northern Shale and Limestone Belt; and the Coastal Plain Area. The second and third divisions contains the reach of the subject main stem of the Delaware River.

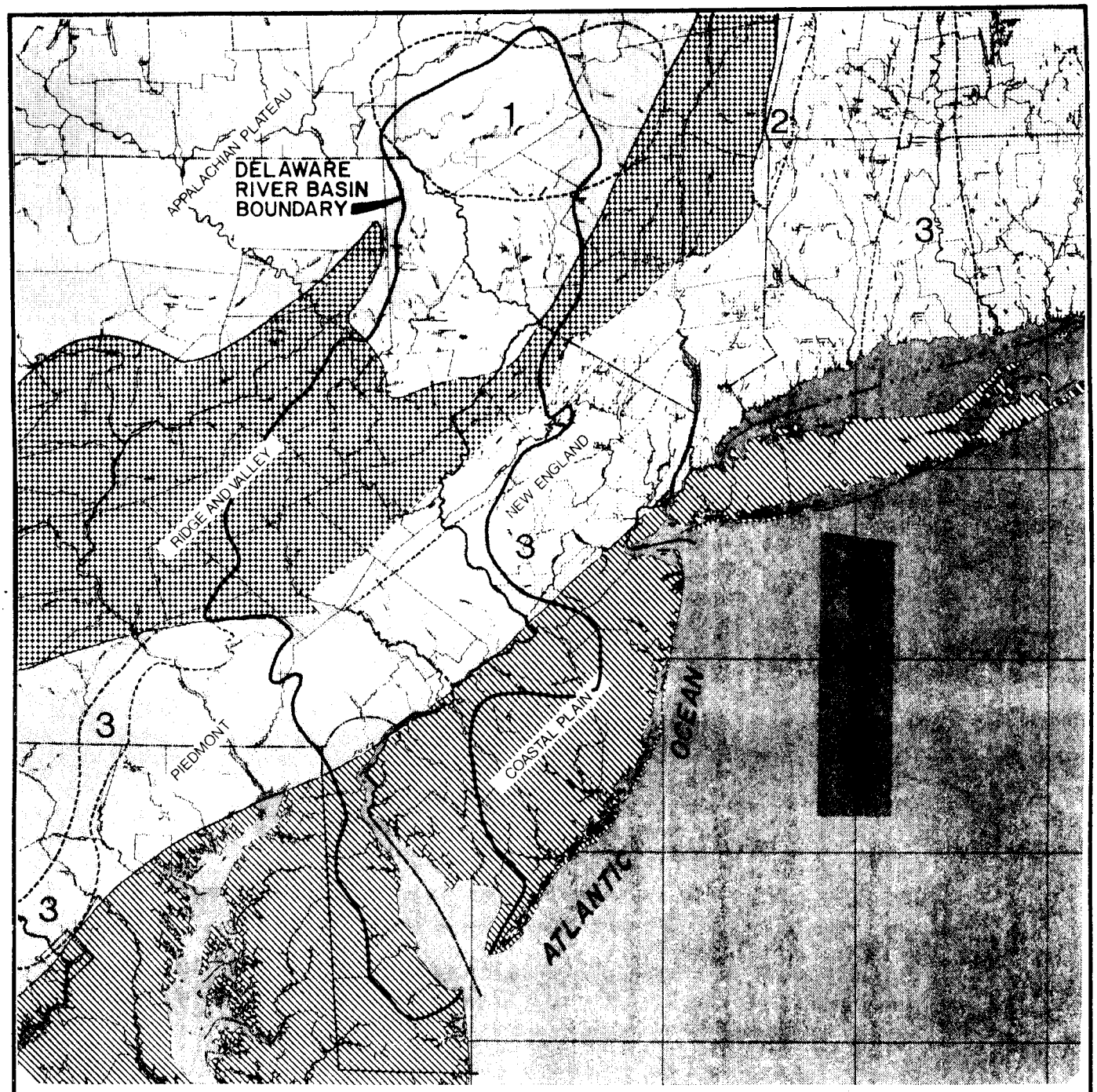
37. RIDGE AND VALLEY AREA. The Ridge and Valley area forms a belt running across the Delaware River Basin from northern New Jersey through eastern Pennsylvania. The two principal subdivisions are the predominantly limestone areas along the south side of the area and the shale and slate belts to the north. The limestones in this area extend from Berks County to the Delaware River and soils derived from these parent rocks belongs to the Ryder and Duffield series. The principal soil derived from the glacical deposits belongs primarily to the Washington Series. In the shale and slate sections the principal soils are Kistler, Weikert and Berks.

38. PIEDMONT PLATEAU SECTION. The Piedmont Plateau section is split by the Triassic Basin into two areas. The northern area forms a belt across the basin from central New Jersey into eastern Pennsylvania. The southern part of the Piedmont Plateau lies in a broad belt across the extreme southeastern part of Pennsylvania and northern Delaware into south central New Jersey. The soils of the Piedmont Plateau are mostly derived from gneisses, schists and quartzites. The principal soils are Chester, Glenelg, Manor, and Glenville.



DELAWARE RIVER BASIN STUDY
LOCATION

FIGURE 2



BASE MAP SOURCE: REGIONAL PLAN ASSOCIATION

0 13 26 51

SCALE IN MILES

LEGEND

- APPALACHIAN PLATEAU PROVINCE
- NEW ENGLAND PROVINCE
- RIDGE AND VALLEY PROVINCE
- COASTAL PLAIN PROVINCE
- PIEDMONT PROVINCE
- 1 CATSKILL MOUNTAIN SUB PROVINCE
- 2 TACONIC MOUNTAIN SUB PROVINCE
- 3 TRIASSIC LOWLAND SUB PROVINCE

DELAWARE RIVER BASIN STUDY

PHYSIOGRAPHY

FIGURE 3

GEOLOGY AND MINERALS

39. Rock formations of the Delaware River Basin range in age from 150 million years to perhaps a billion years. They have been folded, faulted, thrust up into high mountains, worn down into lowlands and encroached upon by ancient seas. The ridge and valley structures which characterize much of the study area can be attributed to alternating strata of resistant, semiresistant, and nonresistant formations. Although there are areas of both igneous intrusion and metamorphism, the rock formations are predominately sedimentary and range from sandstones and conglomerates, which are relatively resistant to erosion processes, to less resistant carbonate limestone and shales. The strata directly relate to the physiographic regions discussed earlier in this section and shown on Figure 3.

CLIMATE

40. The Delaware River Basin is situated in the mid-Atlantic temperate zone and is influenced by two major North American weather systems. Low pressure cells originating in the south move along the coast bringing substantial rainfalls. Canadian high pressure systems bring heavy snowfall and cold temperatures to the upper northwest portions of the region. Cold temperatures are modified in the south and east by coastal influences.

41. Average temperatures vary with elevation; the upper region of the basin is 5 to 10 degrees cooler than southern areas. Annual rainfall varies from 42 to 60 inches in the upper region; from 42 to 50 inches in the central region, and about 43 inches in the lower region. The highest monthly rainfall generally occurs in July or August, comprising 10 percent of the annual total. February and October have the lowest average monthly precipitations.

GROUNDWATER

42. The Pleistocene deposits are a major source of groundwater and supplies good quality water to a large number of wells throughout the Delaware River Basin. Springs along the flank of the river valley supply potable water. These springs, however, are highly dependent on rainfall cycles. The ground water resources west of the Kittatinny Ridge are also dependent upon rainfall; whereas east of the Ridge, the area is heavily dependent on ground water transport through the limestone aquifers and joints and fractures of metamorphic and igneous rocks. The limestone zones east of the Ridge provide groundwater recharge. The water resources of the study area are also dominated by the Delaware River. Individual springs and wells provide potable water to rural areas throughout the region.

SURFACE WATER

43. The surface water resources of the study area include numerous lakes and streams. In the steep mountain areas, excessive rainfall and the rapid melting of snow produce periodic flash floods due to excessive runoff. Most of the region is dominated by the Delaware River and those tributaries which flow directly into it. The Delaware River is one of the largest on the East Coast, with a drainage area of 6,780 square miles and average flow of 12,000 cubic feet per second (cfs) at Trenton, New Jersey. The mean annual flow of the Delaware River at Tocks Island (upstream end of the study area) is approximately 6,735 cfs. Maximum and minimum daily stream flows at this location are estimated to be 230,000 and 513 cfs, respectively.

FLORA AND FAUNA

44. VEGETATION ALONG THE STUDY AREA. The vegetation in the Delaware River Basin can be divided into three major classifications based primarily on plant types and frequency of flooding: marshlands; riparian vegetation; and brush and forests. Differences in plant types occur also as result of variation in forest types as illustrated in Figure 4. Most of the study area is characterized by a free-flowing river containing a number of islands. The right bank of the river facing downstream consists of a fairly wide flood plain. The native, nutrient laden soils have been used for agriculture, thus disturbing a major portion of the native vegetation.

45. The slopes on both sides of the river in the study area are still heavily forested with oak and hickory forests. Portions of the river bank area are steep sided and contain a variety of cliff vegetation probably not found anywhere else in the basin.

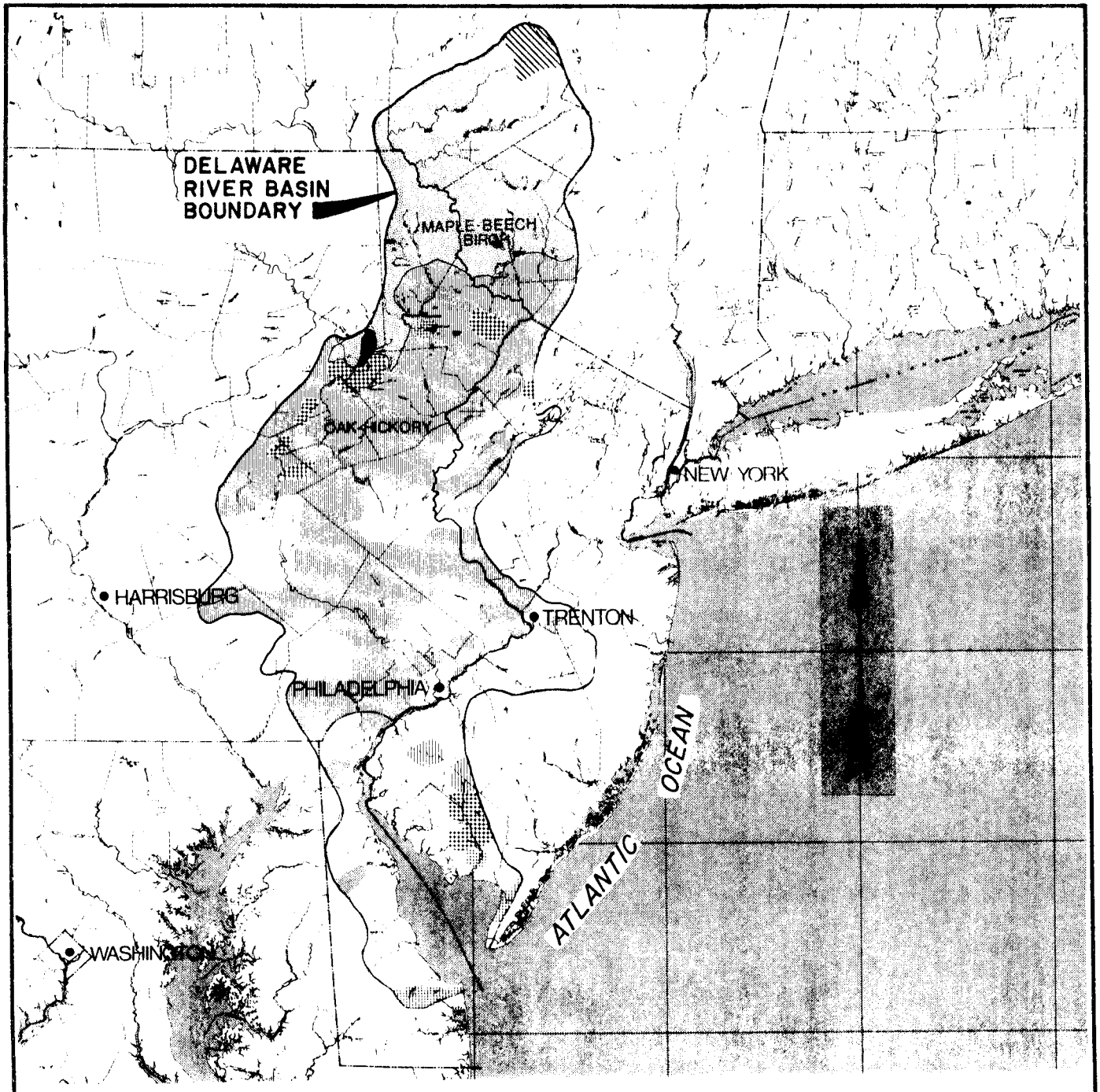
46. FISH AND WILDLIFE. The fish and wildlife resources in the Delaware River upstream of Trenton, New Jersey, and in many of its tributaries, are diverse and abundant. Habitat in these areas is of high quality and undisturbed. Downstream from Trenton, and in other particular problem areas, degradation of water quality and the environment in general has adversely affected these resources. Water quality downstream from Trenton is improving and current conditions provide the potential for a revival of the fishery resource.

47. Other major problems which affect the fish and wildlife resources in the Delaware River Basin are streamflow regimens, temperature fluctuations, degradation of water quality from both point (sewage) and nonpoint (stormwater and agricultural runoff) sources, impingement and entrainment, salinity levels and the need for protection of wetlands and other critical habitat areas. Detailed documentation of the fish and wildlife resources of the study area was provided by the United States Fish and Wildlife Service and this data served as a basis for this reports' environmental evaluation.

DEVELOPMENT AND ECONOMY

48. Following is the summation of social, demographic and economic conditions of the study area. For a complete statistical tabulation of the various conditions, refer to Appendix A.

49. The upper Delaware River has played a major role in national development. The river was a means of transportation, less hazardous and more direct than overland routes in mountain forest terrain. The Appalachian Trail, crossing the Upper Delaware River near Columbia, New Jersey, provided a significant river access and transportation link to early Indian cultures and, later, to pioneer settlers. The inhabitants of this region during the eighteenth century found the main stem convenient for movement of manufactured goods to downstream markets and the adjacent flatlands suitable for agriculture. Statesmen, business leaders and others influential in the affairs of the nation settled near the river in established towns. Modernization during the Industrial Revolution of the 1800's changed the commercial emphasis to downstream areas with better port facilities. A decline of commercial activity was replaced with an increase in manufacturing.



DELAWARE RIVER BASIN STUDY

VEGETATION

FIGURE 4

50. In recent history, many of these manufacturing industries have declined; especially in the older more urban areas such as the flood plain communities. Manufacturing is generally being replaced by services, wholesale and retail trade, and government. However, this replacement is often located outside the flood plains.

51. POPULATION. Based on 1980 Bureau of Census data, the Delaware River Basin Study Area has a population of approximately 626,000. This figure includes only the population of towns, municipalities, boroughs, townships and cities that lie along the main stem from Stroudsburg, Pennsylvania to Burlington, New Jersey. The study area population has grown from 1950 to 1980 at a 1.52 percent annual rate and slowed to only a 0.47 percent annual rate from 1970 to 1980. This compares to a much higher 2.26 percent annual growth rate for the study area counties, as a whole, between 1950 and 1980. In fact, discounting the rapid 4.09 percent per annum increase for the flood plain municipalities in Bucks County, the remainder of the flood plain municipalities have virtually remained the same over the last 30 years. This slower population growth within the flood plain versus the immediate vicinity can be attributed to the lack of developable land. This lack of developable land can be attributed to the following: most of the flood plains are characterized by steep slopes; local communities have initiated nonstructural flood plain measures such as relocation of existing structures, zoning restrictions, and compatible community redevelopment plans; and the effects which the flood threat itself has on some decisions. Projections made using 1980 OBERS* regional statistics indicate continuation of an annual growth rate of only 0.26 percent over the next 50 years. However, based on the aforementioned factors, much of this growth will probably be concentrated outside rather than inside the flood plain.

52. The major population center within the study area is Trenton, New Jersey, in Mercer County. Trenton has lost approximately 36,000 people since 1950 and epitomizes the urban decline which characterizes other older communities within the Delaware River Basin such as Easton in Pennsylvania and Burlington and Philipsburg in New Jersey. The decline of population in these areas since 1950 is in sharp contrast to the rapid increase in the surrounding suburban communities. These two counteracting forces have tended to cancel one another, resulting in the little to no overall growth statistically in the flood plain communities within the last 30 years. These two trends can be expected to continue into the forseeable future. Since more recent flood plain development would have to be in compliance with local land use restrictions and National Flood Insurance Program criteria, it can be concluded that the flood damage potential up to the 100 year frequency has been moderated since 1955 and will continue to be constrained in the future.

53. Population density ranges from 114.0 persons per square mile in Monroe County to 1356.2 persons per square mile in Mercer County. For all the counties in the study area, it is interesting to note that although population increased from 1970 to 1980 at a 1.11 percent annual rate, the number of year round dwelling units increased by a 2.69 percent annual rate. This resulted from a drop of 3.25 people per house in 1970 to 2.78 people per house in

* 1980 OBERS, Bureau of Economic Analysis Regional Projections, Volume I, Methodology, Concepts and State Data, prepared by the U.S. Department of Commerce.

1980. Thus, although population is growing at a slower rate, the greater growth in the number of structures is a more significant factor when estimating and projecting physical flood damages. However, in light of the restrictive legislation and policies adopted since 1970 with respect to flood plain development, much of this development and future development will be situated above the 100-year flood elevation or entirely outside the flood plain.

54. PER CAPITA INCOME. Per capita income within the study area has grown steadily from 1950 to 1980. For 1980, per capita income ranges from a high of $11,173 in Mercer County to a low of $8,090 in Monroe County. Most counties in New Jersey are slightly above the U.S. average while counties in Pennsylvania are slightly below. As a whole, the study area can be characterized as "average middle class" with no major enclaves of poverty. With the exception of a few pockets of affluence, the range of incomes are generally typical. Based on 1980 OBERS regional projection, per capita income in Pennsylvania is expected to grow at a 1.21 percent per annum rate while New Jersey will grow at a slightly lower rate of 0.83 percent.

55. LABOR FORCE AND EMPLOYMENT. The counties which comprise the Delaware River Basin Study area have a labor force which has grown from 586,100 in 1970 to 745,000 in 1980, or by 27 percent. Employment has grown from 565,000 to 696,400 in the same period. The total number of people unemployed has risen from 21,200 to 48,600 giving an unemployment rate of 3.6 percent of the labor force in 1970 and 6.5 percent in 1980. Both are below the national and state averages.

56. Regarding employment by industry, the largest percentage gain by any group during the 1955 to 1980 period was in services followed by wholesale and retail trade and then government. This was true for the counties within the study area, as well as for the rest of the nation. Although still the predominant group in terms of total employment, the manufacturing sector has been the slowest growing. The manufacturing group, which accounted for more than 50 percent of total employment in 1955, has decreased to roughly 25 percent in 1980. This decrease in the importance of manufacturing was largely mitigated by the service sector which had substantial increases in every county during this period. The shift in relative weight from manufacturing to the service group in the study area brings it more in line with national averages. The shift in the entire region from a manufacturing to service oriented industry is expected to continue into the forseeable future as the nation follows its international comparative advantage in the service sector and relies on imports for more of its basic industrial demands.

57. Within the manufacturing group, not only has there been a relative decrease with respect to total employment, but also a shift in relative importance of industries within the group. Although primary metals remains the predominant sector of employment in the counties which comprise the study area, its relative importance has diminished. In fact, in the New Jersey counties where primary metals was a leading group in 1955 employment, it has completely disappeared in 1980. The fastest growing group in the study area from 1955 to 1980 has been the Electrical and Electronics industry growing from only 6,200 in 1955 to 18,600 in 1980. Other groups of importance with respect to flood damage potential are Food and Kindred, Machinery and Paper and allied industries. Overall, the relative shift in manufacturing to more sophisticated technologies has tended to increase the flood damage

potential. This is true not only with industries which have located in the flood plain since 1955 but also with the more established activities which have undergone industrial intensification by switching from mechanical to electronic technologies.

58. TRANSPORTATION FACILITIES. The transportation system in the study area is extensive due to the high levels of population and economic development characterizing the region. Generally, the most extensive transportation networks in the study area accompany the high concentrations of industry and population along the Washington - Baltimore - Wilmington - Philadelphia - Trenton - New York axis of the northeast corridor. In the study area, as the distance from the corridor increases the major interconnectors remain but the local networks become less extensive. Ten separate branches of the Interstate Highway System traverse the region and other major national and state highways complement this system in interconnecting local road networks. In addition, the study area generally has ready access to both air and rail service. The existing transportation network within the study area counties is also described in more detail in Appendix A.

NONSTRUCTURAL PROFILE

59. Along the main stem of the Delaware River, inhabitants of the floodway have, to varying degrees, initiated individual nonstructural protection measures against potential flood damages. There is a broad range of alternative nonstructural measures and combinations that were utilized which will be subsequently detailed. For purposes of analysis the inhabitants of the main stem were categorized by land use type: residential, commercial, industrial, and other. Data on the type of nonstructural measures implemented by land use category were obtained by random sampling techniques employing questionnaires and follow-up interviews. Analysis of the data obtained is summarized in the following paragraphs.

60. Decidedly more residential and related activities have taken some form of nonstructural measure(s) to protect against floods than have commercial or industrial activities. This is due, in part, to different perceptions of the "threat" and, in part, to easier implementation of protective measures. Larger facilities often were constrained by plant operational requirements and other considerations. Some protective measures would have required more formal operation and periodic maintenance procedures. The percent rate of participation in nonstructural protective measures by land use category is shown below. The participation rate in flood insurance by land use category is also indicated.

Land Use	Have Flood Insurance 1/	Have Applied Non-Structural Measures 1/
Residential	59%	61%
Commercial	38%	37%
Industrial	37%	33%
Other	25%	56%

1/ Percentage of those who responded.

61. It should be noted that participation rate in flood insurance is similar to the nonstructural participation rate for each land use type. Responses to the questionnaires and interviews with owners of floodplain structures confirm that the key factor for all flood related activities is the perception of the degree of the flood threat. The low participation rate in nonstructural protective measures in the nonresidential land use types is directly related to calculated business decisions. Since most of the units have not experienced a flood in almost 30 years, the threat is considered small and the risk of being flooded is considered smaller than many of the other risks which are normally taken in business.

RESIDENTIAL

62. The homeowner's "feeling" of a threat to their home and family appears to be more emotional and intense than that of a business person for their business. After a period of threat, especially the 1955 flood, homeowners made quick and usually emotional decisions to apply protection. Most of the measures applied have been simple, inexpensive, and easy to implement usually requiring minimum operation or maintenance. A very disturbing response to the questionnaires and interviews was that only a small percentage of homeowners (26%) were aware of any flood warning system. Of these, most were not aware of any formal evacuation plan.

63. Of the homeowners who said they had taken some nonstructural measure to reduce flood damages, the most predominant measure was to raise items off the floor. This measure is more of a reaction requiring no prior investment. There is a good chance that there may not be enough time to react and that for major floods, items may not be removed entirely above the flood level. Other popular measures were installation of sump pumps, elimination of seepage in basement walls and floors, and permanently raising utilities to higher elevations.

COMMERCIAL

64. The business community views the flood threat as a disruption and an increase in the cost of doing business. Probabilities of recurrence and return of investment enters the decision process. Decisions are neither emotional nor quick and are not made by individuals but must enter the corporate justification process. This delay reduced the "feeling" of a threat and eventually allowed indefinite postponement. Eventually new owners and new work forces who "weren't here in 1955" were making the decisions regarding implementation of protective measures.

65. Many commercial and industrial activities have made the decision to remain self-insured against floods since the premium and deductible provisions would put added pressure on profitability. Businessmen are by nature risk takers and therefore more prone than the general population to take the chance of not being flooded. In addition, any damages actually experienced could more easily be absorbed by business than by individual homeowners.

66. The most popular nonstructural protective measure employed by commercial activities was relying on a flood warning system coupled with a temporary evacuation plan or simply a contingent reaction. They are relying on accurate forecasts and adequate warning to provide sufficient time to take protective or mitigative actions. They believe that they can dramatically reduce damages

at lower flood stages by moving items to higher floors when threatened with flooding. Once again there exists the chance that sufficient time will not be available to react or that the contents will not be moved high enough for major floods.

67. As with residential property owners, other measures such as raising structures, permanently sealing openings and installing flood shields are not popular measures. An additional reason for this is that many businesses rent their structures. Neither the owner nor the occupant appears enthused about investing scarce capital to "primarily benefit the other party."

INDUSTRIAL

68. Industries ran the gamut in flood awareness from two who had constructed earthen ring levees around all structures with protection above a 100 year frequency event to those not aware of a flood threat.

69. As with residential and commercial categories, the most popular nonstructural protective measure employed is a dependency on flood warning and planned or contingent reaction. The difference is that more industrial facilities have formal temporary evacuation plans. Unlike the other land use categories, there are plans for sandbagging around the property and effectively sealing windows and other openings. The higher intended use of sandbagging may be due to the greater availability of labor and equipment at their disposal. Sealing of openings seems to be more acceptable to industrial activities. There appears to be less concern over aesthetic appearance than expressed by homeowners or shopkeepers, and operational inconveniences and constraints do not appear to be as severe.

70. Overall, the majority of industries have neither applied nonstructural measures nor taken flood insurance. In many instances, the nature and type of products involves a "limited" threat and does not "warrant" such action. Even those who are well aware of a "threat" have choosen not to take any actions. They are willing to gamble that flooding will not occur during the time they occupy the structures.

OTHER LAND USES

71. For this discussion, the other land uses include all nonresidential-commercial-industrial land uses such as churches, schools, municipal buildings and historic structures. Although participation in the flood insurance program is the lowest of any group the percent taking nonstructural actions is second only to the residential category. Again the most popular measure is relying on flood warning and their own evacuation plans or contingent action.

72. With the information received, there appears to be no clear reasons why their participation rate in flood insurance is so low or why there exists such a nonpredictive pattern of participation. It is surmised that as they are public and quasipublic institutions, the concern of individuals often may not be sufficient to initiate new actions or programs. Also, this type of institution is more reactive in nature.

73. MUNICIPAL. As a result of the 1955 flood, a number of nonstructural, as well as structural, measures were implemented all along the major damage reaches. As expected, the greater the flood damages sustained in 1955 the greater the response of the community. With the passage of time and no major flooding since 1955, the only significant actions over the last decade have

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.

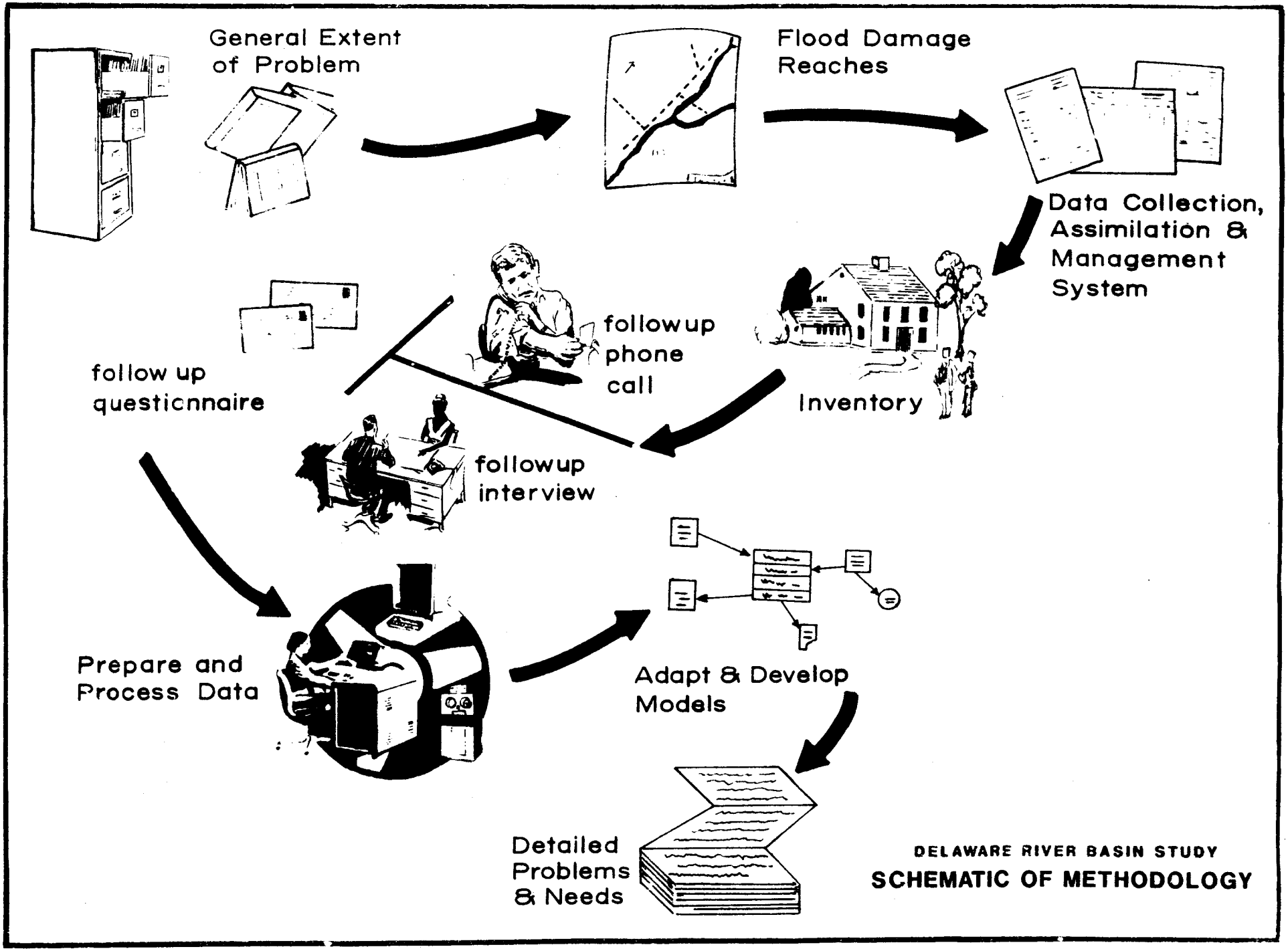

General Extent of Problem
Flood Damage Reaches
Data Collection, Assimilation & Management System
Inventory
followup phone call
follow up questicnnaire
followup interview
Prepare and Process Data
Adapt & Develop Models
Detailed Problems & Needs
DELAWARE RIVER BASIN STUDY
SCHEMATIC OF METHODOLOGY

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).

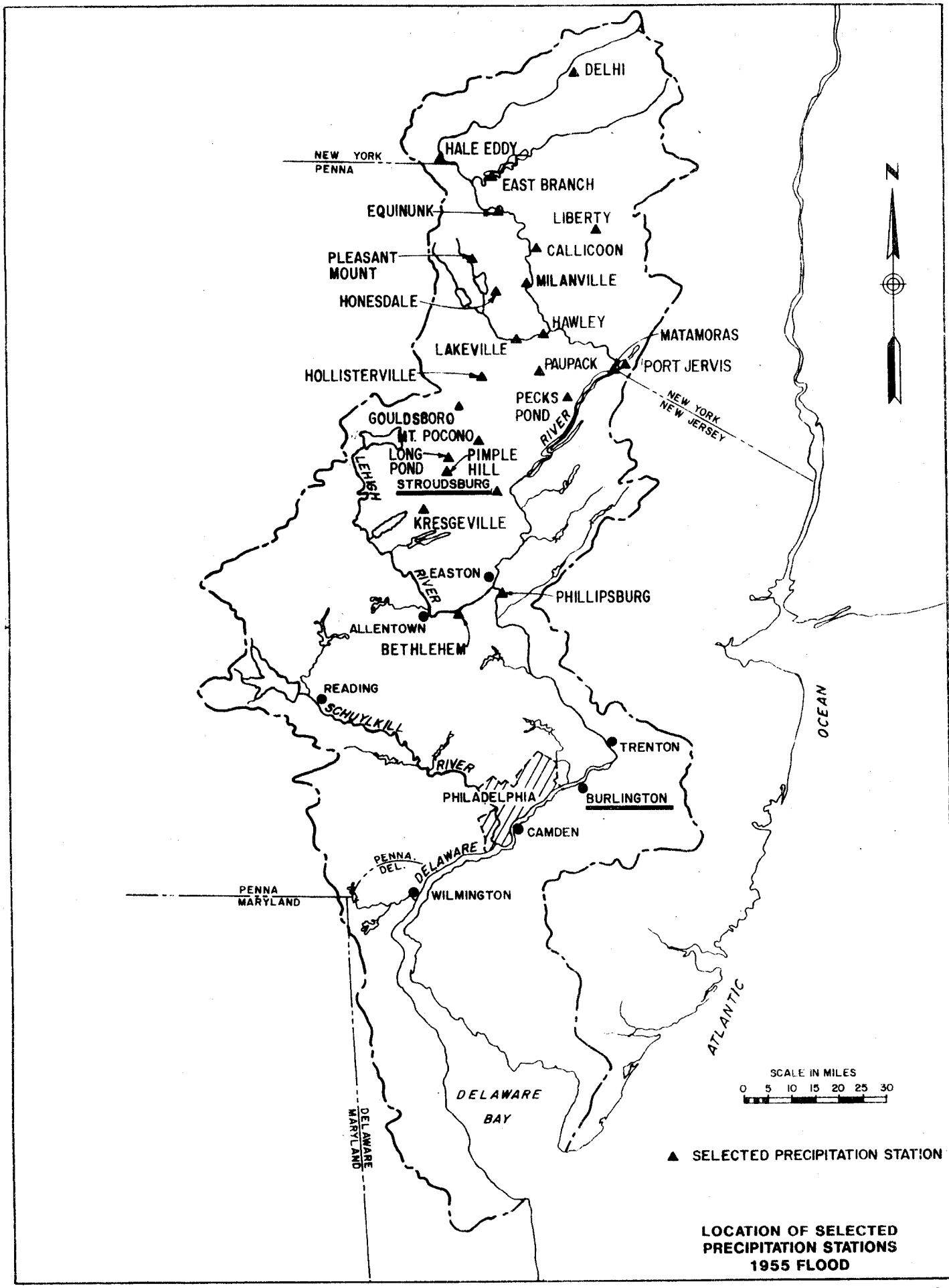
96. A discussion of these damage centers is presented in the following paragraphs. This discussion includes a generalization of what has occurred since the 1955 flood which may have changed flood protection needs. Changes did not necessarily occur because of the flood threat.

TABLE 4

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

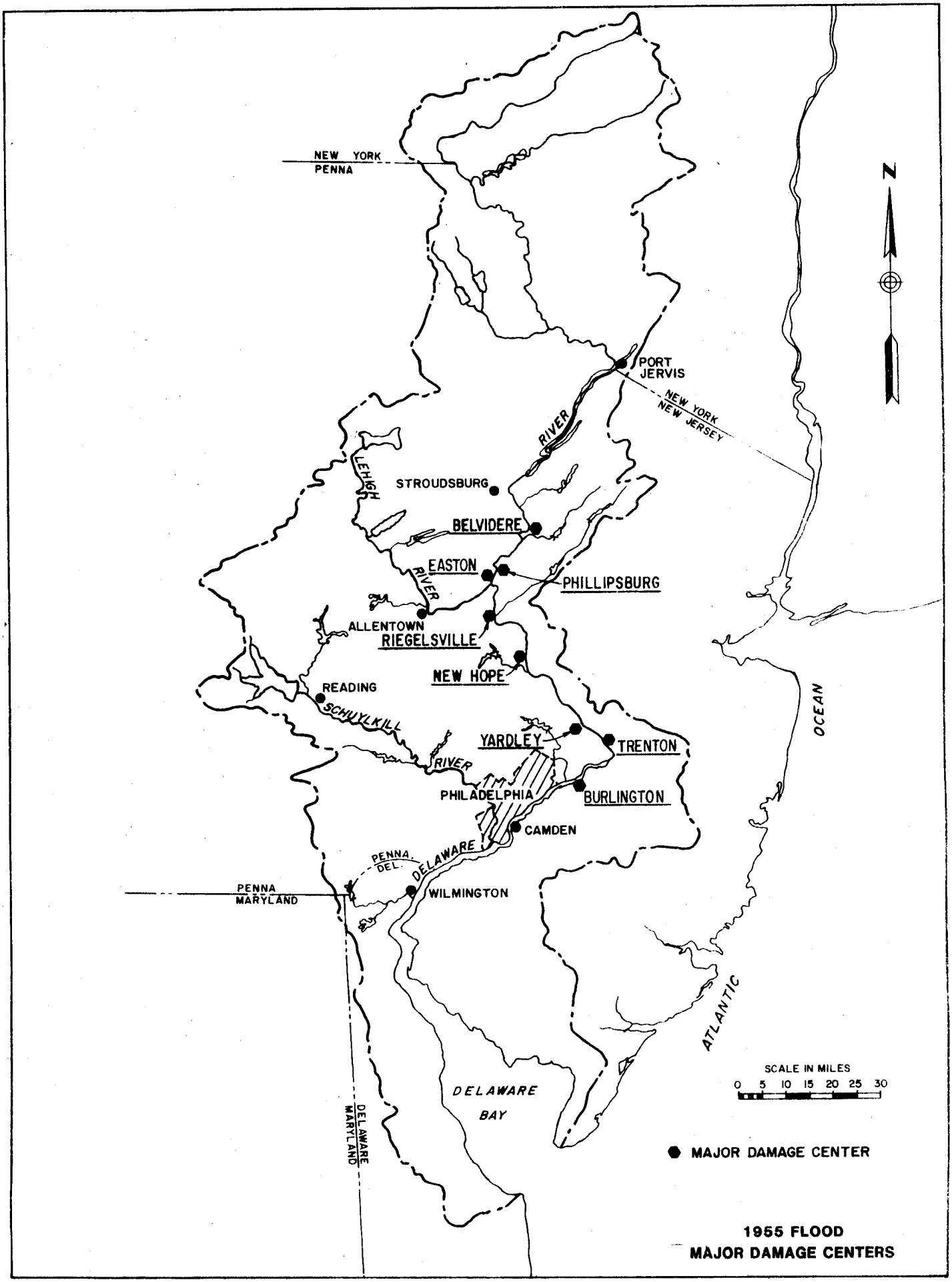
STATION	HURRICANE CONNIE 11-16 Aug Total Inches	HURRICANE DIANE 17 Aug Inches	18 Aug Inches	19 Aug Inches	20 Aug Inches	TOTAL Inches	TOTAL 11-20 Aug Inches
Bethlehem, PA	7.71		.68	2.20		2.88	10.59
Callicoon, NY	4.60	.01	3.00	1.88		4.89	9.49
Delhi, NY	4.11		.93	4.81		5.74	9.85
East Branch, NY	8.94		1.38	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.

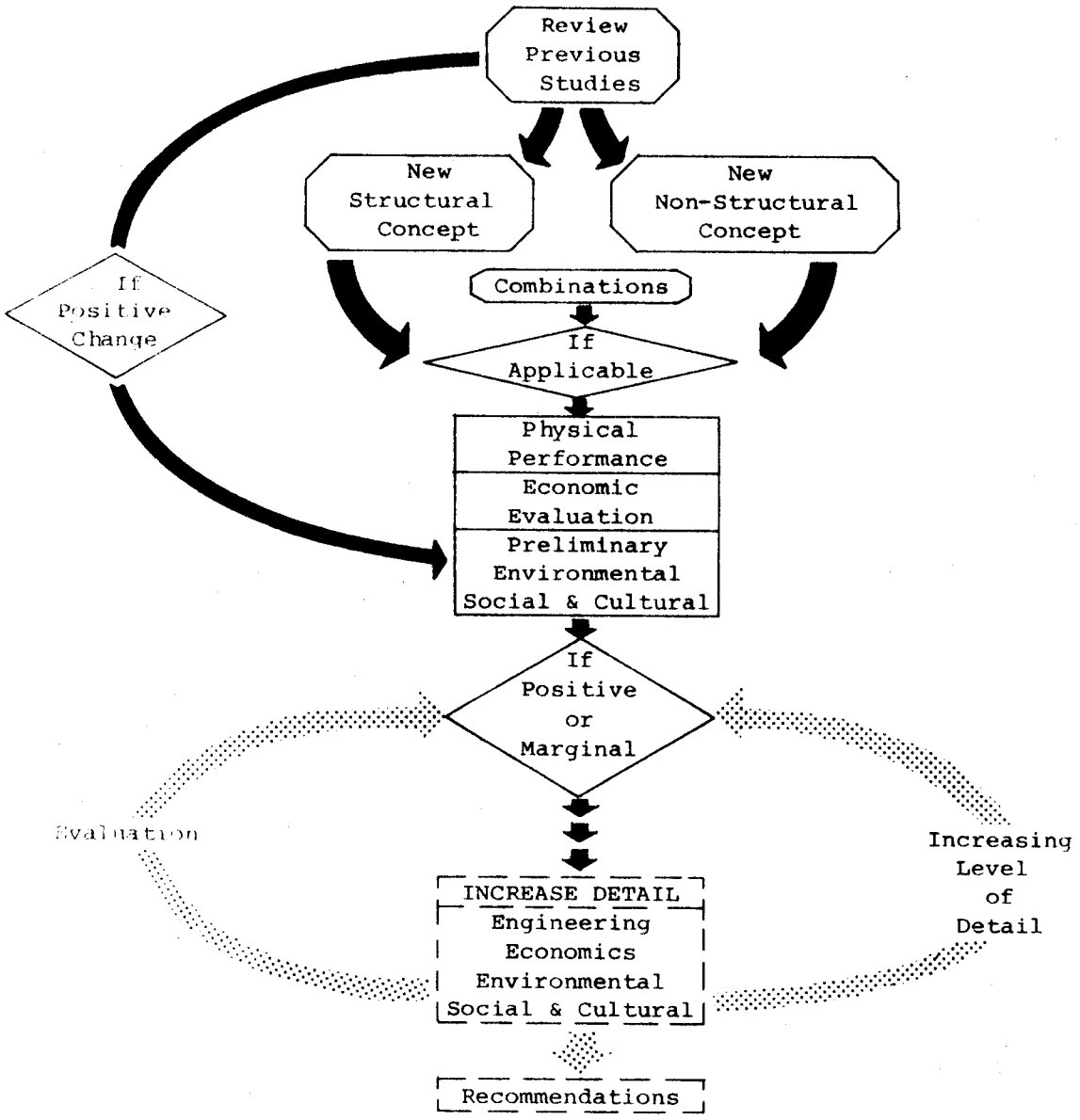
	RES	COM	IND	SER	PUB	UTL	TRN	AGR	HIS	NEC	EMR
Number(%)	83	12	1	2	1	*	N/A	N/A	*	1	N/A
AAD(%)	39	15	24	4	1	5	5	*	*	2	5

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.



DELAWARE RIVER BASIN STUDY

FORMULATION PROCESS

FIGURE 8

PLANNING OBJECTIVES

116. The following planning objectives were used as a guide for this study:

- Develop data and engineering and economic tools in sufficient detail to inspire a high degree of confidence in determining the flood risk potential for communities located within the study area and for evaluating solutions.

- Review past investigations and their recommendations to either confirm or reconsider their conclusions and recommendations.

- Develop new solution concepts, in particular nonstructural concepts and evaluate feasibility.

- Develop a program utilizing structural and nonstructural measures to minimize both flood damages and flood induced social economic disruption.

- Preserve, maintain, and, where possible, enhance existing open spaces, historic structures, archaeologically important sites and other environmentally critical areas.

- Give consideration to the wise and prudent use of land, to enhancement and conservation of fish and wildlife resources and to the overall enhancement of the environment and quality of life.

- Develop data sufficient to determine the impacts of plans on regional development.

PLANNING CRITERIA

117. The formulation, screening and evaluation of alternative plans were constrained by a set of general, technical, economic, social, and environmental criteria. Additional specific criteria often constrained some of the measures being considered. These individual criteria are the following:

118. TECHNICAL CRITERIA. The optimum level of flood protection that can be justified will be determined. Due to the urban nature of the area and the threat to life which would be caused by failure of protective works, protection should be provided, if justified, against a design storm equal to the Standard Project Flood (SPF). Protection must function without causing adverse effects in other areas (primarily downstream). When the National Economic Development (NED) plan is identified, the risk or uncertainty associated with the plan, that is, the magnitude of residual damages or potential catastrophic affects associated with failure above flood design levels, will be evaluated to determine if deviation from the NED plan may be acceptable. The design levels selected for both structural and nonstructural plans will be evaluated based upon those considerations.

119. ECONOMIC CRITERIA. Tangible benefits must exceed project economic costs to warrant further consideration. The scope of the project or program should be developed such as to provide the maximum net benefits. However, benefits may be considered which result from positive nonmonetary contributions to

social well being or environmental quality which cannot be quantified. All possible solutions, whether Federal, state or local responsibilities, will be investigated and evaluated on a comparable basis for accomplishing the same purposes.

120. SOCIAL CRITERIA. Plans should protect public health, safety and well being including possible loss of life. The desires of the affected communities should be reflected in order for plans to be realistic.

121. ENVIRONMENTAL CRITERIA. The development of pleasing aesthetics and other desirable environmental effects should be promoted. Plans should avoid, where possible, detrimental environmental effects, and include features to mitigate such effects if they are found unavoidable. Care should be taken to mitigate adverse effects on fish and wildlife resources.

MEASURES CONSIDERED

122. Many protective measures were considered but, due to the urban nature of the study area, emphasis was initially placed on those preventive measures which could provide SPF protection or a minimum 100-year flood protection. Any measures which would allow an area to still be flooded or which would only reduce damages by a small amount were not initially addressed in the same level of detail. If applicable, they were later considered to supplement other preventive measures or as a substitute if alternatives were not found to be technically feasible or socially and environmentally acceptable.

123. All of the measures which were considered are listed below. The letters (P) and (R) indicate that the measure was considered to be preventive or reductive, respectively. Except for flood or high flow skimming, these measures are local or individual in nature.

STRUCTURAL

- Channel Modifications and Diversions (P)
- Levees and Floodwalls with Interior Drainage System (P)
- Flood or High Flow Skimming Impoundments (P)

NONSTRUCTURAL

- Flood Insurance (R)
- Flood Forecasting, Warning and Preparedness Planning (R)
- Flood Plain Management (R)
- Flood Proofing (P)
- Permanent Flood Plain Evacuation (P)

124. Initially the flood damage/benefit analysis was based on the consideration of individual flood damage reaches which were delineated by dividing floodplains, once defined, on the basis of economic, physical, and hydraulic factors; political boundaries; existing flood control projects; and potential plans for improvement. After screening and analysis, the flood damage reaches were combined to yield a community level analysis and thus provide a uniform level of protection within a specific community.

125. As has been stated, the initial task was to review all previous major studies. Of the prior investigations listed in Table 1, only two are directly concerned with flood control in the study areas of this report. Table 12 contains a discussion of each of the protection measures which were considered in those two studies.

STRUCTURAL MEASURES.

126. The following structural measures were considered as alternative solutions to flood damages along the main stem Delaware River.

127. CHANNEL MODIFICATIONS AND DIVERSIONS. Channel modification involves widening, deepening or straightening of existing channels and the modification of highway and railroad bridges that constrict the channel. The Delaware River through the study area maintains a very mild slope throughout most of its length, limiting the effective flow carrying capacities of any channel modifications.

128. Although flood levels could be reduced through channel modifications, significant reduction would require extensive excavation, relocations, and acquisition of additional lands, all at high costs. For most of the river, the effect of existing bridges on flood flows is minimal. For channel improvement to be effective in lowering flood profiles at the flood damage areas, improvement would have to extend well beyond the actual damage reach. Channelizing only portions of the river would move flood waters more rapidly downstream, thereby accentuating problems in affected areas. In those lower reaches influenced by tides, the effect of channelization would be reduced or nullified. In many instances, the proximity of developed property to the stream bank would require the acquisition of some of that property considered for protection. The possible adverse environmental effect of extensive channel modifications on fish and wildlife, as well as on the conservation and recreation potential of the river are additional factors which must be considered. An evaluation of all these factors led to the elimination of channel modification as a viable alternative measure for flood damage reduction. Similarly, it would be impractical, too costly and environmentally undesirable to effect diversion of flood discharges to other stream valleys by constructing tunnels or massive bypass channels. Channel modifications and diversions were not considered further.

129. LEVEES AND FLOODWALLS. Levees and floodwalls are two structural measures which are commonly used to protect short stretches or portions of damage reaches with concentrated urban development. All necessary modifications of existing interior drainage systems and pumping stations would be included with these measures. A levee (an earth embankment) or floodwall (a concrete wall) is constructed along the banks of a stream. They contain flood waters within the stream channel and protect the adjacent community. They eliminate flood damages from storms that do not cause stream levels to rise above their design height. Typically, levees and floodwalls are designed against rare flood events, thereby providing a high degree of protection. A 100-year flood level of protection was the minimum normally followed in all previous investigations by the Corps and others.

130. Following the 1955 flood of record, many communities developed plans for open space, conservation, park, or recreational development of portions of their flood plain lands. Floodwalls and levees often conflict with these community plans. Existing or potential riverfront resources could be reduced

Table 12

PREVIOUS FINDINGS
PERTINENT FLOOD CONTROL INVESTIGATIONS
MAIN STEM DELAWARE RIVER

Items	Findings	
	Madigan-Praeger 1/	House Document No. 522 2/
Structural		
Channel modifications and diversions	Would accentuate flood problems in downstream areas. Not economically justified.	Do not present favorable potentials for economical protection.
Levees and floodwalls with drainage systems	Not economically justified	The Basin is characterized generally by narrow stream valleys that are cluttered with highways, railroads and numerous small communities. Such physical characteristics generally do not permit economic use of levees or flood walls because of the small area protected per unit length of protection measure.
Flood and high flow skimming impoundments	Valid scheme for water supply. Impractical for flood control. Scheme does not warrant further consideration. Not economically justified.	As discussed under Prior Investigations and Status of Existing Projects and Programs, a series of impoundments were recommended. The study then concluded that since the 386 sites which were investigated exhausted all practical locations offering moderate downstream conditions with regard to flood threats and reasonable relocation and real estate costs, it is apparent that additional small reservoir sites to increase the storage potentials in this category would be difficult to find and probably so expensive as to be infeasible. Furthermore, the small reservoir potentials are extravagant in land inundated per unit of storage.
Non-Structural		
Flood insurance as incentive not to build on flood plain	Not a cure-all measure. Enabling legislation must be adopted for enforcement. Adds to development costs.	The controlled use of flood plains encompasses such measures as prevention of channel encroachment, zoning to regulate the use of the flood plain, reconstruction of existing structures in the area subject to flooding, adjustments in the occupance of structures in
Flood forecasting, warning and preparedness	Not viable alternative by itself. Should be considered as supplemental measure in combination with other nonstructural or structural measures.	

Table 12 (Cont'd)

Items	Findings	
	Madigan-Praeger1/	House Document No. 522[2/]
Flood plain management to control development	Does not protect existing development. Difficult to administer. Effective in preventing future damage.	the flood plain, evacuation of the flood plain either on a permanent basis to provide for parks and other flood damage free developments, or on a temporary basis by flood warning arrangements, and finally, combinations of these various measures. Programs to effectively apply these measures must be initiated and administered by local interests. In fact, zoning and similar devices for controlling flood plain development are said to come under the general category of policing powers, delegated by the Constitution to the states and, in turn, usually delegated to counties, township and municipal governments.
Flood proofing of structures in flood plain	Effective method of minimizing damages. Supplements structural measures.	
Permanent flood plain evacuation	Can be highly effective. Marginal economic justification. Not justified as total program; justified in isolated areas as part of overall plan.	

1/"A Comprehensive Study of the Tocks Island Lake Project and Alternatives"; URS/Madigan-Praeger, Inc. and Conklin and Rossant; New York, New York; June 1975.

2/"Comprehensive Survey of the Water Resources of the Delaware River Basin"; U.S. Army Corps of Engineers, Philadelphia District, House Document 522 of the 87th Congress, 2nd Session; adopted.

or eliminated by levees and floodwalls which preclude visual or physical access to the river. This has been and continues to be a concern in their design and development.

131. Because of the natural and man-made characteristics of the study area, levee/floodwall systems have been difficult to justify. High Zero Damage Elevations (ZDE), steep banks, and the level and complexity of the infrastructure of communities being protected has resulted in high project costs with respect to potential benefits. The evolution of these older urban communities originally depended on their proximity to watercourses for water and power, and later continued with reinvestment at these same locations. This pattern of development results in very high project costs due to difficulties with rights-of-way and foundations as well as topographic limitations. Potential levee/floodwall alignments often contain buildings, utilities and other structures. In addition, the interior protected areas have no room for ponding stormwater drainage, have antiquated storm drainage systems and require large-volume interior drainage systems. Past investigations by others have had differing conclusions on the potential feasibility of levee/floodwall systems.

132. There are many people who believe that even though levees and floodwalls are not the universal solution for the study area, they are viable for many communities and that they have been written off prematurely in the past. An investigation of the economic feasibility of levees and floodwalls was therefore conducted for all applicable damage centers.

133. IMPOUNDMENTS. A flood control impoundment or lake is that area behind a dam used to collect and store flood waters thus preventing them from reaching the areas to be protected. The stored flood waters are later released at reduced (nondamaging) flow rates. House Document 522, 87th Congress, 2nd Session reports on investigations of impoundments which ranged from runoff management in the uppermost headwaters through small detention reservoirs in the intermediate upstream areas to major impounding reservoirs on the principal water courses. For the entire Delaware River Basin, a total of 386 small and 193 major dam and reservoir sites were identified. Of those, 70 sites met minimum storage criteria of 20,000 acre-feet. Work since 1962 has resulted in the identification of 37 more project variations or sites increasing the total to 107. All of these sites were once again considered. This consideration was given not only to traditional flood water impoundments, but also to off-line flood or high-flow skimming.

NONSTRUCTURAL MEASURES.

134. The following nonstructural measures were considered as alternative solutions to flood damages along the main stem Delaware River.

135. FLOOD INSURANCE. Flood insurance offers property owners a means of avoiding catastrophic losses due to floods. Flood insurance is available under the National Flood Insurance Program administered by the Federal Emergency Management Agency (FEMA). It provides for reimbursement of possible financial losses with the payment of a regular premium. In addition to financial protection, the flood insurance program encourages wise use of flood hazard lands through required flood plain zoning and building codes. These reduce future flood losses. Flood insurance does not eliminate the flood hazard and is limited in the amount of financial loss that may be covered by a policy. In addition, it does not eliminate associated costs such as cleanup required after a flood. Because the flood hazard remains, the threat to public safety and loss of life is still present.

136. The payment of the flood insurance premium brings the degree of flood risk to property owners' attention in one of the most direct ways short of a flood. Presumably this easily recognizable cost encourages a modified use and eventual abandonment of hazardous areas. Conversely, in some cases the availability of insurance and avoidance of catastrophic loss may actually encourage continued occupancy and reinvestment in the flood plain because it reduces the true risk. From a national perspective, flood insurance is justified on the basis of proper management of flood plain lands for the future and on its social benefits. Flood insurance would be an inherent part of any plans for the study area that address residual damages.

137. FLOOD FORECASTING, WARNING, AND PREPAREDNESS PLANNING. Flood forecasting, flood warning, and preparedness planning are each individual components of an overall measure. This measure is one which does not, in itself, eliminate damages, but can reduce damages and prevent the loss of life. In recent history, forecasting and warning has existed as part of the regular program of the National Weather Service (NWS). Flood watch and warning information is publicized for areas as a whole. NWS has a "self-help" program of coordinating and developing flood warning systems in conjunction with local governments. Current flood recognition (forecast) and flood warning systems function well and are completely adequate to meet the needs of main stem Delaware River communities. Warnings received at the state, county and/or local level are timely and quite reliable. However, there may be some opportunities to improve existing flood recognition and flood warning arrangements from an efficiency and factor-of-safety standpoint. Flood preparedness plans should also be fully documented and practiced. The weaknesses in providing a complete system lie primarily in preparedness planning and program maintenance. Local plans are often inadequate and public concern tends to wane with time. This is particularly true along an area such as the main stem Delaware River which has not suffered a major flood since 1955.

138. Upon request, and within available funding, the Corps of Engineers can provide technical assistance to aid in the development of flood warning and preparedness plans. The Corps of Engineers can also provide technical assistance in the development of river stage forecast maps under the Corps' Flood Plain Management Services (FPMS) Program. These maps would show areas inundated at various flood stages and would be useful in planning flood response actions. A sample of a typical river stage map is contained in the Flood Warning and Preparedness Planning Appendix to this report. Detailed evaluation of existing flood forecasting warning and preparedness system and suggested areas for improvement are given in that appendix. Also contained is further explanation of the technical assistance that can be provided by the Corps of Engineers. However, although technical assistance can be provided by the Corps of Engineers, detailed emergency plans must be prepared by the responsible local agencies.

139. LOCAL FLOOD PLAIN MANAGEMENT. Proper management of flood plains by local communities is not a single measure. It is a delicate composition of regulatory, taxing and policy measures tailored to the specific flooding problem within a framework of total needs and desires of a community. Regulatory measures consist of zoning and encroachment ordinances, building and housing codes, subdivision and grading ordinances, and sanitary and plumbing codes. Zoning and encroachment ordinances delineate flow and ponding areas, maintain floodways for existing and future conditions, and minimize flood damages by restricting or regulating the use of structures and land.

Building codes reduce flood-related damages by regulating building design and location, the types of materials used for construction, and minimum maintenance requirements to insure safety of occupants. Subdivision and grading ordinances provide for utility services, access during flooding conditions and judicious selection of sites for buildings to minimize damage. Existing tax structures and community development policies could be adjusted to encourage wise use of flood plain lands. It would include taxing measures and policies relating to land values, tax rates, comprehensive planning, extension of public services and related increased services charges, urban renewal and other programs affecting open space.

140. A review was made of regulatory measures, zoning ordinances, local programs and community plans. Those in existence or typically being adopted are the result of state and Federal activity following the 1955 flood; state and Federal community development-type grants; and the National Flood Insurance Program. In essence, the basic guide is to meet minimum flood insurance requirements for floodway encroachment and development with respect to the 100-year flood. When these minimum requirements for floodway encroachment are being met through local flood plain management, an increase in damage potential is often unknowingly being condoned. In many cases, intense development spatially above and beyond this 100-year flood zone is actually increasing the total damage potential of the infrequent flood events. Alternative development concepts or plans would be more rational if the consequences of future flooding were correctly incorporated in those decisions and plans.

141. These management measures do not reduce or prevent damages to existing development but are meant to reduce or eliminate flood damages to future development. Better management of the flood plain should be established and promoted. However, this is embroiled in the total subject of land use control which is currently a local responsibility. Local flood plain management plans for land use control will not be considered any further. However, the study provides technical information which will be suitable for this purpose. Local communities may utilize this information.

142. General flood plain management requirements by local communities would be incorporated with any "basic" flood control plan being recommended. This would include land use management required to protect the "basic" plan, not reduce or eliminate its effectiveness or misuse the plan to encourage noncompatible development. These local flood plain management requirements would be presented in the form of local assurance or requirements of local cooperation.

143. FLOODPROOFING. Floodproofing is designed to protect damageable property from floodwaters by preventing the water from entering a structure. Floodproofing is performed by either raising the structure; providing perimeter protection (levee or floodwall) around the structure; sealing the structure; or reducing the degree of potential damage even if the structure were to be flooded. All exterior losses such as damage to grounds, utilities, roads, crops, etc. would be fully sustained. Raising is more applicable to frame construction; perimeter protection to multi-building installations or small groups of buildings; sealing to heavily constructed masonry or concrete structures; and water damage reduction techniques to almost all units. Floodproofing is not applicable for every situation. Floodproofing is generally applicable for the following:

- Moderate flooding with low velocities and short duration;
- Individual solutions without collective action or where collective action is not possible; and
- Activities dependent on flood plain locations, thereby requiring some degree of protection.

144. Previous investigations, such as the Madigan-Praeger Report, have indicated that as little as 15 percent of the existing structures in a flood plain lend themselves to a floodproofing solution. However, flood problem areas throughout the study area do exist which have high zero damage elevations (ZDE) and development characteristics suitable for floodproofing. The potential for "blanket application" was never expected but partial application was expected; therefore, floodproofing was considered for all structures.

145. PERMANENT FLOOD PLAIN EVACUATION. The objective of permanent evacuation is to remove people and damageable property from the flood hazard area. Not only is evacuation applicable for entire or partial sectors, it is also very effective for completing a total plan for flood protection by application to outlying structures that cannot be incorporated with the other measures of the plans.

146. With the removal of flood-susceptible buildings, an opportunity exists for increasing open space, park, and recreational development; for promoting natural and conservation areas; and for advancing compatible utilization such as parking, transient storage or pedestrian malls for commercial development. Permanent evacuation, if not part of a more comprehensive community plan, can have a positive impact on a community. On the other hand, the removal of property can upset a neighborhood; decrease the communities' tax base; and, in general, have adverse social and economic effects. Effective and implementable plans will undoubtably include tradeoffs in zoning and uses with nonfloodplain lands and require a general review of community long term objectives and future plans. Unfortunately, it often becomes obvious that flood control benefits are secondary. They are not as great as the benefits which could be realized from other purposes or uses. In these cases, flood control benefits should be considered as strong secondary or additional benefits for areas being considered for other purposes such as redevelopment, open spaces, conservation, or recreational development.

147. The practicality of evacuation depends upon the frequency and severity of flooding and upon the value of the property. Many of the structures which were flooded in 1955 have either been abandoned or demolished and removed. Yet, past investigations have estimated that a maximum of approximately 20 percent of the structures that are subject to relatively frequent flooding could be purchased and the occupants permanently evacuated. Flood plain evacuation was investigated but solely from the perspective of flood control project investment; not as a secondary purpose.

EVALUATION OF STRUCTURAL ALTERNATIVES

148. Based on the rationale presented in the preceding paragraphs, levee/floodwall systems and flood water storage impoundments were the only structural measures selected for further consideration. These were evaluated through a screening process for each of the damage reaches. The number of screenings for each damage reach was determined by the potential for economic

justification and technical feasibility after each screening. With each successful screening the data used was more refined and the methods and analytical tools used for evaluation were more sophisticated. The level of detail increased with each screening but with an assurance that any inherent inaccuracies or uncertainties always favored benefits. In this way, a potential measure was not prematurely eliminated. This increasing detail was brought to a level which was sufficient to insure that the measure was suitable for incorporation into alternative plans.

LEVEES AND FLOODWALLS.

149. All areas which had a concentration of floodprone structures or major individual plants or facilities were reviewed for levee/floodwall protection. Because of the large number of potential levee/floodwall applications, a series of three screenings was conducted with an increase in the depth of analysis with each sucessive screening. In this manner, areas for which levee/floodwall projects could not be justified were methodically eliminated.

150. The initial screening of levees and floodwalls consisted of a comparison of average annual damages (AAD) with the length, height, and complexity of protective works which would be required. Areas in which the magnitude of AAD was such that it obviously would not support the costs of levee/floodwall projects were eliminated. The areas which were considered beyond the initial screening are shown in Figure 9.

151. The second screening used AAD directly as an intentional overestimate for average annual benefits (AAB) and a "cost curve" approach for estimating average annual cost (AAC). A level of protection equal to the SPF was initially analyzed. Sensitivity runs were then conducted with costs being reduced by first 25 percent and then 50 percent. This was done to insure that possible cost variances were not critical and to serve as a proxy for multiple analyses at lower levels of protection. Even with those inflated benefits and lower costs, BCR's are much less than unity for many of the areas investigated. It was concluded that no variations of design would be economically justified for those areas that did not survive the second screening

152. The third screening of levee/floodwall measures was conducted for the remaining areas. Initially, SPF projects were investigated using AAD for benefits with more detailed cost estimates. Once these results were reviewed, levee/floodwall systems for a 100-year level of protection were investigated at selected areas. Once again, sensitivity runs were conducted. Since better cost estimates were developed for these measures, only the sensitivity of a 25 percent reduction in total cost was tested. However, because of the complexity of interior drainage requirements, the sensitivities of reducing interior drainage by first 25 percent and then 50 percent were tested.

153. Relatively high zero-damage stages, relatively steep and narrow flood plains, past individual self-help efforts and community flood plain management efforts in the areas evaluated have resulted in lowering average annual damages (AAD) and, consequently, lowering potential average annual benefits (AAB). At the same time, older urban communities have very complex infrastructures along potential project alignments which result in very high relocation and construction costs. These factors have resulted in the infeasibility of levee and floodwall protection. The only levee/floodwall

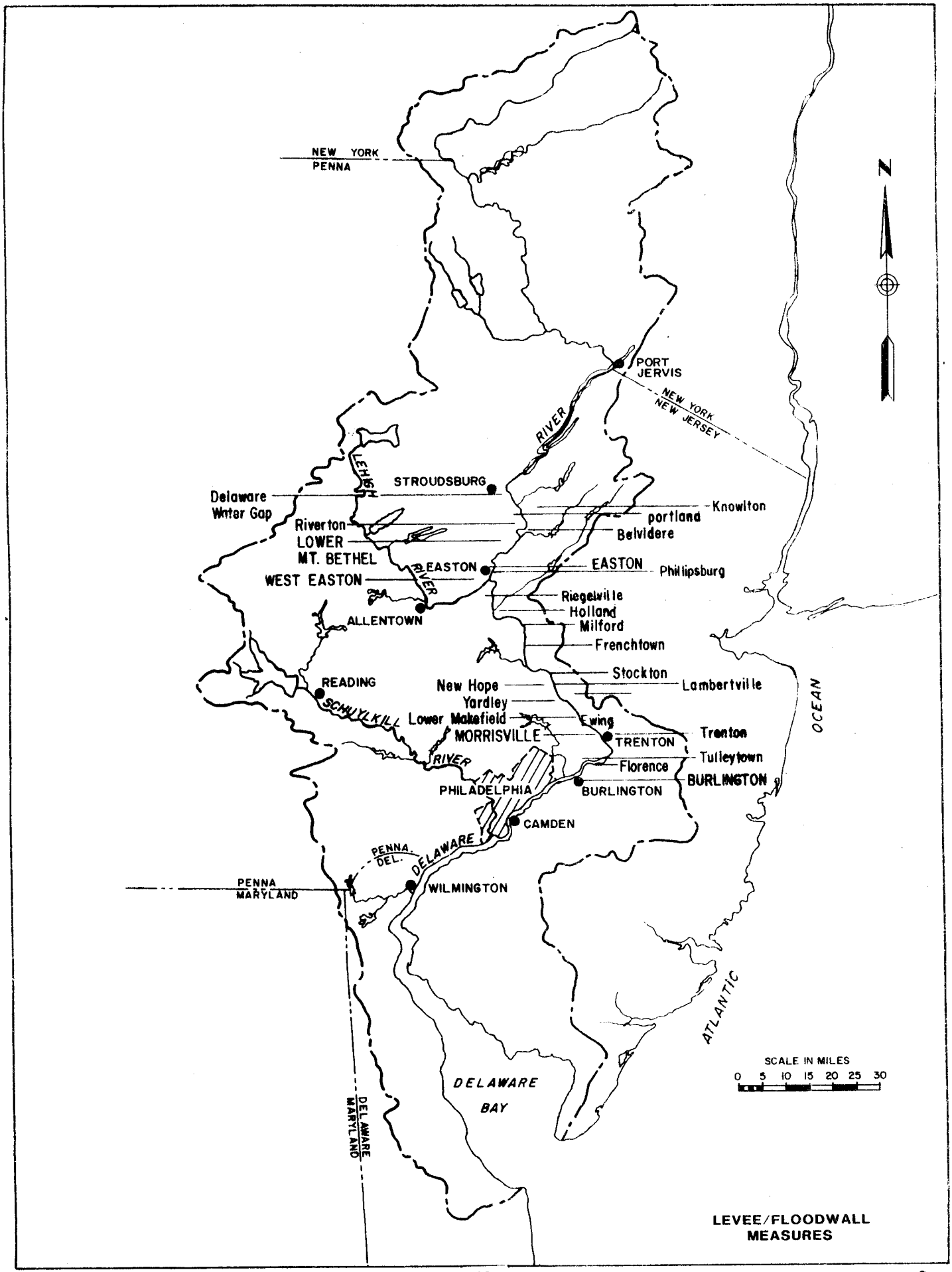

NEW YORK
PENNA
PORT
JERVIS
NEW YORK
NEW JERSEY
RIVER
LEHIGH
STROUDSBURG
Delaware
Water Gap
Riverton
LOWER
MT. BETHEL
WEST EASTON
EASTON
RIVER
ALLENTOWN
Knowlton
portland
Belvidere
EASTON
Phillipsburg
Riegelville
Holland
Milford
Frenchtown
Stockton
Lambertville
New Hope
Yardley
Lower Makefield
Ewing
MORRISVILLE
TRENTON
Trenton
Tulleytown
Florence
BURLINGTON
BURLINGTON
READING
SCHUYLKILL
RIVER
PHILADELPHIA
CAMDEN
PENNA.
DEL.
DELAWARE
RIVER
PENNA
MARYLAND
WILMINGTON
DELAWARE
MARYLAND
DELAWARE
BAY
ATLANTIC
OCEAN
N
SCALE IN MILES
0 5 10 15 20 25 30
LEVEE/FLOODWALL
MEASURES

FIGURE 9

measure demonstrating even marginal feasibility is the SPF protection project for Morrisville, Pennsylvania. Even that project has a BCR less than unity.

154. A summary of the evaluation of levee/floodwall measures is presented in Table 13. This table contains the location, first cost, average annual cost (AAC), average annual benefits (AAB), benefit-cost ratio (BCR), sensitivity BCR (when the costs are for the second screening and 25 percent for the third screening) reduced by 50 percent, and the screening in which the project was eliminated.

IMPOUNDMENTS.

155. All forms of impoundments and all potential impoundment sites for controlling flood waters were reviewed. They included new sites, increasing existing flood control capacity, and the addition of flood control storage at new or existing multipurpose and single purpose projects. "Dry dams", as well as permanent pool projects and off-line flood skimming projects were all reviewed. From the beginning it was obvious that the difficulty with impoundments lies in developing enough control to significantly lower stages along the main stem of the Delaware River without use of a main stem reservoir. Although it was the optimum main stem project, the Tocks Island project discussed earlier in this report was rejected primarily because it would impound one of the last major free flowing rivers in the northeast. For these reasons main stem impoundment was not considered further.

156. The objective of this review was to evaluate all previously identified potential impoundment sites under present-day conditions. Reservoir locations that were previously identified by the Corps of Engineers or other agencies were reviewed. The site locations were obtained from House Document 522, the Madigan-Praeger Report, TAMS reports, the Delaware River Basin Electric Utility Group (DRBEUG), the DRBC and the Level "B" Study. The locations of these sites are shown on Figures 10 and 11. It is considered highly unlikely that after more than 30 years of study, additional impoundment locations exist that could potentially make a measureable contribution to flood control along the main stem Delaware River.

157. Because of the large number of sites and multiple variations at each site, a series of screenings was conducted. Each screening concentrated on one or two criteria. The screening criteria are discussed below and summaries of the screening analysis for the impoundments shown on Figures 10 and 11 are displayed in Tables 14 and 15, respectively. The numbers below indicate the screening step for which the criteria was used.

1. Projects should be located above the City of Trenton, New Jersey, to be considered as having any real contribution to the study area. Below Trenton, floods are caused by a combination of fluvial and tidal influences.

2. Projects should have as a minimum 20,000 acre-feet of storage available for flood control. Conventional storage projects should control a minimum drainage area of 50 square miles which is currently uncontrolled. Projects were considered further if the potential exists to pump water into the reservoir and, therefore, control a much larger drainage area.

TABLE 13
BENEFIT/COST SUMMARY
LEVEE/FLOODWALL MEASURES
SECOND AND THIRD SCREENING
(March 1983 Dollars and Conditions)

LOCATION	FIRST COST ($000)	AAC ($000)	AAB ($000)	BCR	SENSITIVITY BCR 1/	ELIMINATED IN SCREENING
BUCKS COUNTY, PA						
Lower Makefield Twp	10269	934	239	0.26	0.51	2
Morrisville Boro 2/	3578	292	64	0.22	0.26	3
Morrisville Boro 3/	5195	424	291	0.69	0.78	3
New Hope Boro 2/	4208	381	166	0.44	0.87	2
New Hope Boro 3/	7159	637	58	0.09	0.18	2
Rieglesville Boro	6851	623	45	0.07	0.15	2
Tullytown Boro 2/	1140	103	9	0.09	0.17	2
Tullytown Boro 3/	3293	298	14	0.05	0.09	2
Yardley Boro 2/	10860	984	141	0.14	0.29	2
Yardley Boro 3/	18593	1684	238	0.14	0.28	2
NORTHAMPTON COUNTY, PA						
Easton City 3/	25869	2115	130	0.06	0.08	3
Lower Mt. Bethel Twp 2/	2565	233	7	0.03	0.06	2
Lower Mt. Bethel Twp 3/	6016	492	20	0.04	0.06	3
Portland Boro	2649	239	31	0.13	0.26	2
West Easton Boro 3/	19895	1627	55	0.03	0.05	3
MONROE COUNTY, PA						
Delaware Water Gap Boro	1619	146	47	0.32	0.64	2
BURLINGTON COUNTY, NJ						
Burlington City 2/	19475	1593	82	0.05	0.07	3
Burlington City 3/	26031	2128	238	0.11	0.14	3
Florence Twp	1770	161	3	0.02	0.04	2
HUNTERDON COUNTY, NJ						
Frenchtown Boro	8680	786	70	0.09	0.18	2
Holland Twp	5990	534	120	0.22	0.45	2
Lambertville City 2/	2674	242	20	0.08	0.17	2
Lambertville City 3/	7465	676	255	0.38	0.75	2
Milford Boro 2/	2946	292	88	0.30	0.60	2
Milford Boro 3/	32276	266	73	0.27	0.55	2
MERCER COUNTY, NJ						
Ewing Twp	4936	477	50	0.11	0.22	2
Trenton City	9321	844	232	0.27	0.55	2
WARREN COUNTY, NJ						
Belvidere Twp	3300	299	15	0.05	0.10	2
Knowlton Twp	6983	633	24	0.04	0.08	2
Phillipsburg Twp	5148	466	10	0.02	0.04	2

1/ 50% Reduction in Costs for 2nd Screening
25% Reduction in Costs for 3rd Screening
2/ 100-year protection
3/ SPF protection

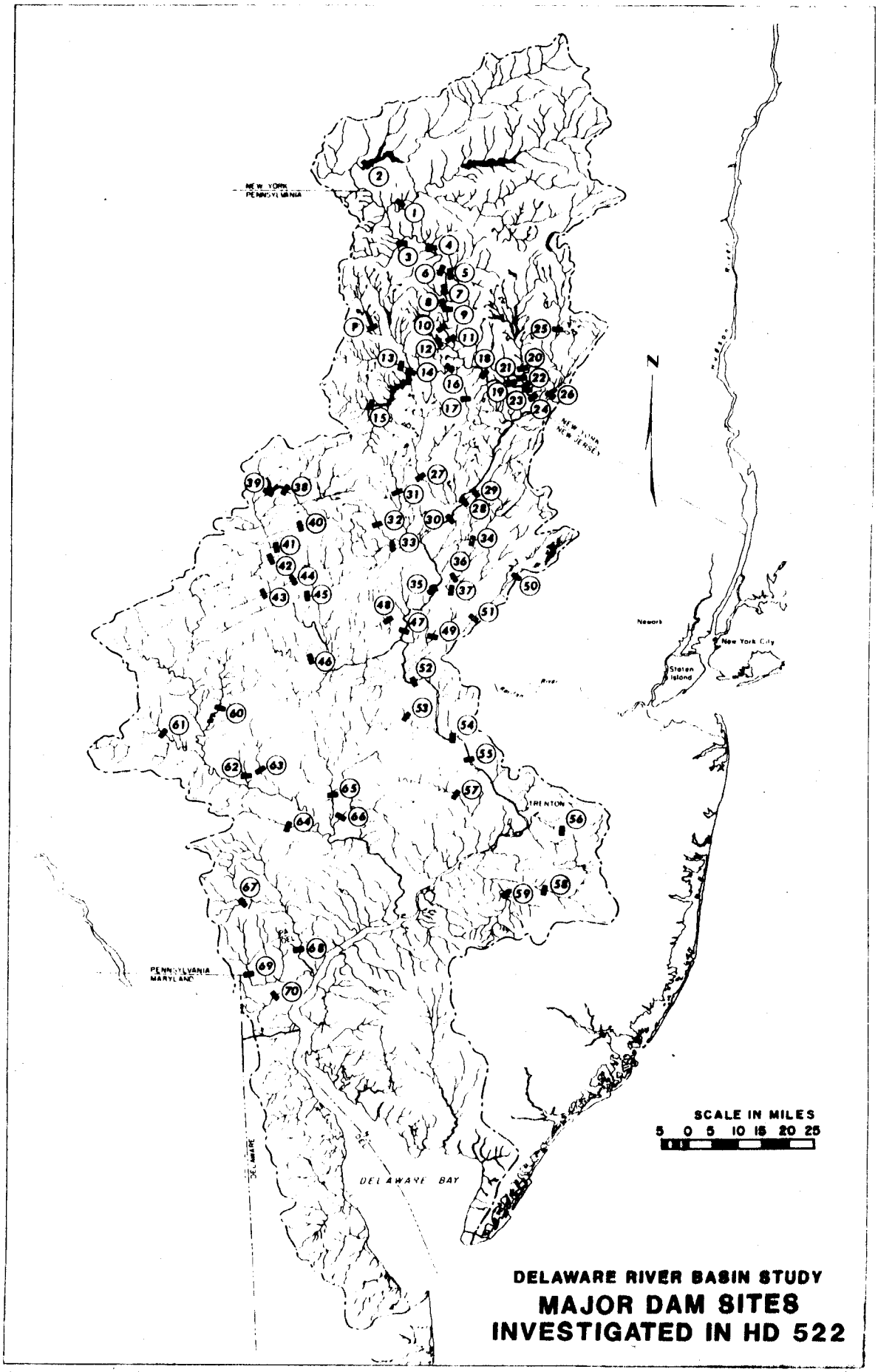

NEW YORK
PENNSYLVANIA
NEW JERSEY
PENNSYLVANIA
MARYLAND
DELAWARE
DELAWARE BAY
TRENTON
Newark
New York City
Staten Island
N
SCALE IN MILES
5 0 5 10 15 20 25
DELAWARE RIVER BASIN STUDY
MAJOR DAM SITES
INVESTIGATED IN HD 522

FIGURE 10

TABLE 14
IMPOUNDMENT SITES
PREVIOUSLY IDENTIFIED
HD522 SUMMARY

Index #	Project	Location	Eliminated in Screening
1	Hawk Mountain	East Branch Delaware River	5
2	Connorsville	West Branch Delaware River	4
3	Equinunk	Equinunk Creek	3
4	Hankins	Delaware River	3
5	Callicoon	Callicoon Creek	5
6	Callicoon River	Delaware River	3
7	Cochecton	Delaware River	3
8	Milansville	Calkins Creek	2
9	Skinners Falls	Delaware River	3
10	Narrowsburg	Delaware River	3
11	Tusten	Delaware River	3
12	Masthope	Masthope Creek	2
13	Hawley	Middle Creek	5
14	Wallenpaupack	Wallenpaupack Creek	5
15	Sterling	Wallenpaupack Creek	4
16	Lackawaxen	Lackawaxen Creek	5
17	Shohola Falls	Shohola Creek	5
18	Barryville	Delaware River	3
19	Knights Eddy	Delaware River	3
20	Rio	Mongaup River	4
21	Delaware	Mongaup River	2
22	Mongaup	Delaware River	3
23	Hawks Nest	Delaware River	3
24	Sparrow Bush	Delaware River	3
25	Bridgeville	Neversink River	5
26	Basherkill Stream	Neversink River	5
27	Girard	Bushkill Creek	5
28	Wallpack Bend	Delaware River	3
29	Flat Brook	Flat Brook	3
30	Tocks Island	Delaware River	3
31	Pine Mountain	Brodhead Creek	5
32	Bartonsville	Pocono Creek	2
33	McMichael (4A)	McMichael Creek	5
34	Paulina	Paulins Kill	5
35	Belvidere	Delaware River	3
36	Sarapta	Beaver Brook	2
37	Pequest	Pequest River	5
38	Tobyhanna	Lehigh River	2
39	F.E. Walter	Lehigh River	4
40	Mud Run #1	Mud Run	2
41	Stoney Creek #2	Stoney Creek	2
42	Bear Creek #3	Bear Creek	2
43	Mahoning	Mahoning Creek	2
44	Beltzville	Pohopoco Creek	4
45	Aquashicola	Aquashicola Creek	

TABLE 14 (Continued)
IMPOUNDMENTS
HD522

Index #	Project	Location	Eliminated in Screening
46	Trexler	Jordan Creek	5
47	Chestnut Hill	Delaware River	3
48	Belfast	Bushkill Creek	2
49	Washington	Pohatcong Creek	2
50	Hackettstown	Musconetcong River	4
51	New Hampton	Musconetcong River	5
52	Holland	Delaware River	1
53	Tohickon	Tohickon Creek	1
54	Eagle Island	Delaware River	1
55	Goat Hill	Delaware River	1
56	Crosswicks	Crosswicks Creek	1
57	Newtown	Neshaminy Creek	1
58	Birmingham	North Branch Rancocas Creek	1
59	Ergrestown	South Branch Rancocas Creek	1
60	Maiden Creek (Moselem)	Maiden Creek	1
61	Blue Marsh	Tulpehocken Creek	1
62	Monocacy	Monocacy Creek	2
63	Fancy Hill	Manatawny Creek	1
64	French Creek	French Creek	1
65	Spring Mountain	Perkiomen Creek	1
66	Evansburg	Skippack Creek	1
67	Buck Run	Buck Run	1
68	New Castle	Brandywine Creek	1
69	Newark	White Clay Creek	1
70	Christiana	Christina River	1

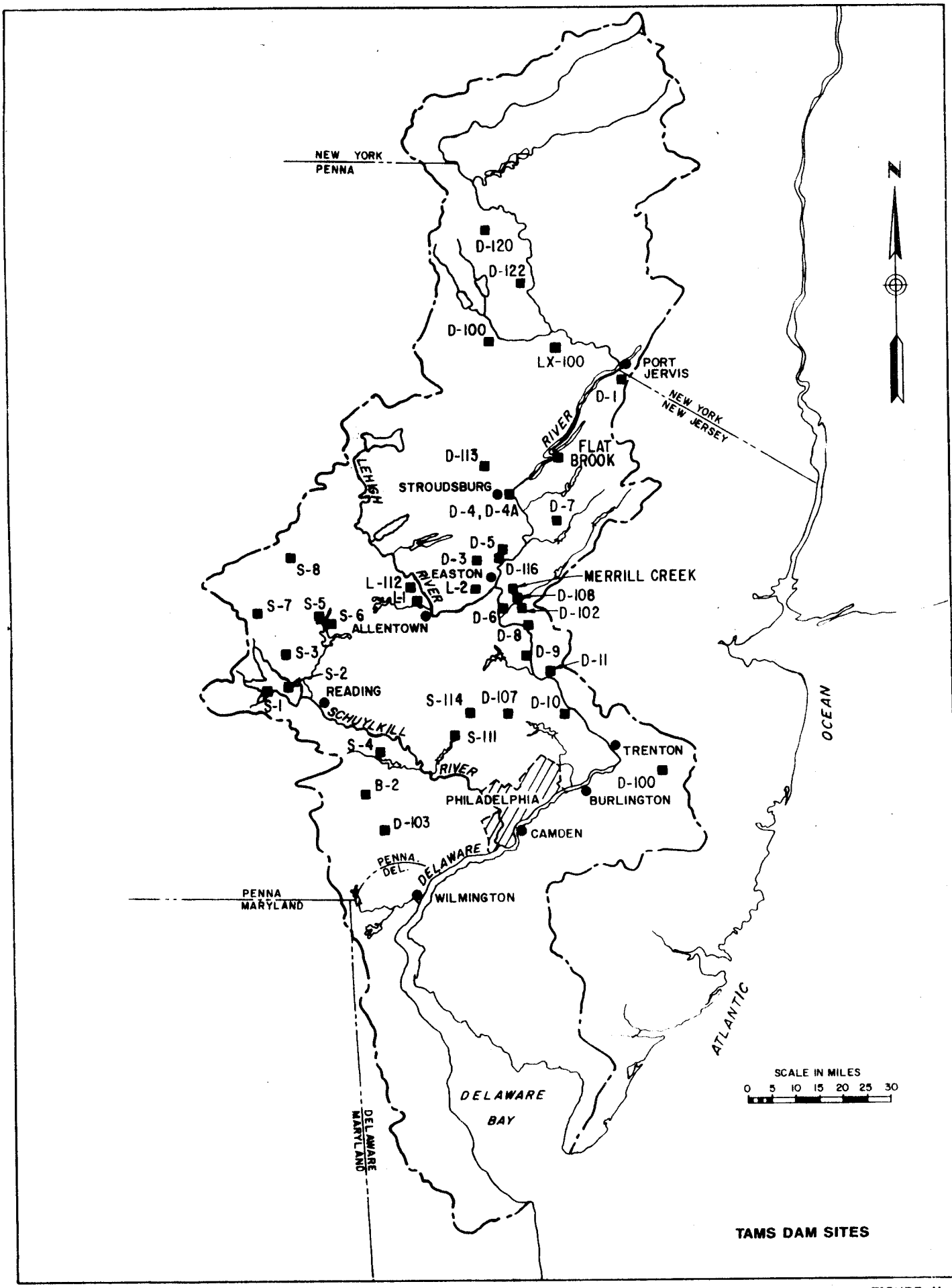

NEW YORK
PENNA
D-120
D-122
D-100
LX-100
PORT JERVIS
D-1
NEW YORK
NEW JERSEY
RIVER
FLAT BROOK
D-113
LEHIGH
STROUDSBURG
D-4, D-4A
D-7
D-5
D-3
EASTON
D-116
MERRILL CREEK
S-8
L-112
L-2
L-1
RIVER
D-108
S-7
S-5
S-6
ALLENTOWN
D-102
D-6
D-8
D-9
D-11
S-3
S-2
READING
S-1
S-114
D-107
D-10
SCHUYLKILL
S-111
S-4
RIVER
TRENTON
B-2
PHILADELPHIA
D-100
BURLINGTON
D-103
CAMDEN
PENNA.
DEL.
DELAWARE
PENNA
MARYLAND
WILMINGTON
OCEAN
ATLANTIC
DELAWARE
BAY
DELAWARE
MARYLAND
N
SCALE IN MILES
0 5 10 15 20 25 30
TAMS DAM SITES

FIGURE 11

TABLE 15
IMPOUNDMENT SITES
PREVIOUSLY IDENTIFIED
TAMS STUDY SUMMARY

TAMS #	Project	Location	Eliminated in Screening
D-1	Clove Brook	Clove Brook	5
D-3	Bushkill Creek	Bushkill River	5
D-4	Cherry Creek #1	Cherry Creek	5
D-4A	Cherry Creek #2	Cherry Creek	
D-5	Little Martin's Creek	Little Martin's Creek	4
D-6	Lower Pohatcong Creek	Lower Pohatcong Creek	5
D-7	Beaver & Muddy Brooks	Beaver & Muddy Brooks	5
D-8	Hakihokake Creek	Hakihokake Creek	5
D-9	Tinicum Creek	Tinicum Creek	5
D-10	Pidcock Creek	Pidcock Creek	5
D-11	Wichecheake Creek	Wichecheake Creek	5
D-100	Crosswicks #1	Crosswicks Creek	1
D-102	Bloomsbury	Musconetcong Creek	5
D-107	Bridgepoint	Neshaminy Creek	1
D-108	Old Greenwick	Pohatcong Creek	2
D-113	Pocono Mountains	Paradise Creek	2
D-116	Martin's Creek	Martin's Creek	2
D-120	Equinunk Creek	Equinunk Creek	3
D-122	Milanville Creek/Pumping	Calkins Creek	2
L-1	Hokendauqua Creek	Hokendauque Creek	5
L-2	Shoeneck Creek	Shoeneck Creek	5
L-112	Kreidersville	Hokendauqua Creek	5
Lx-100	Hawley/Pumping	Middle Creek	5
S-1	Spring Creek	Spring Creek	1
S-2	Plum Creek	Plum Creek	1
S-3	Irish Creek	Irish Creek	1
S-4	Pigeon Creek	Pigeon Creek	1
S-5	Pine Creek	Pine Creek	1
S-6	Stoney Run	Stoney Run	1
S-7	Red Creek	Red Creek	1
S-8	Locust Creek	Locust Creek	1
S-111	Lederach	East Branch Perkiomen Creek	1
S-114	Tylersport	East Branch Perkiomen Creek	1
B-2	Marsh Creek	Marsh Creek	1
B-103	Sconneltown	East Branch Brandywine Creek	1
	Flat Brook/Pumping	Flat Brook	3
	Merrill	Merrill	4

3. Projects will not be located on Federal or state designated scenic rivers or protected areas, nor on the main stem of the Delaware River.

4. Projects which are part of the Level "B" Comprehensive plan, and are designated for water supply, are considered unavailable to provide protection unless they have additional capacity to add-on flood control.

5. Projects cannot require such an "extensive" relocation of major roads, railways, or structures which makes them "obviously" economically infeasible.

6. Environmentally and socially sensitive areas would not preclude further consideration in itself but would reinforce other negative findings. However, sites which have been previously eliminated or deferred for environmental, social or cultural reasons will automatically be eliminated.

7. Projects cannot be economically feasible as a single purpose flood control project if they are already infeasible as a flood control component of a multipurpose project. The advantages of a multipurpose project would preclude this; however, the concepts were reviewed for any abnormal situations.

158. Only two projects, Aquashicola and Cherry Creek, remained after the screening process. It is emphasized that all of these projects were evaluated with a primary purpose of flood control and conclusions are made solely for flood control. Conclusions may not be valid for other purposes or considerations such as using the sites for water supply or hydropower alone or jointly with flood control.

159. Aquashicola, as a single-purpose flood control impoundment, has a relatively small capacity and would control only Lehigh River flows entering the Delaware River at Easton, Pennsylvania, well below much of the study area. It was therefore eliminated from further consideration as a means of reducing main stem flood damages. Cherry Creek, being an off-line flood skimming project requiring main stem diversion by pumping stations and tunnels, was eliminated becasue of its small flow reduction potential and prohibitively high costs.

EVALUATION OF NONSTRUCTURAL ALTERNATIVES

160. The wide range of nonstructural flood damage reduction measures can be grouped into two categories. The first category contains those individual nonstructural measures designed to limit flood damages to particular structures and properties that are subject to flooding. These measures, applied either alone or in combination, include floodproofing, individual floodwalls, elevating, and buying of structures. The second category consists of areal measures including flood plain management and flood warning and preparedness plans. As stated previously, both elements of this second category would be included in any flood damage reduction plan, and therefore, the development and evaluation of basic nonstructural plans focused on those measures that are applied to individual structures.

161. Because of the individuality of most of the nonstructural measures and the different characteristics between and among the land uses in a damage reach, different mixes of nonstructural measures had to be evaluated. The analysis was based on an optimization procedure which analyzed each reach for

each stage of flooding and applied the least expensive measure for each structure at that stage. The benefit analyses were conducted with the Structural Inventory of Damages (SID) and Equivalent Annual Damages (EAD) computer models. The cost analyses was accomplished with a Nonstructural Cost (NSC) computer model which was developed for this study.

162. The purpose of the NSC program is to determine the most cost effective combination of nonstructural measures in order to estimate the cost of implementation. The program accesses SID data files to obtain information such as use, size, elevations and construction type of each structure. A library of nonstructural cost curves was preprogrammed for various types of structures. These curves relate stage with respect to first floor to a cost per square foot for nonstructural application. At each stage the cost entered is for the least expensive measure for that construction type and protection level relative to the first floor. The output for each reach and each stage within the reach includes the number of structures of each land use type to which each measure is applied, the total number of structures, the number not receiving nonstructural protection, and the average annual cost.

163. A brief description of each of the nonstructural measures evaluated is presented below. The results of the nonstructural screenings are summarized in the following paragraphs. Details are presented in the Formulation Appendix.

- No Action - applicable to structures which are receiving no nonstructural measures since they are not prone to flooding at the selected level of protection.

- Minor Floodproofing - selected when the level of protection is greater than a basement elevation but less than a Zero Damage Elevation (ZDE). It is mostly applied to structures with brick or masonary walls which are prone to basement seepage problems or nuisance type flooding. It generally involves the use of sealants for exterior and interior walls, valves to prevent sewer backup, sump pumps, and other methods of floor pressure relief.

- Major Floodproofing - applicable to structures where the level of protection varies from the basement floor elevation to three feet above the first floor. This type of protection includes temporary and permanent closures and shields for doorways and windows, large pumps, and hydrostatic protection. Considerations include the physical feasibility of closing all openings below the selected level of protection, the impermeability of exterior walls and whether the structure is capable of withstanding the anticipated hydrostatic pressure including buoyancy.

- Individual Floodwalls - applicable to structures where the level of protection rises from the Zero Damage Elevation (ZDE) to a maximum of four feet above the first floor. Floodwalls are considered when minor and major floodproofing cannot be applied because the hydrostatic pressure directly against the walls causes possible slab uplift, wall collapse, and/or flooding.

- Elevate Structure - selected for structures where the level of protection varies from three feet to seven feet above the first floor. Although any structure can be raised it is more appropriate for single and two-story frame structures on raised foundations as

opposed to structures with slab on grade foundations or structures with basements. Structure elevation is selected when economic, hydrostatic and/or aesthetic conditions warrant it.

- Buy - applicable to structures where the level of protection exceeds seven feet above the first floor. Buying a structure at market value does not include costs associated with relocation, such as new land or the actual relocation activity.

FIRST SCREENING

164. In the first screening, at each selected stage for each reach in the study area average annual least costly nonstructural combinations were developed from the NSC computer model and compared to the average annual benefits from the EAD computer model. The combination resulting in the maximum net average annual benefit (i.e. average annual benefits minus average annual costs) was designated as the selected nonstructural policy elevation at the index location for the entire reach.

165. In order to minimize the risk of rejecting an economically feasible nonstructural measure, average annual benefits were intentionally overstated. Similarly, a benefit-cost ratio of 0.80 or greater was selected as the criteria for a reach to advance to the next screening.

SECOND SCREENING

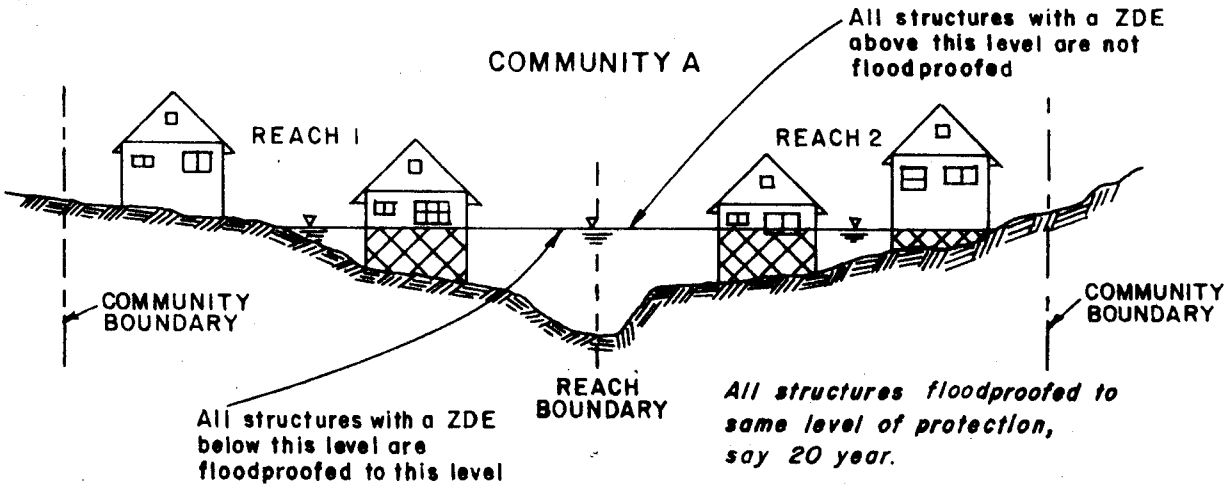
166. The second screening concentrated on increasing the accuracy of estimated benefits and costs. This was accomplished by removing benefits from the computer models which cannot be claimed for nonstructural measures. These benefits include: transportation (roads and bridges), agriculture, and emergency costs. Benefits and costs for each reach were further scrutinized for overall reasonability. It should be emphasized that even with this increased accuracy which generally lowered benefits, the benefits were still intentionally overestimated although less so than in the first screening. This was in keeping with the philosophy that at this stage of the formulation, nonstructural measures should not be eliminated prematurely. As in the first screening, a BCR of 0.80 or greater was selected as the minimum economic viability for progressing to the third screening.

THIRD SCREENING

167. Of the 440 original reaches, only 24 remained after the first two screenings, and these were analyzed in a third screening comprised of two steps. The first step further refined benefit and cost estimates and deleted those benefits (reduction of residential landscaping costs, pumping costs, etc.) which were designed to prevent premature elimination by overstating the damages reduced by nonstructural measures. The second step aggregated the 24 reaches into their 19 respective communities and evaluated all the reaches in each community at the selected level of protection for the viable reach. Each community's level of protection was developed by determining the frequency (in

years) of the selected protection level for the economically viable reach or reaches within each specific community and using this frequency as the target level of protection for the entire community. In effect, only those structures with a zero damage elevation (ZDE) at or below the target level will receive nonstructural floodproofing measures. This approach provides a uniform level of protection throughout a community (see figure below). The nonstructural measure applied depends on the protection level with respect to the first floor, and the construction and land-use type of each structure.

FLOODPROOFING TO SPECIFIED FLOOD TARGET LEVEL



NOTE: Cross hatched area represents amount of floodproofing for each structure

168. The results of the screening analysis of the nonstructural measures are summarized in Table 16. Seven of the nineteen communities analyzed in the third screening had a BCR less than unity and were therefore eliminated from further evaluation.

COMMUNITIES REMAINING AFTER THIRD SCREENING

169. There were 12 communities which met the screening criteria (BCR equal to or greater than unity) and therefore surpass a minimum level of economic justification. Those communities are listed in Table 17 with the types of nonstructural measures evaluated and the number of structures requiring each type of measure. A discussion of each of those twelve communities follows.

BUCKS COUNTY, PENNSYLVANIA

. Bridgeton Township. The nonstructural analysis yielded a BCR of 1.6 at a 22-year level of protection at a total cost of approximately $422,000. The structures requiring the application of nonstructural protective measures are irregularly and loosely grouped in a rural area along the Delaware River.

. Bristol Borough. The analysis yielded a BCR of 2.2 at a 66-year level of protection at a total cost of approximately $109,000. Of those structures requiring the application of nonstructural protective measures, eleven

TABLE 16

SUMMARY OF NONSTRUCTURAL SCREENINGS[4/]

COMMUNITY	NUMBER OF STRUCTURES (SPF BOUNDARY)	STRUCTURES REQUIRING PROTECTION (PERCENT)	LEVEL OF PROTECTION (FREQUENCY IN YEARS)	AVERAGE ANNUAL BENEFITS ($000)	AVERAGE ANNUAL COSTS ($000)	BENEFIT COST RATIO	SCREENING 1/
BUCKS COUNTY, PA							
Bensalem Twp	121	73	2/	9.84	31.42	0.31	2
Bridgeton Twp	152	33	22	52.80	33.20	1.60	3
Borough of Bristol	66	79	66	18.95	8.56	2.20	3
Bristol Twp	136	16	50	47.40	20.60	2.30	3
Durham Twp	25	40	2/	0.14	5.97	0.02	1
Falls Twp	4	100	2/	57.68	479.36	0.12	2
Lower Makefield Twp	639	46	2/	1.27	39.25	0.03	2
Borough of Morrisville	33	85	2/	3.05	32.66	0.09	2
Borough of New Hope	278	7	22	66.16	33.89	1.95	3
Nockamixon Twp	6	16	50	0.56	1.56	0.36	3
Plumstead Twp	16	12	28	31.62	6.41	4.93	3
Borough of Reigelsville	197	26	2/	0.49	6.70	0.07	1
Solebury Twp	97	63	167	78.39	153.60	0.51	3
Tinicum Twp	211	9	13	85.80	36.80	2.33	3
Borough of Tullytown	17	94	333	7.38	22.06	0.33	3
Upper Makefield Twp	304	9	22	29.83	34.15	0.87	3
Borough of Yardley	328	37	35	97.41	148.27	0.66	3
NORTHAMPTON COUNTY, PA							
City of Easton	260	22	50	98.66	152.87	0.64	3
Forks Twp	71	63	2/	1.66	12.47	0.13	1
Lower Mt. Bethel Twp	202	5	17	24.04	13.42	1.79	3
Borough of Portland	37	89	2/	5.47	53.15	0.10	1
Upper Mt. Bethel Twp	122	41	2/	6.81	50.30	0.14	2
Williams Twp	117	20	2/	1.89	8.28	0.23	2
MONROE COUNTY, PA							
Borough of Delaware Water Gap	35	72	2/	1.35	6.93	0.19	2
Smithfield Twp	141	50	2/	84.25	658.14	0.13	2

TABLE 16 (Continued)

SUMMARY OF NONSTRUCTURAL SCREENINGS[4/]

COMMUNITY	NUMBER OF STRUCTURES (SPF BOUNDARY)	STRUCTURES REQUIRING PROTECTION (PERCENT)	LEVEL OF PROTECTION (FREQUENCY IN YEARS)	AVERAGE ANNUAL BENEFITS ($000)	AVERAGE ANNUAL COSTS ($000)	BENEFIT COST RATIO	SCREENING 1/
BURLINGTON COUNTY, NJ							
City of Beverly	No Structures		2/				2
City of Bordentown	2	50	2/	0.91	0.38	0.95[3/]	2
Bordentown Twp	No Structures		2/				1
City of Burlington	2966	81	2/	790.42	3188.38	0.25	2
Burlington Twp	13	93	2/	14.96	99.15	0.15	2
Delanco Twp	45	15	7	13.67	3.27	4.18	3
Delran Twp	73	100	2/	16.15	188.33	0.09	1
Edgewater Park Twp	No Structures		2/				1
Borough of Fieldsboro	2	0	2/				1
Florence Twp	1	100	2/	0.02	4.36	0.01	2
Mansfield Twp	2	100	2/	0.39	1.38	0.28	2
Riverside Twp	163	7	25	22.78	9.82	2.32	3
HUNTERDON COUNTY, NJ							
Alexandria Twp	47	86	2/	8.67	43.04	0.20	2
Delaware Twp	20	60	2/	7.97	15.78	0.51	2
Borough of Frenchtown	206	30	2/	1.50	20.11	0.17	2
Holland Twp	37	16	35	12.00	8.43	1.42	3
Kingwood Twp	70	38	95	17.35	32.91	0.53	3
City of Lambertville	450	55	2/	108.45	166.45	0.65	2
Borough of Milford	90	44	2/	0.85	24.58	0.04	2
Borough of Stockton	140	39	2/	0.37	17.42	0.02	1
W. Amwell Twp	4	100	2/	0.47	14.32	0.03	2
MERCER COUNTY, NJ							
Ewing Twp	200	65	2/	21.25	151.91	0.14	1
Hamilton Twp	10	70	50	67.81	22.82	2.97	3
Borough of Hopewell	98	15	2/	4.70	13.40	0.35	2
City of Trenton	646	84	2/	113.65	858.58	0.13	2

TABLE 16 (Continued)

SUMMARY OF NONSTRUCTURAL SCREENINGS[4/]

COMMUNITY	NUMBER OF STRUCTURES (SPF BOUNDARY)	STRUCTURES REQUIRING PROTECTION (PERCENT)	LEVEL OF PROTECTION (FREQUENCY IN YEARS)	AVERAGE ANNUAL BENEFITS ($000)	AVERAGE ANNUAL COSTS ($000)	BENEFIT COST RATIO	SCREENING 1/
WARREN COUNTY, NJ							
Town of Belvidere	191	83	2/	24.08	179.76	0.13	1
Harmony Twp	175	11	10	23.77	13.10	1.81	3
Knowlton Twp	140	32	2/	4.59	47.20	0.10	2
Lopatcong Twp	1	0	2/				2
Pahaquarry Twp	2	0	2/				1
Town of Phillipsburg	118	52	2/	4.82	115.68	0.04	2
Pohatcong Twp	113	25	2/	1.16	30.17	0.04	2
White Twp	60	45	2/	4.78	13.91	0.34	2

1/ The screening indicated is the last screening to which the community progressed. A community did not advance to the next screening if it had a BCR less than 0.8 (1.0 in third screening).

2/ Nonstructural analysis in screenings 1 and 2 was done exclusively on a reach by reach basis. Therefore the level of flood protection of a community eliminated in the 1st and/or 2nd screenings varies by reach within the community because the selected level of protection is the optimum level for each reach and therefore not consistent throughout the community.

3/ Only one structure received nonstructural action within the community and because of this constraint the community did not advance to the next screening.

4/ March 1983 price level. Discount rate of 7 7/8%.

TABLE 17

DELAWARE RIVER BASIN STUDY - NONSTRUCTURAL ANALYSIS
NONSTRUCTURAL ACTIONS

Community	No Action (No Protection Required)	Minor Floodproof	Major Floodproof	Individual Floodwall	Elevate	Buy
BUCKS COUNTY, PENNSYLVANIA						
Bridgeton Twp	101	6 (Res)	25 (Res) 2 (Com)	4 (Res) 1 (Ser)	13 (Res)	0
Bristol Boro	14	11 (Com)	40 (Res) 1 (Ser)	0	0	0
Bristol Twp	114	0	2 (Res)	15 (Res) 1 (Pub)	4 (Res)	0
New Hope Boro	257	1 (Res) 1 (Com)	2 (Res) 4 (Com)	1 (Res) 5 (Com)	7 (Res)	0
Plumstead Twp	14	0	0	1 (Res)	0	1 (Res)
Tinicum Twp	192	1 (Res)	3 (Res) 1 (His)	7 (Res) 1 (Ser)	2 (Res)	3 (Res) 1 (Com)
NORTHAMPTON COUNTY, PENNSYLVANIA						
Lower Mt. Bethel Twp	193	1 (Res)	0	4 (Res)	4 (Res)	0
BURLINGTON COUNTY, NEW JERSEY						
Delanco Twp	38	1 (Com)	3 (Res)	1 (Res) 1 (Com)	1 (Res)	0
Riverside Twp	152	0	3 (Res) 2 (Com)	6 (Res)	0	0
HUNTERDON COUNTY, NEW JERSEY						
Holland Twp	31	0	1 (Res)	3 (Res)	1 (Res)	1 (Res)
MERCER COUNTY, NEW JERSEY						
Hamilton Twp	3	0	1 (Com)	1 (Com) 1 (Ind)	1 (Com)	1 (Com) 2 (Ind)
WARREN COUNTY, NEW JERSEY						
Harmony Twp	156	5 (Res)	5 (Res)	5 (Res)	3 (Res)	1 (Com)

commercial establishments and one municipal garage are loosely grouped at the mouth of a small tributary to the Delaware River. The remaining structures are apartments in a complex in an urbanized area along the Delaware River.

. Bristol Township. The analysis yielded a BCR of 2.3 at a 50-year level of protection at a total cost of about $261,000. The structures requiring protective measures are irregularly and loosely associated in groups of not more than eight in an urbanized area along the Delaware River and Neshaminy Creek.

. New Hope Borough. The nonstructural analysis yielded a BCR of 2.0 at a 22-year level of protection at a total cost of about $430,000. The structures requiring protective measures are loosely grouped along the Delaware River in the urbanized area of downtown New Hope.

. Plumstead Township. The nonstructural analysis yielded a BCR of 4.9 at a 28-year level of protection at a total cost of about $81,000. The structures requiring protective measures consist of two residential properties in a rural area along the main stem Delaware River.

. Tinicum Township. The nonstructural analysis yielded a BCR of 2.3 at a 13-year level of protection at a total cost of approximately $427,000. The structures requiring protective measures are irregularly and loosely associated in groups of not more than eight in a mostly rural area along the main stem Delaware River.

NORTHAMPTON COUNTY, PENNSYLVANIA

. Lower Mount Bethel Township. The analysis yielded a BCR of 1.8 at a 17-year level of protection at a total cost of about $170,000. The structures requiring protective measures, located in a rural area along the Delaware River, consist of a group of six residential properties with the rest of the structures scattered throughout the township.

BURLINGTON COUNTY, NEW JERSEY

. Delanco Township. The nonstructural analysis yielded a BCR of 4.2 at a 7-year level of protection at at total cost of about $41,000. The structures requiring protective measures are located in an urban area along both the Delaware River and Rancocas Creek.

. Riverside Township. The analysis yielded a BCR of 2.3 at a 25-year level of protection at a total cost of approximately $125,000. The structures requiring protective measures are scattered throughout the urbanized area at the mouth of Rancocas Creek.

HUNTERDON COUNTY, NEW JERSEY

. Holland Township. The analysis yielded a BCR of 1.4 at a 35-year level of protection at a total cost of about $107,000. The structures requiring protective measures are located along the Delaware River in a mostly rural area.

MERCER COUNTY, NEW JERSEY

. Hamilton Township. The nonstructural analysis yielded a BCR of 3.0 at a 50-year level of protection at a total cost of about $290,000. The structures requiring protective measures are located within a complex of a group of six oil companies and distributors, made up of small office buildings and oil storage tanks, and a small marine repair shop in a rural area along the Delaware River.

WARREN COUNTY, NEW JERSEY

. Harmony Township. The nonstructural analysis yielded a BCR of 1.8 at a 10-year level of protection at a total cost of approximately $166,000. The structures requiring the application of protective measures are located in a rural area along the main stem Delaware River in a group of 5 residential properties and a loosely associated group of 13 residential properties, including some cottages, and a commercial establishment.

170. In aggregate and on a community basis at a survey level of analysis, the application of nonstructural protective measures is economically justified for 223 structures (or approximately 1.9 percent) of the over 12,000 structures inventoried in the floodplain (as defined by the SPF) of the 105 river miles of the main stem Delaware River from Stroudsburg, Pennsylvania, to Burlington, New Jersey. These structures are distributed among 12 of the 58 communities in that reach. The total cost of the nonstructural protection of these 12 communities is approximately $2,629,000. Before a nonstructural protection plan could be implemented, however, a more detailed analysis would be required.

DESIGNATION OF THE NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN

171. Application of nonstructural measures to selected structures within the communities listed in Table 17 is the NED plan. Of all the measures evaluated for this study, this plan would provide the maximum net benefits with minimal environmental effects.

FUTHER STUDIES REQUIRED

172. Further detailed studies remain to be done before any nonstructural measures could be implemented. Those studies would include, but not be limited to, a more accurate determination of flood plain limits, engineering studies of each structure affected and a more precise determination of costs and potential benefits. Giving due consideration to the estimated construction costs and comparison of anticipated remaining study costs to potential project benefits, it may be appropriate that further studies be conducted in accordance with the provisions of Section 205 of the 1948 Flood Control Act. That Act, as amended, authorizes the Secretary of the Army to construct small projects for flood control and related purposes not specifically authorized by Congress when in the opinion of the Chief of Engineers such work is advisable. A non-Federal entity that is interested in sponsoring further studies must be identified before further action can be taken under the cited authority. Local officials for each of the 12 communities listed in Table 17 and for each of the Counties in which those communities are located were contacted to ascertain non-Federal interest in sponsoring further studies. Those contacts and results are discussed in the following section.

COORDINATION WITH LOCAL INTERESTS

173. In accordance with the resolution authorizing this study, close coordination has been maintained with the DRBC. That coordination was initiated concurrent with the start of this study and has been maintained throughout. That effort has included exchange of correspondence, meetings between members of the respective offices, and the furnishing of data pertinent to the study by DRBC. That office was given the opportunity to review and comment on this report throughout the various study phases. It is believed that this coordination effort and information furnished by the DRBC has strengthened the findings and conclusions reached as a result of the study. Pertinent documentation on this coordination effort is included at the end of this report.

174. The officials of each of the 12 municipalities for which nonstructural flood control measures were found to be economically justified were contacted by letter and by telephone to advise them of the findings and to determine their interest in sponsoring further studies of those measures. One community, the Township of Bristol, Pennsylvania, advised that it would be willing and able to act as a non-Federal sponsor.

175. The counties in which those 12 municipalities are located were also contacted and advised of the study findings and of the degree of interest expressed by the municipalities in sponsoring further studies. The counties were offered the opportunity to act as non-Federal sponsor in those instances where the municipalities declined to do so. No county accepted the offer.

176. Pertinent correspondence on the matter of non-Federal sponsorship is also included at the end of this report.

ENVIRONMENTAL EVALUATION

177. While the absence of a recommendation for Federal construction under this study authority precludes the need for a formal environmental assessment or impact statement, certain measures have been identified as feasible for Corps implementation under Section 205 of the Flood Control Act of 1948 or by non-Federal interests. These actions could have an effect on ecological and cultural resources and the following evaluation reviews the various options with a goal toward impact minimization. In the absence of detailed specific proposals, only a general evaluation indicating overall impacts is possible.

FLOOD WARNING

178. Flood warning has proven invaluable in saving lives and giving people in flood prone areas an opportunity to remove or protect some of their possessions. Given a sufficient period of notice, a sizable reduction in property damage can occur, with a commensurate reduction in social disruption.

179. No significant environmental impacts are associated with implementing a floodwarning system. Impacts could involve only the temporary inconvenience associated with noise, turbidity, and dust that accompany the placement of such items as gaging stations or sensing equipment to provide automation and remote data transfer.

OTHER NONSTRUCTURAL MEASURES

180. Several different means of providing flood protection to individual structures are involved. Each causes different types of impacts, the extent of which depends to a large degree on site specific conditions.

181. Floodproofing, while much more practical when applied to new construction, has viability for certain existing structures. Benefits would be limited to prevention of damage to structure contents. Ecological impacts should be minor, and at most, limited to disturbance of shrubbery adjacent to the structure. With this vegetation being generally located in an open suburban habitat, the effect of its disturbance on wildlife should be minor.

182. Cultural resource impacts would be dependent on the type of structure being modified and the nature of the modification. Care would need to be taken with historical properties to insure that alterations do not damage an important cultural attribute or alter the historic value of the setting; external above ground modifications should generally be prohibited.

183. Construction of individual floodwalls and levees would necessitate relatively intensive site construction. They have the advantage of protecting the whole enclosed areas rather than just the buildings. These measures are also useful for protecting buildings for which other floodproofing measures cannot be used because of a building's size or lack of structural strength. However, walls and levees may sometimes be unattractive, are subject to failure and/or overtopping or may even intensify flood problems on adjacent property by redirecting flood flows. Ecological impacts would be dependent on the type and amount of terrestrial habitat eliminated. The historic setting of the protected or adjacent sites could be altered and this would affect overall cultural significance of historic structures.

184. Another frequently used nonstructural method is elevation of buildings above expected flood levels. Existing structures can sometimes be raised and the original foundation extended upward with walls, piers, or columns. These measures are best suited for smaller structures with basements or crawl spaces. Ecological impacts would be primarily limited to disturbance of adjacent shrubbery and have minor permanent wildlife impact. Impacts to historic structures would depend on the amount and type of elevation proposed. Preservation of an appropriate historic setting would be difficult with major raisings.

185. Acquisition of floodplain property includes relocating existing buildings to safe sites or demolishing undesirably located structures and providing replacements in a flood free site. Coupled with zoning it can allow for creation of needed open park space in a community. The social benefits of reduced flood trauma must be balanced against that of forced relocation. Depending on the subsequent land use, wildlife enhancement is possible. For historic buildings, acquisition and conversion to a use with contents less susceptible to flood damage would be recommended as opposed to relocation or demolition.

CONCLUSIONS

186. Although there exists a potential for catastrophic losses if the area should suffer an occurrence of an event equal to or greater than the 1955 flood, local structural measures could not be justified solely on the basis of

flood reduction benefits. This is because high zero-damage elevations in the study area and the older and complex infrastructure that characterize the main stem result in high project costs relative to flood damages reduced. Main stem control requirements, unavailability of many sites, and high relocation costs at many sites render single purpose flood control impoundments infeasible. However, flood control should still be considered as an add-on to reservoirs being considered for development by non-Federal interests for other purposes.

187. Based on a survey level analysis using March 1983 price levels and a discount rate of 7-7/8 percent, there are 12 communities out of a total of 58 communities in the study area for which varying levels of individual nonstructural protection are economically justified. A sensitivity analysis determined that the use of more current price levels (May 1984) and discount rate (8-1/8 percent) would not affect that finding. Those structures for which nonstructural protection may be feasible comprise a very small percentage (less than 2 percent) of the total floodplain structures (12,000) along the main stem Delaware River within the study area. Interest at the local level in sponsoring further studies of nonstructural protective measures for their community is extremely limited. Only one community, the Township of Bristol in Bucks County, Pennsylvania, stated that it was willing and able to act as non-Federal sponsor of further studies.

188. Flood warning and preparedness plans for the main stem Delaware River were also examined. It was found that existing NWS flood forecasting systems function well and that flood warnings are timely and reliable. However, the effectiveness of river stage forecasts and subsequent state and county flood warning issuances decreases with diffusion to the local level. This is because local flood warnings and preparedness plans are left largely to the discretion of local interests with a subsequent wide variety in plans and procedures. More coordinated and uniform local preparedness plans would help maintain a high level of effectiveness of regional flood warning extending to the local level. Federal participation in flood damage reduction along the main stem can also include the provision of data and technical assistance to State and local authorities in the area of flood warning and emergency preparedness.

RECOMMENDATIONS

189. It is my recommendation that, after giving due consideration to the results of the studies reported on herein, the nature of the study area, the type and scope of protective measures that showed economic justification and the limited interest indicated by local officials in further studies, that no further action should be taken by the Corps of Engineers under the current Survey Authority.

190. The Continuing Authorities program should be utilized for further studies of nonstructural protective measures in those communities that are willing and able to sponsor such studies.

Ralph V. Locurcio
Lieutenant Colonel, Corps of Engineers
District Engineer

NADDE (Sep 84) 1st Ind
SUBJECT: Delaware River Basin Study

DA, North Atlantic Division, Corps of Engineers, 90 Church Street, New York, NY 10007-9998 24 September 1984

TO: CDR, USACE, (DAEN-BR/Resident Member), Kingman Building, Fort Belvoir, Virginia 22060

I concur in the District Commander's conclusions and recommendations.

Charles E. Dandeneau COL CE

FOR: PAUL F. KAVANAUGH
Brigadier General, USA
Division Commander

PERTINENT CORRESPONDENCE

NAPEN-R

28 JUN 1979

Mr. Gerald M. Hansler, Executive Director
Delaware River Basin Commission
P.O. Box 7360
West Trenton, N. J. 08628

Dear Mr. Hansler:

Submitted herewith is an advance copy of the Delaware River Basin Study Reconnaissance Report containing the results of the Stage I planning effort. Your review and comments would be appreciated.

The report defines the scope of the study as the formulation and evaluation of alternative flood damage reduction programs for the main stem of the Delaware River in the reach that would have been afforded a degree of protection by the Tocks Island Lake Project. It is requested that your agency furnish a letter verifying the scope of the study. The letter will then be included in the report.

Our schedule for submission of the report to higher authority for approval is mid-July 1979. Receipt of your letter verifying the scope of the study in time to meet our scheduled submission date would be appreciated.

Sincerely,

1 Incl
As stated

D. J. SHERIDAN
Acting Chief, Engineering Division

EXHIBIT A

DELAWARE RIVER BASIN COMMISSION
P. O. BOX 7360
WEST TRENTON, NEW JERSEY 08628

(609) 883-9500

GERALD M. HANSLER
EXECUTIVE DIRECTOR

HEADQUARTERS LOCATION
25 STATE POLICE DRIVE
WEST TRENTON, N. J

July 6, 1979

Mr. D. J. Sheridan
Acting Chief, Engineering Division
Philadelphia District
Corps of Engineers
Custom House - Second and Chestnut Streets
Philadelphia, Pennsylvania 19106

Dear Mr. Sheridan:

Re: NAPEN-R
June 28, 1979

We have reviewed your advance copy of the Delaware River Basin Study Reconnaissance Report containing the results of your Stage I planning effort to formulate and evaluate alternative flood damage reduction programs for the main stem of the Delaware River from Tocks Island to Burlington, New Jersey.

We concur with the scope of the study as contained in the Reconnaissance Report and agree that the planning objectives and major study tasks proposed for Stages II and III, when completed, will meet the study objectives requested by this Commission.

Attachment 1, enclosed herewith, contains some specific comments and suggestions regarding the report.

We look forward to further coordination with you on the next phases of the study.

Sincerely,

Jerry

Gerald M. Hansler

Enclosure

July 6, 1979
Attachment 1

DRBC Comments on Delaware River Basin Study
Reconnaissance Report - Philadelphia District,
Corps of Engineers - July 1979

Page 7, Paragraph No. 3

Since the DRBC has far broader authority than indicated in the first three sentences of this paragraph, revise to read as follows:

3. With the Delaware River Basin Commission (DRBC). The DRBC was established in 1961 by interstate-federal Compact with concurrent legislation from Congress and New York, New Jersey, Pennsylvania and Delaware. The five DRBC commissioners are the governors of those four states and the Secretary of the Interior. The DRBC is charged with planning, development, management and protection of the water resources of the four-state river system, including all of its tributaries.

Page 10, 4th line

After "Bear Creek" add (renamed Francis E. Walter).

Page 11, 1st full paragraph, 6th line

Delete the words, "was the primary consideration which"

Page 15, 1st line

Change "Bay" to "Estuary".

Page 27

The last part of the last sentence is missing.

Page 60, 1st full paragraph

This appears to repeat statements in the previous paragraph.

NAPEN-P

14 OCT 1982

Mr. Robert L. Goodell
Delaware River Basin Commission
P.O. Box 7360
West Trenton, NJ 08628

Dear Mr. Goodell:

We are completing the second stage of our Delaware River Basin Study at the present time. Our intention is to coordinate this work with you following its completion. It is anticipated that this should take place during November.

In general, our inventory has encountered more units than was reported in House Document 522. However, this does not necessarily imply a general trend of new development; in fact, most of the structures appeared of a pre-1955 vintage. We attribute some of the differences to some new construction in the flood plain between the limits of the 100-year and 1955 floods but most of the difference probably lies in the fact that not all units were included in the 1955/1958 inventory. The 1955/1958 inventory concentrated its efforts to high-damage areas where significant average annual damages were expected and projects contemplated.

I am inclosing some preliminary data which summarizes our inventory of flood prone structures. At this time, we intend this for your use. Until the information has been completed and analyzed, we ask that it is not made public.

If you have any questions or wish to discuss this further, do not hesitate to call me or Paul Gaudini, directly.

Sincerely,

1 Incl
As stated

NICHOLAS J. BARBIERI, P.E.
Chief, Planning/Engineering Division

NAPEN-P

Mr. Robert Goodell
Delaware River Basin Commission
P. O. Box 7360
West Trenton, NJ 08628

29 OCT 1982

Dear Bob:

As I reported to you in my letter dated 14 October 1982, we are completing the second stage of our Delaware River Basin Study. At this time, we wish to coordinate our findings to date as well as the direction of the remainder of the study.

I am inclosing copies of a working notebook containing a preliminary draft of our findings. The purpose of this notebook is for your working level review and as a basis for discussion. The information has not undergone a complete review and, therefore, not appropriate for general use.

If your schedule permits, we wish to schedule a meeting in early November. Paul Caudini will be available to address any questions or provide additional information which you or your staff may require.

Sincerely,

2 Incl (dupe)
As stated

NICKLAS J. BARLIEPI, P.E.
Chief, Planning/Engineering Division

DELAWARE RIVER BASIN COMMISSION
P.O. BOX 7360
WEST TRENTON, NEW JERSEY 08628

(609) 883-9500

GERALD M. HANSLER
EXECUTIVE DIRECTOR

HEADQUARTERS LOCATION
25 STATE POLICE DRIVE
WEST TRENTON, N.J.

December 20, 1982

Mr. Paul Gaudini
U.S. Army Corps of Engineers
2nd and Chestnut Streets
Custom House
Philadelphia, Pennsylvania 19106

Dear Mr. Gaudini:

Your visit with Dan Price and Gary Rohn to my office last week was informative since it gave me and my staff the opportunity to learn in detail the progress of your work on the Phase II - Delaware River Basin Study. As we discussed, I believe it necessary to incorporate by appropriate reference into your report the Commission's Flood Plain Regulations, a copy of which you now have. For your information, I am also enclosing copies of the Commission's Water Conservation Management Plan and the draft report on the Good Faith Recommendations of the Parties to the U.S. Supreme Court.

As part of our review of your Phase II study notebook, I am sending separately to you one of your report copies which has been reviewed for typographical and other related errors. Overall, your report represents a very detailed study effort which has updated in several areas information required to effectively analyze the impact of floods in this basin. We look forward to working with you toward the completion of the final report and the hope that your extensive study effort will lead to some program for implementation to ameliorate the flood threat in the study area.

Sincerely,

Robert L. Goodell
Chief Engineer

Enclosures

EXHIBIT A-6

APR 04 1984

Planning Branch

Mr. Gerald M. Hansler, Executive Director
Delaware River Basin Commission
P.O. Box 7360
West Trenton, New Jersey 08628

Dear Mr. Hansler:

This is in reference to our ongoing flood control study of the main stem of the Delaware River, the Delaware River Basin Study. As was discussed with members of your staff at a meeting on March 2, 1984 we have identified twelve municipalities for which nonstructural flood control measures appear to be economically justified.

The governing officials of each of these municipalities have been contacted by letter, copy enclosed, and asked whether they are interested in sponsoring further investigation of the nonstructural measures in their communities. The counties within which they are located have also been contacted, copy enclosed, and advised of our findings.

We will keep you advised of the outcome of our contacts with these municipal and county governments.

Sincerely,

Signed by: S. J. BUCOLO

Nicholas J. Barbieri, PE
Chief, Planning/Engineering Division

Enclosures

EXHIBIT A-7

Planning Branch

JUL 30 1984

Mr. Gerald M. Hansler
Executive Director
Delaware River Basin Commission
P. O. Box 7360
West Trenton, New Jersey 08628

Dear Mr. Hansler:

This is to follow-up on my letter of April 4, 1984 concerning the Delaware River Basin Study and to advise you that we are preparing our final report on the study for transmittal to our higher authority.

The final report findings, conclusions and recommendations will be as contained in the draft report. Revised pages for the draft report were furnished to your office earlier for incorporation into your copies of the report. Along with other changes, those revised pages made appropriate reference to the Delaware River Basin Commission's Flood Plain Regulations as had been requested by your office.

As you are aware, this study made an extensive evaluation of alternative flood protection measures along the main stem Delaware River in the absence of the Tocks Island Lake project. It was found that none of the structural alternatives were economically justified and that nonstructural protective measures appeared to be economically justified for 12 municipalities along the main stem Delaware River.

As stated in my letter of April 4, 1984, the governing officials of those municipalities and the counties in which they are located had been contacted to determine their interest in sponsoring further studies. Our follow-up contacts with those officials have been completed. Only one community, Bristol Township, has expressed interest in acting as a non-Federal sponsor for further studies.

At a meeting earlier this year with Mr. Powell and others of your staff, it was stated that the Delaware River Basin Commission does not presently have a program by which it could provide sponsorship for further studies.

Our final report on the study will contain a statement on the limited availability of non-Federal sponsorship for further studies. It will also make the recommendation that no further action be taken by the Corps of Engineers under the current Survey Authority and that any studies of nonstructural protective measures for Bristol Township or other communities that are willing and able to sponsor such studies be pursued under the Continuing Authorities program.

In accordance with our continuing mutual coordination effort on this study, your concurrence in this recommendation is requested.

Sincerely,

Nicholas J. Barbieri, PE
Chief, Planning/Engineering Division

EXHIBIT A-8

DELAWARE RIVER BASIN COMMISSION
P.O. BOX 7360
WEST TRENTON, NEW JERSEY 08628

(609) 883-9500

GERALD M. HANSLER
EXECUTIVE DIRECTOR

HEADQUARTERS LOCATION
25 STATE POLICE DRIVE
WEST TRENTON, N.J.

August 7, 1984

Mr. Nicholas Barbieri, PE
Chief, Planning/Engineering Division
U. S. Army Corps of Engineers
Second and Chestnut Streets
Philadelphia, Pennsylvania 19106

Dear Mr. Barbieri:

We have reviewed the final draft report for the Delaware River Basin Study. It is unfortunate that full funding to implement the recommendations are not available from Federal or non-Federal sponsors.

It seems due to the economic guidelines followed in the study that the 12 communities listed portray the worst areas susceptible to flood losses. We hope the full recommendations of the study will be implemented to reduce the impact of floods on these communities.

We concur with the results of this study. We also concur with your proposed recommendation that no further action be taken by the Corps of Engineers under the current Survey Authority and that any further studies of nonstructural protective measures be pursued under the Continuing Authorities program.

Sincerely,

Gerald M. Hansler

EXHIBIT A-9

Planning Branch

MAR 21 1984

Mr. Kenneth L. Brewer, Jr.
Chairman of Supervisors
Lower Mt. Bethel Township
Municipal Building
Box 213R
Martins Creek, Pennsylvania 18063

Dear Mr. Brewer:

This is in reference to the findings of our latest analysis of flooding problems along the main stem Delaware River. This study, which was authorized by Congress, examined flood damage reduction alternatives for the section of the river from Stroudsburg, Pennsylvania, to Burlington, New Jersey. That area would have been provided with a degree of flood protection from the deferred Tocks Island Lake project.

Our analyses to date indicate that it would be economically feasible to implement non-structural measures that would reduce the degree of potential flood damages in portions of several communities. Non-structural measures proposed for a portion of your community and the costs and benefits associated with those measures are described in enclosures 1 and 2. The areas of your community where those measures would be applied are shown on enclosure 3. Also furnished, as enclosure 4, is a booklet on floodproofing measures.

Further detailed studies remain to be done before any non-structural measures could be implemented. The best vehicle to conduct those further studies is under the Corps' Continuing Authorities Program. However, those studies will not be pursued unless a non-Federal entity can be identified that is interested in sponsoring further studies. That agency must be legally and financially capable of satisfying certain local cooperation requirements.

At present, reconnaissance phase and feasibility phase study costs are 100 percent Federal. However, cost-sharing arrangements included in legislation currently under consideration by Congress, when and if implemented, will provide for the detailed planning to be cost-shared equally with a non-Federal sponsor. Enclosures 5, 6 and 7 are provided for information purposes only on the proposed study cost-sharing arrangements.

If you are interested in seeing our studies of non-structural floodproofing measures for your community continue and are willing and able to act as a non-Federal sponsor, please so indicate within 30 days of the receipt of this letter. A formal application (such as shown on enclosure 5) is not needed at this time. However, we would require a letter stating that your community is interested in the Corps' plan for utilizing non-structural measures to reduce flood damages. Your letter should also state that the municipality is willing and able to sponsor further studies.

Should you have any questions or wish to arrange a meeting to discuss this matter further, please feel free to contact Mr. Daniel E. Price, Chief of Basin Planning at 215/597-4684.

Sincerely,

Nicholas J. Barbieri, P. E.
Chief, Planning/Engineering Division

Enclosures

DELAWARE RIVER BASIN STUDY
NON-STRUCTURAL FLOOD DAMAGE REDUCTION MEASURES
DATA SHEET

NAME OF COMMUNITY: Lower Mount Bethel Township
Northampton County, PA

REQUIRED PROTECTIVE MEASURES* (FOR FURTHER DETAILS SEE ENCLOSURE 2): Minor Floodproof (1)
Individual Floodwalls (4)
Elevate (4)

* NUMBERS IN PARENTHESIS INDICATES NUMBER OF STRUCTURES INVOLVED.

ESTIMATED INITIAL IMPLEMENTATION COST* (MARCH 1983 PRICE LEVEL) $170,000

* BASED ON IMPENDING LEGISLATION, NON-FEDERAL SHARE SHALL BE GREATER OF 35% OF TOTAL COSTS OR VALUE OF LANDS, EASEMENTS, RIGHTS-OF-WAY AND RELOCATIONS REQUIRED FOR PROJECT.

ESTIMATED AVERAGE ANNUAL COST
(MARCH 1983 PRICE LEVEL) $13,000

ESTIMATED AVERAGE ANNUAL FLOOD REDUCTION BENEFITS
(MARCH 1983 PRICE LEVEL) $24,000

BENEFIT/COST RATIO: 1.8

ESTIMATED PERCENT AVERAGE ANNUAL FLOOD DAMAGE REDUCTION: 20%

LEVEL OF PROTECTION: 17YEAR EVENT (THE INTERIORS OF ALL BUILDINGS WOULD BE PROTECTED AGAINST DAMAGE FROM ALL FLOODS OCCURRING MORE FREQUENTLY THAN THIS EVENT)

ENCLOSURE 1

Minor Floodproofing - Mostly applied to structures with brick or masonary walls which are prone to basement seepage problems or nuisance type flooding. Generally involves the use of sealants for exterior and interior walls, valves to prevent sewer backup, sump pumps, and other methods of floor pressure relief.

Major Floodproofing - Applicable to structures where the level of protection varies from the basement floor elevation to three feet above the first floor. This type of protection includes temporary and permanent closures and shields for doorways and windows, large pumps, and hydrostatic protection. Considerations include the physical feasibility of closing all openings below the selected level of protection, the impermeability of exterior walls, and whether the structure is capable of withstanding the anticipated hydrostatic pressure including buoyancy.

Individual Floodwalls - Applicable to structures where the level of protection rises from the Zero Damage Elevation (ZDE) to a maximum of four feet above the first floor. Floodwalls are considered when minor and major floodproofing cannot be applied because the hydrostatic pressure directly against the walls causes possible slab uplift, wall collapse, and/or flooding.

Elevate Structure - Selected for structures where the level of protection varies from three feet to seven feet above the first floor. Although any structure can be raised it is more appropriate for single and two-story frame structures on raised foundations as opposed to structures with slab on grade foundations or structures with basements. Structure elevation is selected when economic, hydrostatic and/or aesthetic conditions warrant it.

Buy - Applicable to structures where the level of protection exceeds seven feet above the first floor. Buying a structure at market value does not include costs associated with relocation, such as new land or the actual relocation activity.

SAMPLE: CONTINUING AUTHORITIES PROGRAM
APPLICATION LETTER

(SPONSOR'S LETTERHEAD)

(date)

District Engineer
U. S. Army Engineer District, Philadelphia
Custom House, 2d & Chestnut Streets
Philadelphia, Pennsylvania 19106
ATTN: NAPEN-P

Dear Sir:

In accordance with the provisions of Section 205 of the 1948 Flood Control Act, as amended which authorizes the Secretary of the Army to construct small projects for flood control and related purposes not specifically authorized by Congress, when in the opinion of the Chief of Engineers such work is advisable, the

_____
(Sponsoring Agency)

hereby makes formal application for a study of

_____
(Waterway, County, State)

The _____
(Sponsoring Agency)

under authority contained in the Laws of _____
(State)

_____ can and will provide the
(cite pertinent statue)

following local cooperation and participation if studies indicate a project to be feasible.

We understand that this request implies a commitment on our part to participate in two types of cost sharing. The first of these involves study cost sharing and includes 50% of the costs for the Detailed Project Study. Of this 50% amount, up to one-half may be in the form of in-kind services.

ENCLOSURE 5

The second involves project cost sharing and shall be the greater of

a. 35% of the total costs after the Detailed Project Study or

b. the value of lands, easements, rights-of-way and relocations required for project construction.

Other specific requirements for consideration under Section 205 are to:

(1) Hold and save the United States free from damages due to the construction, operation and maintenance of the project, except for damages due to the fault or negligence of the United States or its contractors;

(2) Maintain and operate the project after completion in accordance with regulations prescribed by the Secretary of the Army;

(3) Assume full responsibility for all project costs in excess of the Federal cost limitation, presently established as $4,000,000;

(4) Prevent future encroachment which might interfere with proper functioning of the project for flood control;

(5) Contribute the local share of project construction costs, determined in accordance with existing policies for authorized projects, in view of recreational benefits, land enhancement benefits, or other special or local benefits expected to accrue;

(6) Comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P. L. 91-646) and implementing regulations; and

(7) Execute assurance of compliance with Title VI of the Civil Rights Act of 1964 (P. L. 88-352).

Sincerely,

Date_____

_____
Executive Officer of Sponsor

CERTIFICATION OF AUTHORITY

It is hereby certified that the ____(local sponsor)_____ has the authority to comply with the items of local cooperation as set forth in this letter.

Date_____

_____
Attorney or Chief Legal Officer of Sponsor

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS

STATEMENT OF LT. GENERAL J.K. BRATTON
CHIEF OF ENGINEERS
U. S. ARMY CORPS OF ENGINEERS
BEFORE THE SUBCOMMITTEE ON ENERGY AND WATER DEVELOPMENT
COMMITTEE ON APPROPRIATIONS
HOUSE OF REPRESENTATIVES
ON THE FY 1985 CIVIL WORKS BUDGET

FEBRUARY 6, 1984

Continuing Authorities Program

The Small Projects Program under Construction, General is designed for quick response in assisting local interests to solve their water problems. As Mr. Gianelli discussed, the program was restructured, and all the modified procedures are in place. These procedures provide a detailed and orderly process from the time a small flooding, beach erosion or navigation problem is identified. For example, our objective is to provide all planning funds to the District Engineer as soon as he requests them for both the reconnaissance and detailed project study phases, and for preparation of plans and specifications.

One other point. We reduced our FY 1983 backlog of small projects available for construction, utilizing funds from the FY 1983 Jobs Bill. In the aggregate, we completed, placed under construction, or scheduled for construction over 100 small projects utilizing about $26 million of those funds. As a result, I believe that the $36.7 million requested for FY 1985, up almost $12 million from FY 1984, will be sufficient to provide a good continuing requirements for 12 of the FY 1983 and FY 1984 budgeted new construction starts that are on hold, pending FY 1984 Congressional action, and five commercial harbor projects for which additional engineering and design is continuing. Funding of the new construction starts reflects the cost sharing and financing proposals worked out between the local sponsors and the Department of the Army.

DEPARTMENT OF THE ARMY

OFFICE OF THE ASSISTANT SECRETARY OF THE ARMY (CIVIL WORKS)

COMPLETE STATEMENT

OF

WILLIAM R. GIANELLI

ASSISTANT SECRETARY OF THE ARMY (CIVIL WORKS)

BEFORE THE SUBCOMMITTEE ON ENERGY AND WATER DEVELOPMENT

COMMITTEE ON APPROPRIATIONS

HOUSE OF REPRESENTATIVES

ON THE FY 1985 CIVIL WORKS BUDGET

FEBRUARY 6, 1984

XI. CONTINUING AUTHORITIES PROGRAM

General Bratton testified last year concerning efforts to restructure the Continuing Authorities Program. This has now been accomplished. The restructured program features a five-step process: (1) initial appraisal; (2) reconnaissance phase; (3) detailed planning phase; (4) plans and specifications; and (5) project implementation. The first two steps are to be accomplished at full Federal expense; the third step would be shared equally between the Corps and a non-Federal entity, and the last two would be shared on the same basis as a comparable, specifically authorized large project.

Management of the restructured Continuing Authorities Program is analogous to that of congressionally authorized studies and projects. The goal is the same: a more effective and efficient planning process and a more effective use of planning and construction funds.

We are requesting $36.7 million in FY 1985 for new and/or continuing planning and construction under the six individual programs. These funds will allow the Corps to be responsive to the priority water needs of local communities.

ARMY CIVIL WORKS PROGRAM

FY 1985 NEW STARTS PROGRAM SUMMARY: UPFRONT NON-FEDERAL FINANCING OBJECTIVES AND RECOMMENDATIONS

CATEGORY	NON-FEDERAL SHARE OF ASSIGNED FIRST COSTS (1)	ARMY RECOMMENDS THAT OMB (2)
SMALL CONTINUING AUTHORITIES PROGRAM		
Flood Control (Sections 205 and 208)....	35 percent or the value of lands, easements, rights-of-way and relocations required for project construction, whichever is greater.	
Navigation (Section 107).....	100 percent, with 75 percent upfront.	
Beach Erosion (Section 103)..	50 percent upfront.	
Navigation Mitigation (Section 111).	No policy established.	
Emergency Work (Section 14)..	Same as traditional (lands, easements, and rights-of-way).	

LIST OF PARTICIPANTS [illegible] LETTERS SIMILAR TO EXHIBIT A-9

DELAWARE RIVER BASIN STUDY
LOCAL INTERESTS

PENNSYLVANIA

Ms. Carolyn Sabatini
Chairman of Supervisors
Bridgeton Township
Upper Black Eddy Fire Hall
Upper Black Eddy, PA 18972

Mr. Stanley Gawel
Manager
Bristol Borough Municipal Building
Pond & Mulberry Streets
Bristol, PA 19007

Mr. Robert Lewis, Jr.
President of Commissioners
Bristol Township
Township Building
2501 Oxford Valley Rd.
Levittown, PA 19057

Mr. Kenneth L. Brewer, Jr.
Chairman of Supervisors
Lower Mt. Bethel Township
Municipal Building Box 213R
Martins Creek, PA 18063

Mr. Jay P. Snyder
Mayor
New Hope Borough
Borough Hall
41 N. Main Street
New Hope, PA 18938

Mr. James B. Kiel, Jr.
Chairman of Supervisors
Plumstead Township
P. O. Box 14
Fountainville, PA 18923

Mr. Frank H. Lewis
Chairman of Supervisors
Tinicum Township
R. D. 1, Box 326
Pipersville, PA 18947

NEW JERSEY

Mr. Robert Breen
Mayor
Delanco Township
Municipal Building
Burlington Ave.
Delanco, NJ 08075

Mr. John R. Rafferty
Mayor
Hamilton Township
2090 Greenwood Avenue
Trenton, NJ 08650

Mr. Arthur Schwarz
Mayor
Harmony Township
R. D. 2, Box 155
Phillipsburg, NJ 08865

Mr. John B. DiSarro
Mayor
Holland Township
R. D. 1, Box 112A
Church Road
Milford, New Jersey 08848

Mr.Robert E. Renshaw
Mayor
Riverside Township
P. O. Box 188
Riverside, NJ 08075

EXHIBIT A-11

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
Planning Branch

APR 02 1984

Dr. Harold Colburn
Freeholder Director
Burlington County Office Building
49 Rancocas Road
Mount Holly, New Jersey 08060

Dear Dr. Colburn:

This is in reference to the findings of our latest analysis of flooding problems along the main stem Delaware River. This study, which was authorized by Congress, examined flood damage reduction alternatives for the section of the river from Stroudsburg, Pennsylvania, to Burlington, New Jersey. That area would have been provided with a degree of flood protection from the deferred Tocks Island Lake project.

Our analyses to date indicate that it would be economically feasible to implement non-structural measures that would reduce the degree of potential flood damages in portions of several communities including two townships in Burlington County. They are Delanco Township and Riverside Township. Further detailed studies remain to be done before any non-structural measures could be implemented. The best vehicle to conduct those further studies is under the Corps' Continuing Authorities Program. However, those studies will not be pursued unless a non-Federal entity can be identified that is interested in sponsoring further studies.

This office has sent a letter to the Mayor of each of those townships informing them of our findings and asking for an indication of interest in sponsoring further studies. A copy of our letter to the Mayor, with all enclosures, is furnished for your information.

That letter with enclosures explains the type of non-structural measures involved and the associated costs and benefits. It also provides information on sponsorship requirements. If the Township should decline to sponsor further studies, the opportunity would be offered to the County.

Should you have questions or wish to arrange a meeting to discuss this letter further, please feel free to contact Mr. Daniel E. Price, Chief of Basin Planning at 215/597-4684.

Sincerely,

Nicholas J. Barbieri, PE
Chief, Planning/Engineering Division

Enclosures

DELAWARE RIVER BASIN STUDY
COUNTY OFFICIALS

PENNSYLVANIA

Mr. Carl Fonash
Chairman of Commissioners
Bucks County
Administration Building
Doylestown, Pennsylvania 18901

Mr. Eugene Hartzell,
County Executive
Northampton County
Government Center
7th & Walnut Streets
Easton, Pennsylvania 18042

NEW JERSEY

Dr. Harold Colburn
Freeholder Director
Burlington County
Burlington County Office Building
49 Rancocas Road
Mount Holly, New Jersey 08060

Mr. George D. Muller
Freeholder Director
Hunterdon County
Administration Building
Flemington, New Jersey 08822

Dr. William Klepper
President of Board
Mercer County
Mercer County Administration Building
P. O. Box 8068
Trenton, New Jersey 08650

Mr. Charles Lee
Freeholder Director
Warren County
Court House
Belvidere, New Jersey 07823

Township of Bristol

BUCKS COUNTY • PENNSYLVANIA

April 12, 1984

Mr. Nicholas J. Barbieri, P.E.
Chief, Planning/Engineering Division
Department of the Army
Philadelphia District, Corps of Engineers
Custom House-2D & Chestnut Streets
Philadelphia, PA 19106

Dear Mr. Barbieri:

Please be advised that the Board of Commissioners are much interested in seeing your studies of non-structural floodproofing measures for our community. We continue and are willing and able to act as a non-Federal Sponsor. We are also able to sponsor further studies as outlined in your letter and enclosures.

On behalf of the Board of Commissioners, thank you for your interest in our community.

Sincerely,

Stanley P. Gawel
Township Manager

SPG/aw

2501 OXFORD VALLEY ROAD • LEVITTOWN, PA 19057 • (215) 785-0500

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
Planning Branch

Mr. Carl Fonash
Chairman of Commissioners
Bucks County
Administration Building
Doylestown, Pennsylvania 18901

Dear Mr. Fonash:

This is in reference to our April 2, 1984 letter regarding non-Federal sponsorship of further studies of flood damage reduction measures along the main stem Delaware River. In response to our letters to the officials of Bridgeton, Bristol, Plumstead and Tinicum Townships and to the officials of Bristol and New Hope Boroughs; we received a letter from Bristol Township indicating that they would act as a non-Federal sponsor. Officials of the other townships and boroughs have indicated that those communities would not so act. As stated in our previous letter, if the townships and boroughs declined to act as non-Federal sponsors, the opportunity would be offered to the county.

If the county is interested in seeing studies of non-structural flood damage reduction measures continue and is willing and able to act as a non-Federal sponsor of such studies, it is requested that this office be advised within 30 days of receipt of this letter. At this time, a formal application is not needed; however, we would require a letter stating that Bucks County is interested in the Corps' plan for utilizing non-structural measures to reduce flood damages. Your letter should also state that the county is willing and able to sponsor further studies.

Should you have any questions or wish to arrange a meeting to discuss this matter further, please feel free to contact Dr. John A. Burnes, Chief of Planning Branch at 215/597-5951.

Sincerely,

Nicholas J. Barbieri, PE
Chief, Planning/Engineering Division

EXHIBIT A-15

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
Planning Branch

MAY 14 1984

Dr. Harold Colburn
Freeholder Director
Burlington County Office Building
49 Rancocas Road
Mount Holly, New Jersey 08060

Dear Dr. Colburn:

This is in reference to our April 2, 1984 letter regarding non-Federal sponsorship of further studies of flood damage reduction measures along the main stem Delaware River. The Township Administrators of both Delanco and Riverside Townships have indicated that they would not act as non-Federal sponsors for further studies. As stated in our previous letter, if the Townships declined to sponsor further studies, the opportunity would be offered to the County. If Burlington County is interested in seeing studies of non-structural flood damage reduction measures continue and is willing and able to act as a non-Federal sponsor of such studies, it is requested that this office be so advised within 30 days of receipt of this letter. At this time, a formal application is not needed, however, we would require a letter stating that Burlington County is interested in the Corps' plan for utilizing non-structural measures to reduce flood damages. Your letter should also state that the county is willing and able to sponsor further studies.

Should you have any questions or wish to arrange a meeting to discuss this matter further, please feel free to contact Dr. John Burnes, Chief of Planning Branch at 215/597-5951.

Sincerely,

Nicholas J. Barbieri, PE
Chief, Planning/Engineerinng Division

A-16

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
Planning Branch

MAY 14 1984

Mr. George D. Mueller
Freeholder Director
Hunterdon County
Administration Building
Flemington, New Jersey 08822

Dear Mr. Mueller:

This is in reference to our April 2, 1984 letter regarding non-Federal sponsorship of further studies of flood damage reduction measures along the main stem Delaware River. The clerk of Holland Township has indicated that the township would not act as a non-Federal sponsor for further studies. As stated in our previous letter, if the township declined to sponsor further studies the opportunity would be offered to the county.

If the county is interested in seeing studies of nonstructural flood damage reduction measures continue and is willing and able to act as a non-Federal sponsor of such studies, it is requested that this office be advised within 30 days of receipt of this letter. At this time, a formal application is not needed; however, we would require a letter stating that Hunterdon County is interested in the Corps' plan for utilizing nonstructural measures to reduce flood damages. Your letter should also state that the county is willing and able to sponsor further studies.

Should you have any questions or wish to arrange a meeting to discuss this matter further, please feel free to contact Dr. John A. Burnes, Chief of Planning Branch at (215) 597-5951.

Sincerely,

Nicholas J. Barbieri, P. E.
Chief, Planning/Engineering Division

EXHIBIT A-17

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
Planning Branch

Dr. William Klepper
President of Board, Mercer County
Mercer County Administration Building
P. O. Box 8068
Trenton, New Jersey 08650

Dear Dr. Klepper:

This is in reference to our April 2, 1984 letter regarding non-Federal sponsorship of further studies of flood damage reduction measures along the main stem Delaware River. Mr. John DiMemmo, the head engineer for Hamilton Township, has indicated that the township would not act as a non-Federal sponsor for further studies. As stated in our previous letter, if the township declined to sponsor further studies the opportunity would be offered to the county.

If the county is interested in seeing studies of non-structural flood damage reduction measures continue and is willing and able to act as a non-Federal sponsor of such studies, it is requested that this office be advised within 30 days of receipt of this letter. At this time, a formal application is not needed; however, we would require a letter stating that Mercer County is interested in the Corps' plan for utilizing non-structural measures to reduce flood damages. Your letter should also state that the county is willing and able to sponsor further studies.

Should you have any questions or wish to arrange a meeting to discuss this matter further, please feel free to contact Dr. John Burnes, Chief of Planning Branch at 215/597-5951.

Sincerely,

Nicholas J. Barbieri, PE
Chief, Planning/Engineering Division

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
Planning Branch

MAY 14

Mr. Eugene Hartzell
County Executive
Northampton County
Government Center
7th & Walnut Streets
Easton, Pennsylvania 18042

Dear Mr. Hartzell:

This is in reference to our April 2, 1984 letter regarding non-Federal sponsorship of further studies of flood damage reduction measures along the main stem Delaware River. Mr. Robert Taylor, Zoning Officer of Lower Mt. Bethel Township, has indicated that the township would not act as a non-Federal sponsor for further studies. As stated in our previous letter, if the township declined to sponsor further studies the opportunity would be offered to the county.

If the county is interested in seeing studies of non-structural flood damage reduction measures continue and is willing and able to act as a non-Federal sponsor of such studies, it is requested that this office be advised within 30 days of receipt of this letter. At this time, a formal application is not needed; however, we would require a letter stating that Northampton County is interested in the Corps' plan for utilizing non-structural measures to reduce flood damages. Your letter should also state that the county is willing and able to sponsor further studies.

Should you have any questions or wish to arrange a meeting to discuss this matter further, please feel free to contact Dr. John A. Burnes, Chief of Planning Branch at 215/597-5951.

Sincerely,

Nicholas J. Barbieri, PE
Chief, Planning/Engineering Division

EXHIBIT A-19

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
Planning Branch

MAY 1

Mr. Charles Lee
Freeholder Director
Warren County
Court House
Belvidere, New Jersey 07823

Dear Mr. Lee:

This is in reference to our April 2, 1984 letter regarding non-Federal sponsorship of further studies of flood damage reduction measures along the main stem Delaware River. The Mayor of Harmony Township has indicated that the township would probably not act as a non-Federal sponsor for further studies. As stated in our previous letter, if the township declined to sponsor further studies the opportunity would be offered to the county.

If the county is interested in seeing studies of nonstructural flood damage reduction measures continue and is willing and able to act as a non-Federal sponsor of such studies, it is requested that this office be advised within 30 days of receipt of this letter. At this time, a formal application is not needed; however, we would require a letter stating that Warren County is interested in the Corps' plan for utilizing nonstructural measures to reduce flood damages. Your letter should also state that the county is willing and able to sponsor further studies.

Should you have any questions or wish to arrange a meeting to discuss this matter further, please feel free to contact Dr. John A. Burnes, Chief of Planning Branch at (215) 597-5951.

Sincerely,

Nicholas J. Barbieri, P. E.
Chief, Planning/Engineering Division

TOWNSHIP OF DELANCO

MUNICIPAL BUILDING
DELANCO, NEW JERSEY 08075

OFFICE OF THE CLERK 461-0561

Army Corp. of Engineers
Custom House
2nd and Chestnut St.
Philadelphia, Pa. 19106
Attn: Burns

May 17, 1984

Dear Mr. Burns:

Your proposal for a flood control project was discussed as a matter of the township committee on May 7, 1984. After a review of the project it was determined by the Township Committee of the Township of Delanco that although this project was a worthy project budget constraints as well as the timing of the project make such an undertaking impossible at this time. If you have any questions on this matter please do not hesitate to call.

Sincerely,

Jeffrey S. Latcher
Administrator

OFFICE OF THE COUNTY ENGINEER

COUNTY ROAD AND BRIDGE DEPARTMENT
ADMINISTRATION BUILDING
FLEMINGTON, NEW JERSEY - 08822

DAVID W. STEM, P.E.
County Engineer
JOHN P. GLYNN
Superintendent of Bridges
WILLIAM W. WINTER
County Road Supervisor

(201) 782-4300
Ext. 227
Ext. 227
Ext. 178

May 21, 1984

Mr. Nicholas J. Barbieri, P. E.
Chief, Planning/Engineering Division
Department of the Army
Philadelphia District, Corps of Engineers
Custom House-2 D & Chestnut Streets
Philadelphia, Pennsylvania 19106

RE: Flood Damage Reduction Measures
Delaware River
Township of Holland

Dear Mr. Barbieri:

Please be advised that your correspondence concerning the above captioned matter has been referred to this office.

Having reviewed the matter and discussed it with our County Planning Staff, it is my opinion and recommendation that the County should not become directly involved with the program. I would, however, like to take this opportunity to offer the following comment and suggestions:

Although government has generated a great wealth of information which needs to be disseminated, it appears that the program participants should be individual home or property owners-not government.

In the future, consideration should be given to developing a low cost mailer which could be sent to owners within any delineated areas. In addition to summarizing the benefits and cost effectiveness of low cost waterproofing, it could direct interested people on where to get more detailed information; i.e., copies of the booklet "Introduction to Flood Proofing-An Outline of Principles and Methods."

May 21, 1984

Mr. Nicholas J. Barbieri, P. E.
Chief, Planning/Engineering Division
Department of the Army

For your information, I have enclosed copies of the appropriate section of the Holland Township Tax Map and Owners Listings.

Very truly yours,

David W. Stem, P. E.

DWS:mrg

CC: George D. Muller, Freeholder Director
John W. Kellogg, Planning Director

Enclosures

EXHIBIT A 22

COUNTY OF BUCKS

OFFICE OF THE COMMISSIONERS

Administration Building, Doylestown, Pa. 18901

215-348-2911 215-752-0281

June 7, 1984

Mr. Nicholas Barbieri, P.E.
Chief, Planning/Engineering Division
U.S. Army, Corps of Engineers
Custom House, 2nd and Chestnut Streets
Philadelphia, Pa. 19106

RE: Nonstructural Alternatives for Delaware River Flood Control

Dear Mr. Barbieri:

The County of Bucks concurs with your conclusion that local government can better administer and implement the types of nonstructural flood damage reduction measures proposed by your study. If the local governing bodies do not believe that your program is necessary, we do not intend to intercede.

Very truly yours,

Carl F. Fonash

Carl F. Fonash, Chairman
Board of Commissioners

CFF/cg

cc: Robert E. Moore

EXHIBIT A 27

COUNTY PLANNING OFFICE
WARREN COUNTY
BELVIDERE, NEW JERSEY 07823

RUSSELL A. MILES
PLANNING DIRECTOR

PHONE: 201-475-5361
EXT. 235

June 21, 1984

Nicholas J. Barbieri, P. E.
Planning Branch
Philadelphia District, Corp of Engineers
Custom House-2 D & Chestnut Streets
Philadelphia, Pennsylvania 19106

Dear Mr. Barbieri:

This is to inform you that the Warren County Board of Chosen Freeholders did not act on the matter of non-Federal sponsorship of further study of flood damage reduction in Harmony Township.

The Freeholders were advised by the County Planning Board not to sponsor further studies. The Planning Board believed that the estimated costs were to high given the small number of structures to be studied and the flood level they were to be protected to.

Should you have any further questions, please feel free to contact me.

Very truly yours,

Anthony J. DePrima
Assistant Planner

AJP/sp

EXHIBIT A-24

(215) 258-4717

(201) 454-3080

C. DOUGLAS CHERRY & ASSOCIATES

A Professional Association

CONSULTING ENGINEERS - PLANNERS

55 South Main Street Phillipsburg, N J 08865

July 5, 1984

Nicholas J. Barbieri, P.E.
Chief, Planning/Engineering Division
U. S. Army Corps of Engineers
Custom House
Second and Chestnut Streets
Philadelphia, Pennsylvania 19106

Re: Flood Studies
Harmony Township
Warren County, New Jersey
NJ-W-HM-122

Dear Mr. Barbieri:

The Harmony Township Committee at its June 5, 1984 meeting discussed your letter of March 23, 1984 to Mayor Arthur Schwarz concerning the Township's participation in the Corps' continuing authorities program. The Committee determined that it does not desire to participate in the program and has asked me to communicate with you concerning their decision.

The Committee will not participate for the following reasons:

1) The obligation to repair or restore buildings demaged by flooding is not presently an obligation of Harmony Township but one which the State and Federal Governments have assumed. The Township cannot undertake any additional responsibilities at this time.

2) The Township does not have the financial resources to expend an estimated $30,000 for the Study Phase in addition to $50,000 - $60,000 for the Implementation Phase. It further cannot enter into a program that does not have a ceiling attached to it.

3) The Township cannot guarantee funding of its maintenance responsibility.

4) Although the project has a Cost-Benefit Ration of 1.8 the Township will not gain from the benefit and consequently cannot expect to recapture its investment.

5) The ten year recurrence interval level of protection will open the Township to demands by unprotected property owners damaged by an event of greater than 10 year recurrences.

In summary the Township views this as an open ended program at all phases of its operation and cannot financially commit itself to such an undertaking.

If you have any questions regarding this matter, please do not hesitate to contact our office.

Very truly yours,

C. DOUGLAS CHERRY & ASSOCIATES, P.C.

Douglas M. Mace, P.E.

DMM/rd

cc: Mrs. Loyce Johnson, Clerk Harmony Township
Mayor Arthur C. Schwarz
Ms. Maureen E. Babula, Committee Member
Mr. J. Richard Collins, Committeeman
James A. Tirrell, Jr., Esq.