

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	
<u>Structural</u>	<u>Madigan-Praeger 1/</u>	<u>House Document No. 522 2/</u>
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.
<u>Non-Structural</u>		
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 occupancy 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	
	<u>Madigan-Praegerl/</u>	<u>House Document No. 522^{2/}</u>
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 undoubtedly 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