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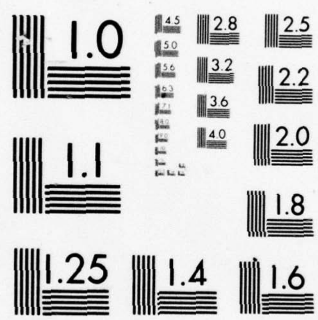
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HEC-SP-08

PROCEEDINGS OF A SEMINAR ON NONSTRUCTURAL FLOOD PLAIN MANAGEMENT MEASURES Held on

4-6 MAY 1976, at Davis, California

11 May 76

Kenneth E./McIntyre, Gary D./Cobb,
Frank H./Thomas, G. Edward/Dickey
Donald B./Duncan

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THE HYDROLOGIC ENGINEERING CENTER

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These seminar proceedings contain 16 papers presented on 4-6 May 1976 at The Institute for Water Resources at Fort Belvoir, Virginia. The papers pertain to a variety of technical, institutional and political problems associated with implementation of nonstructural flood plain management measures. Titles and authors of papers are as follows:

(see next page)

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Introductory Remarks	Kenneth E. McIntyre
A Unified National Program for Flood Plain Management	Gary D. Cobb Frank H. Thomas
Nonstructural Flood Control Planning: Policy Issues in Plan Formulation, Evaluation and Implementation	G. Edward Dickey Donald B. Duncan
Implementing Nonstructural Flood Control Measures in the Local Community	L. Douglas James
Real Estate Policy in Nonstructural Flood Control Planning	E. L. Ingram, Jr.
Screening for Nonstructural Alternatives in the Susquehanna River Basin	Harold L. Nelson
Considerations for "Nonstructural" Flood Control Planning in the Pacific Ocean Division	John R. Pelowski
A Case Study of Nonstructural Measures Considered for Southwestern Jefferson County, Kentucky	Ralph D. Reid
Implementation of Nonstructural Measures - Some Examples	James E. Goddard
Experiences with Nonstructural Measures in the New England Division	Lawrence J. Bergen
Nonstructural Planning Alternatives The South Atlantic Division's Experience	Shelton R. McKeever
Review of Baytown, Texas Evacuation Plan	Carl O. Foley
Analysis of Relationship of Federal Flood Insurance with Evacuation Plan for Burnett, Crystal, and Scott Bays and Vicinity, Bayton, Texas	Frank G. Incaprera
Indian Bend Wash Greenbelt A City of Scottsdale, Arizona Achievement	Charles Ruiz
Analytical Tools in Planning Nonstructural Flood Control Measures	Darryl W. Davis
Flood Proofing at Logan, Ohio and the Flood Hazard Factor	Richard E. McCoy
Great Lakes Open-Coast Flood Levels	L. T. Schutze
Overview of Seminar Issues	James Tang

PROCEEDINGS OF A SEMINAR
ON
NONSTRUCTURAL FLOOD PLAIN MANAGEMENT MEASURES

4-6 May 1976

Co-sponsored by

The Hydrologic Engineering Center
U S Army Corps of Engineers
609 Second Street
Davis, California 95616

Institute for Water Resources
U S Army Corps of Engineers
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Fort Belvoir, Virginia 22060

FOREWORD

Effective flood plain management utilizes the best available means for reducing flood hazards. Traditionally, so called structural measures - levees, reservoirs, flood walls, channel modifications - have been constructed. In recent years other measures, referred to as nonstructural - flood proofing, evacuation, land use acquisition and regulation, flood preparedness - have been implemented. Together they offer a wide range of opportunities to reduce flooding along our Nation's rivers and streams. Our experience in formulating and implementing plans which utilize combinations of these measures is growing as field level planners, policy and review personnel, and researchers seek to resolve various technical, institutional, and political problems. This seminar was organized to bring together persons working on these problems, to have them report on some of the work which has recently been completed or is underway, and to have them help identify issues which deserve attention in the future.

The seminar was sponsored jointly by The Hydrologic Engineering Center and Institute for Water Resources and was held at the Institute at Fort Belvoir, Virginia, 4-6 May 1976. The papers included here were presented at the seminar and are in general, frank discussions by the authors. They are not official Corps documents, nor are they intended to modify or replace official guidance or directives such as engineer regulations, manuals, circulars or technical letters issued by the Office of the Chief of Engineers.

CONTENTS

Page

INTRODUCTORY REMARKS

BRIGADIER GENERAL KENNETH E. McINTYRE
DEPUTY DIRECTOR OF CIVIL WORKS
OFFICE OF THE CHIEF OF ENGINEERS
DEPARTMENT OF THE ARMY, WASHINGTON, D. C.
before the
JOINT INSTITUTE FOR WATER RESOURCES HYDROLOGIC ENGINEERING CENTER
SEMINAR ON NONSTRUCTURAL FLOOD CONTROL PLANNING
4 MAY 1976
Fort Belvoir, Virginia

I am pleased to speak to you this morning on behalf of General Graves, Director of Civil Works. One of the Corps' most pressing problems today is the development of sound policies and procedures for carrying out non-structural flood control planning. Your seminar will be covering most of the ingredients to these policies and procedures. The seminar is timely because we in OCE are still in the process of formulating guidance to the field on nonstructural measures in planning and welcome the discussions that will take place over the next three days as input into our decision-making process.

Much of the material you will be covering has been the result of a joint HEC/IWR effort over the past year. I think this is an excellent example of these two research organizations working together. I'm glad you are now taking the time to bring some attention to this area by holding this session in Washington.

While we have not yet issued detailed guidance on implementing the well-known Section 73, Public Law 93-251, the Chief of Engineers has most definitely established a policy of consideration of nonstructural measures in reducing the Nation's flood damages.

Be assured that the Chief, and the Chairman of the Board of Engineers for Rivers and Harbors, expect to see in each and every planning report a full discussion and supporting data on nonstructural measures. This includes reports submitted to OCE for approval and those which will be sent to Congress for authorization.

The field planner is in a dilemma. On the one hand, I have admitted our inability to give him detailed guidance on formulating and evaluating nonstructural measures, while on the other hand, we are requiring him to show how he considered such alternatives in his reports. The dilemma gets worse if the planner's evaluation of the nonstructural measures show them to be superior to structural measures. OCE has not given him a cost sharing policy. To the contrary, we have told him to not recommend any cost sharing for nonstructural measures, but to obtain local support for them anyway.

Corps planners are resourceful. Where there is a will, there is a way. For the New England Division, the way led to the Charles River project; for the St. Paul District, the Prairie du Chien project. These seminar proceedings may well lead the way for future reports and future Federal participation in solving our nation's flood problems with modern day approaches. The Congress has provided us the support to look at non-structural measures, and we are committed to not only comply with the law but also to do the best job of planning we can for the people. I challenge you to overcome the numerous obstacles in your way and to take the initiative that the Congress and the Chief have offered you.

I have brought two members of the OCE Civil Works staff with me today to provide a discussion on the policy aspects of nonstructural flood control planning. Mr. Berge, Director of Real Estate is also here to provide us some insights into the real estate aspects of nonstructural solutions. I would like to briefly point out the role of each of the two Civil Works staff participants in this morning's discussion.

Ken Murdock will be bringing you up to date on the problems confronting OCE, since the enactment of Section 73, which have not permitted the issuance of detailed guidance on Corps implementation of the provisions of that law. Ken is the Alternate Army representative to the Council of Representatives of the Water Resources Council, among his other duties in the Office of Policy. He has been very much involved in the discussions with the Office of the Assistant Secretary of the Army for Civil Works and the Office of Management and Budget on The Section 80 Study and on implementation of Section 73.

Tom Whitman, Chief of the Program Management Branch of the Planning Division in OCE will be discussing some problems we have encountered in the drafting of a regulation on implementing Section 73, particularly those which relate to formulating and evaluating nonstructural alternatives. Alex Shwaiko, Chief of the Planning Division was unable to address you this morning due to other commitments, but I know that he is most interested in the discussions which will take place over the next three days.

I also see a number of other OCE personnel in the audience who are anxiously awaiting the answers to questions for which they have been unable to get answers for the past year.

Corps planners are not the only people who want answers. The Chief of Engineers recently received a letter from the Division of Water Resources of the Illinois Department of Transportation, urging prompt publication and execution of guidelines for nonstructural flood protection measures to solve a number of flood problems in Illinois which may not otherwise be solved. From what I have seen, you have strong public support for fully considering nonstructural measures as an integral part of your planning. Not only from the State of Illinois, but from a number of conservation organizations who have communicated with our office in the past year. The public can probably do a good job in providing you guidance on formulating and evaluating nonstructural alternatives. Just give them the chance.

How do you give them the chance? By showing equality in presenting alternatives to problems the Corps has traditionally handled in only one or two ways. In fact, take the risk, when the occasion is right, to even show some bias toward nonstructural alternatives and comprehensive flood-plain management rather than traditional structural solutions to local flood problems. Do your homework - then educate the public. Get the assistance of other agencies who are also charged with the responsibility of protecting the health and welfare of the people, such as HUD. And get the engineers in our District offices interested in the opportunities for solving flood problems with other than levees and channels.

I am not asking you to give up our well deserved reputation for getting the job done and solving the problem. I am asking you, and the Congress and the Chief have directed you, to not recommend structural flood control solutions until you have thoroughly investigated nonstructural alternatives. Listen well over the next three days, for this may well be all the guidance you may get for some time to come.

Thank you for having me open this important seminar. I too will be listening well and look forward to receiving a copy of the proceedings.

A UNIFIED NATIONAL PROGRAM FOR FLOOD PLAIN MANAGEMENT

Comments of Gary D. Cobb and Frank H. Thomas [1]/

Mr. Cobb and I are delighted with the opportunity to participate in the Corps' Seminar on Non-Structural Flood Control Planning and to share with you the results of an intensive effort by the Water Resources Council (WRC) to develop a flood plain management package that would harness together and give common direction to the vast array of Federal, State and local programs affecting the Nation's flood plains. As you know, the Council consists of eight cabinet level members and the Department of the Army has played a central role in the development of the flood plain management package. Several people from the Corps who have been major contributors to the Council's effort are here today - General McIntyre, Ken Murdock, and George Phippen. Gentlemen, we greatly appreciate your efforts and those of your colleagues.

In this paper, the historical background to the flood plain management package will be reviewed and the Unified National Program for Flood Plain Management and its associated Executive order will be briefly described to set a context for discussion of non-structural flood control planning.

Historical Background

The flood plain management package to which I alluded is composed of two parts - the report "A Unified National Program for Flood Plain

1/Mr. Cobb is Deputy Director and Dr. Thomas is Staff Specialist, United States Water Resources Council.

Management," and "Executive Order 11296, Revised." The origin of each of these documents can be traced back to the 1966 Federal Task Force on Federal Flood Control Policy which drafted House Document 465, entitled: "A Unified National Program for Managing Flood Losses."[2/] Included amon the recommendations of the Task Force were a Presidential Executive Order directing Federal agencies to carry out flood hazard evaluations and for Congressional enactment of a National Flood Insurance Program. In response, Executive Order 11296[3/] (Flood Hazard Evaluation) was issued in 1966 and Congress passed the National Flood Insurance Act of 1968[4/] which among other things directed the President to prepare a Unified National Program for Flood Plain Management.

The task of preparing a unified program was given to WRC and draft reports were completed in 1972, 1973, and June 1975. These drafts proved unacceptable to the Council or to the Office of Management and Budget (OMB). The 1975 draft was considered deficient because of inadequate development of the Federal role in flood plain management.

2/ Task Force on Federal Flood Control Policy. A Unified National Program For Managing Flood Losses, House Document 465, 89th Congress, 2nd Session (August, 1966). U.S. Government Printing Office, Washington, D.C.

3/ The President. Executive Order 11296, Evaluation of Flood Hazard in Locating Federally Owned or Financed Buildings, Roads, and Other Facilities, and in Disposing of Federal Lands and Properties. (The Federal Register, Vol. 31, No. 155--Thursday, August 11, 1966.)

4/ Section 1302 (c), P. L. 90-448, as amended.

Executive Order 11296 directed the heads of Federal agencies to evaluate flood hazards and take action to preclude the uneconomic, hazardous or unnecessary use of flood plains. In March, 1975 the Comptroller General reported to Congress that Federal agencies did not evaluate flood hazards adequately.[5]

Thus, by mid 1975 it was apparent that revision and strengthening of the Executive order and the Unified National Program draft report were needed. A strategy was adopted to couple revision of the Executive order with the redrafting of the Unified National Program into a single package with the Executive order assuming the added function of becoming the device through which the Unified National Program would be implemented. This package is the focus of the ensuing discussion.

A Unified National Program for Flood Plain Management[6]

The Unified National Program consists of five sections which: (a) provide a conceptual framework for decisionmakers, (b) summarize basic strategies and tools for flood loss reduction, (c) review develop-

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5/Comptroller General of the United States. National Attempts to Reduce Flood Losses From Floods by Planning For and Controlling the Uses of Flood-Prone Lands. Washington, D. C., General Accounting Office, March 7, 1975. 74p.

6/Water Resources Council. COM Agenda, Item M-76-7, Appendix Item 7B. April 1, 1976.

ments in flood plain management 1966-76, (d) examine the implementation capability of existing Federal and State institutions, and (e) provide recommendations for achieving a unified program. Flood plain management is defined broadly to include planning, decisionmaking implementation and evaluation as parts of a management process.

The Conceptual Framework consists of sets of general and working principles for the guidance of flood plain decisionmakers. The four general principles set the context for management decisions. First, it must be recognized that although the Federal Government has a fundamental interest, the basic responsibility for regulating flood plains lies with State and local governments.

Second, the flood plain must be considered a definite area of interrelated water and land to be managed within the context of its community, its region, and the Nation.

Third, flood loss reduction must be viewed as one of several management considerations which must be addressed in planning for economic efficiency and environmental quality.

Fourth, sound flood plain management is built upon the following premises:

(a) The goals of flood plain management are defined as wise use, conservation, development, and planning of interrelated land and water resources;

(b) Future needs and the role of the flood plain must be understood in the context of both the physical and the socio-economic systems of which it is a part;

(c) All strategies for flood loss alleviation must be given equal consideration for their individual or combined effectiveness;

(d) There must be full accounting for all benefits and costs and for interrelated impacts likely to result from flood plain management actions;

(e) All positive and negative incentives must be utilized to motivate individuals making decisions influencing the flood plain;

(f) Government programs must be coordinated at and between all levels of government as well as among the different areas of flood plain management;

(g) There must be on-going evaluation of management efforts with periodic reporting to the public.

The working principles consist of definitions and statements of relationships supportive of the general principles.

Strategies and Tools for Flood Loss Reduction are discussed in the context of the premise that flood loss reduction is a major management constraint but not the sole purpose of flood plain management. Three strategies for flood loss reduction are presented with a brief description of the management tools appropriate for each strategy. One strategy is to modify floods themselves through the traditional structural tools of dams and levees. A second strategy is to modify susceptibility to flood damage and disruption through such tools as flood plain regulations, floodproofing and flood forecasting and warnings. The third strategy is to modify the impact of flooding through such tools as insurance, tax adjustments, flood fighting and post-flood recovery. It is emphasized that these strategies and tools are not mutually exclusive and almost always some complementary mix is appropriate.

Flood Plain Management Developments, 1966-76 are reviewed using House Document 465 as the reference point. In the decade since House Document 465 made its 16 recommendations for improving flood loss management, most of the recommendations have been followed by action. Most notable are Executive Order 11296 (Flood Hazard Evaluation) and the passage of the National Flood Insurance Act (as amended) which through its requirements and sanctions extend non-structural regulations across the flood plain. Other important legislation extending non-structural approaches include the land use controls required for participation in the Coastal Zone Management Program,[7] the dredge and fill permit program and the areawide waste treatment planning requirements of the Federal Water Pollution

7/Public Law 92-583.

Control Act Amendments of 1972, [8/] the hazard alleviating land use and construction practices required by the Disaster Relief Act of 1974,[9/] the review and public display element of the environmental impact statements required by the National Environmental Policy Act of 1969,[10/] and of course, Section 73 of the Water Resources Development Act of 1974.[11/] Because of the recency of much of this legislation, the implementation and operational coordination of the new planning and regulatory tools provided is often found wanting.

Implementation of a Unified Program is dependent upon the coordination of seriously fragmented management responsibility characteristic of all levels of government. Using the Federal level for an example, 28 agencies have responsibilities for nine different program purposes including construction planning and insurance. In Fiscal Year 1974, there were 797 urban flood damage reduction projects implemented by 11 agencies under 44 legislative authorities. The fragmentation of Federal program responsibility created by the Congress is mirrored by State and local division of responsibility. However consolidating legislation appears unlikely at any level.

Geographic fragmentation is also a common problem. Flood plain management actions at one site can affect across stream and downstream locations. This requires regional management decisions most often

8/Public Law 92-500.
9/Public Law 93-288.
10/Public Law 91-190.
11/Public Law 93-251.

coordinated by State governments and sometimes by multi-state organizations. Yet the responsibility to initiate management activity is usually fixed at the local level, though State and Federal participation may be required.

From examining the problems of implementation, it has been concluded that existing management programs and tools need to be more fully implemented and coordinated as opposed to having new programs and legislation initiated.

The Recommendations for achieving "A Unified National Program for Flood Plain Management" are directed at the Federal and State levels of government. At the Federal level, a number of recommendations directly relate to non-structural measures for flood plain planning. Most important, Federal agencies are called upon to support cost sharing policies that facilitate a desirable mix of structural and non-structural approaches to flood hazards, or in other words, support Section 73 of Public Law 93-251. It is recommended that Executive Order 11296 be revised to reflect the objectives of the National Flood Insurance Program and that flood plain management programs be required as a prerequisite to Federal expenditures for flood control and disaster relief. Other related recommendations call for acceleration of flood plain and hazard studies, especially insurance studies, and for improvements in hydrological data, flood forecasting and warning systems, and social research on flood plain occupance.

Among the more general recommendations is the establishment of a Federal Flood Plain Management Technical Committee under the auspices of the Water Resources Council to serve as a focal point of coordination encouraging consistency among Federal programs, Federal relationships with the States, and reporting to the Congress and the public. This too should assist the planning of non-structural measures for flood hazard alleviation.

At the State level, three recommendations relate directly to non-structural approaches. Those States without such legislation are called upon to enact enabling legislation supporting flood plain management. All States are called upon to apply the concepts of Executive Order 11296 in flood hazard evaluation and to establish a single State agency as a coordinating office for flood plain management.

The recommendations of the unified program dwell heavily upon non-structural approaches to flood hazard alleviation and should facilitate greatly the implementation of these approaches.

Executive Order 11296, Revised. 12/

As issued in 1966, Executive Order 11296 consists of four whereas statements and four sections directing action by Federal agency heads. The whereas statements recognize that flood losses have been increasing

12/ U.S. Water Resources Council. COM Agenda, Item M-76-7, Appendix Item 7B. April 1, 1976. Washington, D.C.

despite continuing Federal investment in flood control structures, and that construction, financial assistance, and land disposal activities of the Federal government affect land use and contribute to the amount of property at risk to flood losses. The first action section directs Federal agency heads to evaluate flood hazards, and to take action to minimize the exposure of facilities to potential flood damage and the need for future flood protection and disaster relief when planning the location of new Federal facilities, the administration of Federal financial assistance programs involving the construction of non-Federal facilities, and the disposal of Federal lands or properties. The second section directs that appropriate evaluation regulations be issued. The third section indicates procedures for disseminating flood hazard information. The fourth section requires that appropriation requests transmitted to the Office of Management and Budget for Federal construction of new facilities shall be accompanied by a statement indicating the findings of flood hazard evaluations in the development of such requests.

The thrust of the Executive order - to assure that implementation of Federal programs and activities will not contribute to the toll of the Nation's flood losses - has not been satisfactorily achieved in the opinion of the Comptroller General.

> "There has been little progress toward curtailing disastrous flood losses by planning for and controlling the uses of flood-prone lands. Development of such lands has continued, making the program's objective more difficult to achieve."[13]

13/Comptroller General of the United States. Op. cit.

This opinion was shared by Gilbert White and Eugene Haas who wrote:

> "...direct experience of the Federal government with enforcement of Executive Order 11296 has not been analyzed in a broad fashion, although evidence that it is not being enforced accumulates." 14/

In revising the Executive order as part of the flood plain management package, the order has been strengthened by taking account of legislation enacted since 1966 and the Unified National Program for Flood Plain Management, and by placing a greater burden of responsiblity for flood hazard evaluation and alleviation action upon Federal agency heads. An underlying principle is that the Federal government should require of itself no less than it requires of non-Federal parties in the use of flood plain lands. This principle is particularly important in view of the sanctions imposed by the National Flood Insurance Program on communities which fail to comply with program requirements for regulating flood plain land use.

In the revision, the whereas section has been expanded to express the following thought sequence:

a) Annual flood losses are unacceptably high and increasing;

b) Federal structures, financial assistance and land disposal affect land use and may increase exposure to flood risk;

14/White, Gilbert F. and Haas, J. Eugene. Assessment of Research on Natural Hazards. Cambridge, Maas.: MIT Press. 1975. p. 264.

c) Federal agencies need to be more consistent in flood hazard evaluation;

d) New legislation, especially the National Flood Insurance Act, requires Federal leadership in flood plain management; and

e) Flood hazard evaluation is an integral part of a Unified National Program for Flood Plain Management.

The action sections of the revision direct Federal agency heads to:

a) provide leadership in undertaking flood hazard evaluation and alleviation efforts when planning the location and construction of new facilities, providing financial assistance or protection, disposing of Federal lands or properties or other actions affecting land use;

b) consider the alternative of removing flood damaged properties;

c) comply with the requirements of the National Flood Insurance Act and the Flood Disaster Protection Act;

d) certify that flood hazard evaluation and alleviation efforts have been carried out when submitting authorization and appropriations requests to OMB;

e) implement their programs consistent with the Unified National Program;

f) cooperate in servicing flood hazard information requests; and

g) issue flood hazard evaluation guidelines within one year.

Thus, the revised Executive order incorporates the specific flood hazard evaluation criteria of the National Flood Insurance Program and the implementation of the Unified National Program for Flood Plain Management. It places a more explicit burden of responsibility upon Federal agency heads.

The Flood Plain Management Package

Taken together the Unified National Program and the revised Executive order offer a conceptual framework to guide Federal, State, and local decisionmakers toward a balanced consideration of alternative goals, strategies and tools; recommendations for improving and coordinating flood plain management activities, within each level of government and between each level of government; and direction to Federal agency heads to take leadership in flood plain management, implementation of a unified program, and strengthening flood loss reduction efforts. This package was placed before the WRC Council of Members on April 1, and action is expected May 24, 1976.

On the topic of non-structural management measures, the package takes a positive, firm posture. The unified program recommends that all Federal agencies support cost sharing policies that facilitate achievement of a desirable mix of structural and non-structural approaches to flood hazard adjustment. The conceptual framework advocates consideration of all alternative strategies for alleviating flood losses evaluated individually and in combination.

Yet, major issues remain to be resolved and especially the question of Federal cost sharing policy for non-structural measures. Section 73(a) of the Water Resources Development Act of 1974 states that flood protection projects must give consideration to non-structural measures and Section 73(b) provides for up to 20 percent non-Federal cost sharing. In 1974, OMB requested that WRC provide cost sharing recommendations for Section 73 and this was done two months later. Thereafter, OMB took the position that Section 73 cost sharing should be considered as a part of the study to be conducted for the President under Section 80 of the Water Resources Development Act of 1974. Consequently, in deference to the Section 80 study, no cost sharing recommendations are included in the Unified National Program. The cost sharing recommendations of Section 80 are now before the President but action seems unlikely until the later months of 1976. Meanwhile, OMB has not seen fit to release funds for implementation of Section 73(b) for non-structural measures while it seeks to establish consistent policy.

The timeliness of this seminar is further highlighted by other activities of WRC. Preliminary findings of the National Water Assessment and Appraisal Program indicate that average annual flood damages now exceed $2 billion and are expected to rise in spite of flood loss reduction programs. Findings of the Section 80 Study indicate that more than 50 percent of Federal water resource expenditures for planning, construction, and operation and maintenance are through grant programs not covered by the WRC Principles and Standards and a so-called "Bridge" is being considered to extend coverage to grant programs. These grant programs are frequently the source of funds for non-structural approaches and their coverage under the Principles and Standards would enhance consideration of non-structural approaches. Effective implementation of non-structural approaches to flood loss reduction is one of the pressing issues of water resource planning and this seminar should help move policy and planning out in front of the issues.

NONSTRUCTURAL FLOOD CONTROL PLANNING: POLICY ISSUES IN PLAN FORMULATION, EVALUATION AND IMPLEMENTATION

By

G. Edward Dickey and Donald B. Duncan1/

INTRODUCTION

This paper addresses one of the most important policy areas in the Army's Civil Works Program. Although nonstructural flood control planning has been underway for several years, we are still confronted with a maze of policy issues which need to be resolved to fully incorporate nonstructural measures into the Civil Works Program.

It should be recognized that many of the problems associated with the formulation and evaluation of nonstructural flood control projects are also associated with the evaluation of structural projects. However, some kinds of so-called nonstructural flood control measures differ from traditional flood damage reduction measures in some very important ways. Consequently, there is a set of policy issues which are unique to nonstructural measures. These differences must be laid out before proceeding further because not only do nonstructural measures differ from traditional measures, they also differ among themselves as to their impacts.

Of all the nonstructural measures, flood proofing is most like traditional projects in that its benefits consist primarily of the reduction of physical flood damages. However, flood proofing differs from traditional projects in that it does not require collective action because, by definition, protection is provided on a structure-by-structure basis.

Flood plain acquisition, relocation and evacuation appear to be similar with regard to the nature of their benefits. However, these benefits are quite different from the benefits derived from structural projects. As discussed below, in assessing the benefits of these measures the planner must measure the value of alternative land uses, with and without these kinds of plans.

1/ The authors are, respectively, the Economic Advisor and the Deputy for Policy, Planning and Legislative Affairs, Office of the Assistant Secretary of the Army for Civil Works, Washington, D. C.

Flood plain zoning appears to be yet another category of measure in that its costs are largely indirect and are borne by those who are denied use of the flood plain. At the same time the flood damage reduction benefits associated with zoning consist largely of savings to those who would not use the flood plain but who, without zoning, would bear the costs of flooding.

In summary, the differences we have identified involve issues concerning (1) the need for collective as opposed to individual action, (2) the need for alternative land use analyses, and (3) the need for analysis of external economies and diseconomies. These inherent differences among measures to reduce water damages are the principal sources of our difficulties in incorporating nonstructural measures into our planning process within the Army Civil Works Program.

In this paper we have tried to address a few select items which, we believe, require careful attention in the areas of plan formulation, benefit evaluation and plan implementation, including cost sharing policy and the Federal role.

PLAN FORMULATION

There has been a great deal of discussion in recent years about the problems encountered in trying to formulate nonstructural alternatives. Although the problems should not be minimized, we sometimes forget that formulation of structural plans also requires imagination and tough decision-making. Let us cite a couple of examples from recent studies. The flood control studies of the James River through Richmond, Virginia, presented several unusual situations. The water treatment facilities for the City of Richmond are subject to flooding. The alternative solutions to this problem that were studied involved protection for that single facility. A floodwall was recommended as a structural flood control project, but OMB, in recommending that the project not be authorized, viewed the problem as a design deficiency in the water supply system.

In another part of the city a decision had to be made regarding various levee alignments which included or excluded certain facilities, namely the sewage treatment plant. It was concluded that the levee alignment should not include protection for the treatment plant because of the lack of incremental economic justification and the adverse backwater effects that the levee would induce. A study was then made of potential nonstructural measures that might reduce flood damages to the treatment plant. Flood proofing offered the greatest potential but was not economically justified (benefit-cost ratio 0.7). Although the District and Division Engineers did not recommend flood proofing, the BERH recommended authorization of the flood proofing at a cost of $8.2 million based on public health and safety considerations.

Another recent example involved a local flood control project in the fork of two streams. The topography and development patterns provided the planners with numerous levee alignment alternatives involving protection of various increments of development. Separable decisions involved protection of the airport, a major industry and industrial waste ponds.

Protection was not recommended for the airport (incremental benefit-cost ratio of 0.74); protection was recommended for the major industry (incremental benefit-cost ratio of 0.95); protection was recommended for the industry's waste ponds, but at non-Federal expense. We must ask: What regulation provides all the answers for this formulation process? It would be interesting to have all of the Districts make independent studies and recommendations for this situation--no doubt a broad range of recommendations and supporting rationales would surely surface.

We should not be surprised to learn that there are also tough formulation decisions associated with nonstructural alternatives. Although our experience is somewhat limited in assessing the effectiveness of some of the nonstructural measures, our planning experience should enable us to do a good job in the evaluation and assessment of alternatives. The problem of defining separable project increments in structural projects is also a problem in the case of flood proofing. Is a separate analysis required for each individual structure or can groups of structures be treated collectively?

Nonstructural measures are normally associated with local flood control projects. The policy issues related to the formulation of local flood control projects are the result of the planning constraints that may be imposed on the process. The policy issue involving recreation at local flood control projects is an example. The Army has been actively working with OMB to provide definitive policy guidance in this area. One premise is that recreation should be limited to the water related potential created by the flood control project. An alternative premise is that flood control and recreation should be considered as equal purposes in a multiple-purpose project. While new guidance regarding recreation at structural local flood control projects is about to be issued, virtually no progress has been made in addressing the role of recreation in nonstructural flood control plan formulation and evaluation.

The new policy for structural local flood control projects is expected to require evaluation and conclusions based on flood control only. If a flood control project is recommended, only the recreation potential created by the land and water base needed for flood control may be developed. Should such a policy be applied to nonstructural projects? Certainly the answer is not easy. Problems arise with such a policy when evacuation and land acquisition are considered. As will be discussed later, such measures may not be justified on the basis of flood control benefits alone. One thing is clear, however: Definitive policies are needed for implementation of Section 73 of Public Law 93-251 and for environmental quality cost sharing before constraints or limitations are placed on the scope of recreation development at nonstructural projects.

Another issue that will be difficult to resolve is the identification of the Principles and Standards components of objectives (traditional project purposes). This issue is central to the question of Federal interest (cost sharing). For example, a plan for evacuation could be called a flood control plan, a recreation plan, or an environmental quality plan. The plan for resolving the water damage problem at Baytown, Texas, has been described as a mitigation plan for the water supply system, a traditional flood control plan, a hurricane protection plan and an environmental quality plan.

The cost sharing implications of purpose identification are obvious. Should projects be identified on the basis of the source of the problem, the characteristics of the problem, the type measures utilized to resolve the problem, or the project outputs? We need to be consistent on this point. We have had some experience with this problem in dealing with cost sharing for water quality control, but we still have a long way to go in getting general agreement on this point.

BENEFIT EVALUATION

Benefit evaluation is very closely tied to plan formulation. The way in which benefits are measured impacts directly on the way in which plans are formulated and, ultimately, on the nature of the recommended plan itself. Many nonstructural plans produce benefits which are broader than our traditional concept of flood control benefits. Among these are environmental quality and recreation. Both of these benefit categories present evaluation problems, and we are all aware of the particular difficulties planners have with evaluating environmental quality impacts, both beneficial and adverse.

While environmental quality benefit evaluation presents important problems, these problems are not unique to nonstructural "flood control" measures. For this reason, we want to focus on the measurement of economic benefits of nonstructural flood control projects. Our review of the Baytown project, as well as discussions with many field personnel, suggest that there is need for clear policy guidance in the area of economic benefit evaluation.

A fundamental source of confusion is reflected in the claiming of flood damage reduction benefits for projects which result in a change of the use of the flood plain. While it is often said that a goal of the flood control program is to reduce or even minimize flood damages, strictly speaking our economic objective is to enhance the Nation's income by reducing flood damages only when it is economical to do so. Thus, when evaluating nonstructural as well as structural measures, the evaluation should be based on a benefit-cost analysis as opposed to a cost-effectiveness analysis.

Measures such as flood plain acquisition and flood plain evacuation do not generate (except in the case of externalities) flood damage reduction <u>benefits</u>. Here the distinction between impacts and benefits must be clearly made. The benefit category "flood damages reduced" is appropriate <u>only</u> when the use of the flood plain is the same with and without the project. Whenever the use of the flood plain is changed as a result of the project, the applicable benefit category is location or land enhancement.

This is most clearly demonstrated where agricultural land is acquired to prevent agricultural flood damages. By removing flood damageable agricultural activity from the flood plain, flood damages are reduced, but this impact is irrelevant to the calculation of project benefits. To claim flood damage reduction benefits would be analogous to claiming a heart disease reduction benefit by executing heart disease victims. Obviously, reducing the number of people with heart disease through an execution program is not solving the problem even though the statistic of zero percent incidence of heart disease would be impressive. In the same way, zero flood damage obtained by evacuation of all flood plains would not be beneficial to the Nation. Really, our objective is to increase national welfare by reducing flood damages whenever the increase in national income or in other intangible benefits resulting from a project exceeds the cost of the project. On this basis we can expect to have flood damages for some time to come.

The case of urban evacuation and relocation plans is more complex because of the greater importance of externalities, that is, that the costs of flood damages are often not borne by the inhabitants of the flood plain. The extreme case of externalizing flood damages is found in situations where the flood insurance program is applied to existing development. Because of the subsidized insurance provided to existing development there may be cases where irrational flood plain occupancy is encouraged. This is most likely to be the case in situations where hydrologic conditions have changed significantly since the flood plain was initially developed. Thus, we are aware that the National Flood Insurance Program has impacted on the nature and magnitude of benefits associated with evacuation of developed flood plains, but considerable analysis is needed before definitive evaluation procedures can be established. However, reduction of flood damages cannot be credited to evacuation or relocation plans when the damages are suffered by the flood plain occupants themselves.

PLAN IMPLEMENTATION

Cost Sharing

No discussion of the implementation of nonstructural flood control plans would be complete without recognizing the cost sharing policy issues. The opportunities as well as the problems created by Section 73(b) of Public Law 93-251 must loom large in the discussion.

Traditionally, cost sharing in Federal and federally-assisted water resource programs has been largely defined in terms of project outputs or benefits. For example, we find a different cost sharing policy for each of several functional categories--flood damage reduction, water supply and recreation. The principle of output-related cost sharing policies is a long-standing one in water resources, but longevity is not sacredness as is shown by a careful reading of Section 73(a).

> "In the survey, planning, or design by any Federal agency of any project involving flood protection, consideration shall be given to nonstructural alternatives to prevent or reduce flood damages

including, but not limited to, flood proofing of structures; flood plain regulation; acquisition of flood plain lands for recreational, fish and wildlife, and other public purposes; and relocation with a view toward formulating the most economically, socially, and environmentally acceptable means of reducing or preventing flood damage." (emphasis added)

It would appear that Section 73(a) establishes a new project category: Projects which, in addition to providing some array of public benefits--for which there are general cost sharing policies--also reduce flood damages associated with the use of the flood plain without the plan.

Section 73(a) would appear to be saying that flood plain recreation and fish and wildlife projects should be cost shared according to the policy for flood damage reduction projects as opposed to a policy reflecting their direct project benefits. While a rationale for such a policy could perhaps be developed in terms of externalities associated with flood plain occupation by flood damageable activities, neither the Section 73 legislation nor the associated committee reports have articulated such an explanation. In the absence of some rationale, those within the Executive Branch who are concerned with demands on the Federal treasury will continue to question the feasibility of full implementation of Section 73.

Section 73(b) states:

> "Where a nonstructural alternative is recommended, non-Federal participation shall be comparable to the value of lands, easements, and rights-of-way which would have been required of non-Federal interests under section 3 of the Act of June 27, 1936 (Public Law Numbered 738, Seventy-fourth Congress), for structural protection measures, but in no event shall exceed 20 per centum of the project costs."

These words create a number of specific problems:

1. Section 73(a) specifically identifies project outputs other than flood damages prevented--land acquisition for recreation, fish and wildlife and other public purposes. Land acquisition for recreation

would normally be a non-Federal responsibility with credit provided toward its 50 percent share of the overall recreation costs. Section 73(b) stipulates a maximum of 20 percent for the non-Federal share of project costs. Recreation now has two cost sharing policies--50/50 and 80/20.

2. Hurricane protection provided by structural measures requires a 30 percent contribution by non-Federal interests. For nonstructural measures, the maximum non-Federal share is 20 percent.

3. In some regions of the country the standard a-b-c requirements for local flood control projects approach 50 percent of the total project cost. In such cases structural alternatives may require a 50 percent non-Federal contribution while nonstructural measures would require a 20 percent contribution.

4. In addition to the obvious implementation problems associated with flood proofing, the question of flood proofing for future development is a sticky question.

5. Is Section 73(b) applicable to measures such as zoning and flood warning systems?

Federal Role in Implementation

The Federal role in implementing the best water resources plan has traditionally provided opportunities for non-Federal interests to participate, when practical. Major reservoirs are generally constructed and operated by Federal agencies. The inclusion of significant recreation development in flood control projects has resulted in a joint implementation effort. Non-Federal interests may choose to construct facilities in addition to their responsibilities for operation and maintenance. Finally, the Flood Control Act of 1936, as amended, requires direct participation by non-Federal interests in implementing local flood control projects.

The Federal role in implementation of nonstructural measures has not been established and may range from complete implementation to financial assistance. There seems to be general agreement that non-Federal interests should implement measures such as zoning and flood warning systems. Flood plain acquisition and evacuation are within the capability of non-Federal interests in most instances. The expertise for flood plain information studies will probably remain in the Federal agencies for some time. Flood proofing presents many difficulties. There are likely to be as many special cases as there are flood proofing projects. However, we should look to non-Federal interests for implementation of flood proofing schemes unless special circumstances dictate Federal involvement. In any case what is needed is a clear set of policy guidelines which define the respective Federal and non-Federal roles in implementation.

CONCLUSIONS

This paper has focused on those areas within nonstructural flood control planning and implementation which we see as requiring policy development and field guidance. In closing, we would like to set forth five propositions which we believe would serve as basic policy principles:

1. Benefits must be evaluated on the basis of project outputs.

2. Projects should be identified on the basis of project outputs.

3. The conflicts in cost sharing policies need to be reduced to a minimum.

4. A cost sharing policy for environmental quality must be established; 50/50 may be a reasonable and workable policy.

5. Non-Federal interests should implement nonstructural measures unless Federal involvement is required to insure the effectiveness of the overall plan.

While there will, no doubt, be disagreement regarding the validity of these principles, we do not think that anyone will argue that they do not identify areas in which clear Army policies and legislative proposals must be developed.

30 April 1976

IMPLEMENTING NONSTRUCTURAL FLOOD CONTROL MEASURES IN THE LOCAL COMMUNITY

By

L. Douglas James[1]

INTRODUCTION

Program Context

Since Executive Order 11296 requiring investigation of land-use control as an alternative to structural flood control was issued in 1966, the Corps of Engineers has been faced with seeking effective procedures for identifying flood plains where the nonstructural approach is preferable, for deciding which nonstructural measures are "best", and for working with local governments and individuals as appropriate for their implementation. If nonstructural measures are to be compared with structural measures to see which is preferable, some specific combination of nonstructural measures must be identified. If the comparison is going to resolve the issue of whether or not structural measures are appropriate the "best" combination of nonstructural measures must be the one identified. One problem was thus how to select this "best" combination.

Once this first problem is overcome, the Corps is well organized for proceeding if structural measures are found preferable but faces a second problem of finding its appropriate role if nonstructural measures are found preferable. If the preferred nonstructural measures are not implemented by others, should the Corps deny a community a structural flood control program with a favorable benefit cost ratio? If the land-use controls that would have been preferable are not implemented, a day will be reached when structural control is justified and by that time the cost will be significantly higher than if the work would have begun earlier. Executive Order 11296 was intended to reduce structural flood control costs rather than increase them.

The public interest would be better served if something were done to implement the nonstructural program. That creates two more problems. The commitment of the United States to individual freedom places restraints on the tactics government can use, to a large part determined by what voters will accept. The commitment to a constitutional separation of powers that places responsibility for nonstructural programs in the hands of local government places further restraints on a Federal agency. In accord with the American tradition, the preference would be for employing the least governmental effort

[1]Visiting Professor, Department of Civil Engineering, University of Washington.

that would get the job done and the least Federal involvement that would get the local communities to do their job. In fact, the public would probably prefer additional flood damages to certain kinds of governmental activity. The very practical question is what level of nonstructural protection (now and projected to the planning horizon) can be achieved by efforts within these bounds of acceptability. That acceptable level is probably short of the "best" level as determined by an idealized model. In conclusion, planners must face the fact that there are nonstructural measures that would effectively reduce flood damages that cannot be implemented in a democratic society.

Part of the problem lies in the fact that many in the public and many planners conceived and still conceive a nonstructural flood control program as properly eliminating all flood damage caused by events smaller than a design flood now commonly accepted as the 100-year event. Little allowance is being made for the flood plain occupant who can demonstrate net benefits from exposing himself to flood damage, even if these net benefits are far in excess of the damages that he will experience. One may beg this question by bringing up people who are exposing themselves to catastrophy unawares or who are planning to transfer the burden of any losses to the taxpayer, but the fact is that economically, socially, and environmentally acceptable flood risks are not being allowed. The day when a large share of the public perceives losses from complying with nonstructural programs to exceed the benefits gained will be one of reckoning for the flood plain management concept.

Information Needs

One purpose of this paper is, in the above context, to explore what can, has, and needs to be done to resolve these issues in actual flood plain situations. How important are these conceptual problems in actual flood control programs? What information on implementation problems is needed to define the optimal set of nonstructural measures for a given flood plain, to determine what is the most effective way for implementing them, and to decide what restrictions implementation feasibility places on what can be achieved? The state of the art is still a long ways from answering all these questions, but some tools are available for beginning.

CLASSIFICATION OF FLOOD CONTROL MEASURES

For the purpose of this discussion, nonstructural measures are defined to include all efforts to reduce flood damage other than

1. Construction of reservoirs, channels, or levees.

2. Land treatment or other modifications of the tributary watershed to reduce runoff.

3. Actions performed on an emergency basis at the time of the flood event.

For a positive definition, this includes all activities to minimize flood damage through

1. The types of uses made of flood plain land either broadly (agricultural, residential, commercial, etc.) or narrowly (warehouses, canneries, heavy industry, etc.) defined.

2. The spatial pattern in which a given parcel is developed for its chosen use (geometric layout and floor elevations of buildings and use areas).

3. Flood proofing to keep the flood water out of buildings by making them watertight or by other means.

4. The use of building materials, construction methods, or furnishings that are less damage prone or more easily removed during flood events.

The optimal combination of nonstructural measures may thus be thought of as a geometric arrangement of buildings, use areas, and materials and methods used in building construction. A given flood plain location may be viewed as having some optimal combination as determined by its location and the state of the economy at a given point in time. A number of economic models have been proposed for determining this optimal combination for a given flood plain location at a given time,[1] but none of them have proved entirely satisfactory in routine application. The prevailing practice has gone to administrative selection of a 100-year design flood (not necessarily the economic optimal design flood), the designation of some kinds of development as relatively damage prone and other kinds as relatively damage free, and prohibition of "damage-prone" development at locations and elevations subject to inundation by the 100-year flood. The reasons why this has occurred and the wisdom of this approach are interesting topics for discussion on their own right, but do not belong in this discussion of implementation of the selected nonstructural program by whatever means that selection was made.

Before going on, however, it is worthwhile noting that one major difference between the optimal and the administratively selected plan is the much greater variation within the former. Economic optimality (maximization of benefits net of costs) would indicate different design flood return periods, different decisions on land use, and different flood proofing policies parcel by parcel. Consideration of environmental and social factors may even increase this diversity. Implementation and enforcement would be an administrative nightmare. Flood management policy is thus already departing from optimality because of administrative convenience. Is program administration going to be more responsive to convenience than individual rights?

Implementation of the selected nonstructural program involves changing the building and use areas from their current to the selected state. Sometimes

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[1]James, L. D., "Computers in Flood Control Planning," Proceedings of the ASCE, Vol. 95, No. HY6, 1968, pp. 1859-1870.
Day, J. C., "A Recursive Programing Model for Nonstructural Flood Damage Control," Water Resources Research, Vol. 6, 1970, pp. 1261-1270.
Arvanitidas, "A Computer Simulation Model for Flood Plain Development," IWR Reports 72-1, 73-1.

the current state is already the desired one, and implementation involves keeping that state from changing. The feasible land use measures are usually of this sort because of the high cost of reverting developed land to an undeveloped state. Flood proofing existing buildings is considerably more expensive than flood proofing new construction; but once the flood plain is developed, flood proofing is likely to be the least expensive approach. Obviously, information on the current state is very important in determining the optimal program.

For purposes of identifying implementation problems, the two principal nonstructural measures are 1) hazard-commensurate land use and 2) flood proofing. Each of these has two cases depending on whether or not incommensurate land use or unflood-proofed development has already occurred as outlined at the top of Table 2.

AVAILABLE IMPLEMENTATION MEANS

Once a desired nonstructural approach to flood control is selected for a given parcel, an implementation policy somewhere between 1) sitting in the office and hoping that just that idea will dawn on the property manager and 2) purchasing the property and developing it is just that way must be selected. Both of these extremes are likely to be unsatisfactory, but Table 1 presents seven other implementation alternatives covering the spectrum in between that governments can use to motivate a desired response from flood plain property managers. The table defines each means, describes its intended effect, and suggests obstacles likely to stand in the way of success.

In going down the list from means to means, one can see that (as a general trend but not necessarily monotonically on each and every flood plain), 1) implementation cost increases, 2) the probability of political opposition on either financial or constitutional grounds increases, and 3) the probability that the means will indeed generate the desired nonstructural measures increases. The means are not mutually exclusive, and any combination of up to all of them could be employed simultaneously.

PROBABLE RESPONSE PATTERNS

If the manager of every flood plain property would always implement his part of the official flood plain management plan once he received precise definition of his hazard exposure, the entire plan could be implemented simply by disseminating information on the flood hazard. Its low cost and political acceptability (because no one would have to sacrifice any property rights) make this first means on Table 1 ideal if it would only do the job. Experience with the variability of human perceptions, abilities, and objectives, however, makes it unreasonable to expect any such thing.

Table 1. GOVERNMENT MEANS FOR PROMOTING INDIVIDUAL FLOOD CONTROL MEASURES

Means	Intended Effect	Obstacles
1. Disseminate information on flood hazard	People who know of the hazard will be motivated to employ individual measures, and data on the degree of hazard permits better measure design.	Information not received, not reviewed, or not understood. Understood information used to pursue goals that are not in the public interest.
2. Disseminate information on adverse external or ecological effects of flood plain occupancy	People who understand these effects will be motivated to avoid actions that cause them. This can complement risk as a reason to avoid flood plain development.	Same as for flood hazard information but greater variation in understanding and goals is likely.
3. Use taxes or other charges to penalize "inappropriate" individual activity.	A more direct financial incentive will induce greater employment of individual measures.	Difficult to set fair rates and to obtain political approval. places burden on low income groups that cannot afford individual measures.
4. Provide expert advice on the design of individual measures.	People with ready access to information on their range of alternatives and of the details for cost effective designs will select more effective individual measures.	Advised action may be too costly for property manager to implement. People may not understand the technical information or have different goals than the experts providing the advice.
5. Inact and enforce land use and building code regulations.	People will comply with these statutes.	Financial burden for a program of general benefit is concentrated on flood plain property owners. Compliance and enforcement grows lax without a continuing consensus on the wisdom of the regulations.
6. Subsidize financing of individual measures	People can afford measures that are in the public interest but not economical from their personal viewpoint. Financing is provided for those without cash in hand.	Program is costly to finance. Political approval may be difficult. Public money may be wasted if measures are not maintained. Subsidy may encourage flood plain occupancy.
7. Purchase hazard areas for recreation or natural uses.	Public ownership will eliminate private flood plain development. The land can be used to provide recreation opportunities and preserve valuable natural areas.	Purchase is very costly. Condemnation may be difficult or impossible.

One may then ask how far down the list (Table 1) of progressively stronger and more expensive measures does program implementation have to go before universal compliance can be guaranteed. Experience here says that no amount of effort (within the constraints of democratic society) can guarantee universal compliance. Some variances will always occur. In light of this fact, it is manifestly extravagent to attempt to guarantee universal success through nonstructural measures. The marginal cost of eliminating the last few variances rises sharply as one moves closer toward complete success. Failure of one land manager to employ the optimal nonstructural flood control program for his property is not the disaster that failure of a dam or levee is.

Given that guaranteed continuous compliance is manifestly impossible, it is more rational to recognize variances as a fact of life and plan implementation of a nonstructural flood control program from the outset on the basis of a preselected target level of compliance. In order to do this, level of compliance must be defined. A working definition of the concept is best developed by considering how a population of managers of flood plain property would respond to a set of implementation means. Some will respond with just the "right" actions. Others who respond will do something different than the planner intended and may end up with either more or less than optimal protection. Still others will do nothing, either because they still have not become aware of the problem or because they have chosen to ignore it for one of many possible reasons. Many responses that are not quite optimal will be too close to justify greater implementation effort to get that individual to do better.

This conceptualization of the response pattern suggests that a target level of compliance might reasonably be specified in a format 1) along the lines of 80 percent of the flood hazard area will be protected by nonstructural measures to hold expected annual damages to within 10 percent of optimal values, 95 percent within 25 percent, and 99 percent within 100 percent; 2) total expected flood damage will be within 15 percent of optimal values, and 3) no variances that display unreasonable disregard for human safety will be allowed. It is worth noting here that this last specification implies that nonstructural programs have an inherent disadvantage when compared to structural programs for application in areas subject to a flood severity potentially hazardous to human life because they cannot guarantee universal success and lives will be lost.

If this format is acceptable for specifying a target level of compliance, the next problem is how to fill in specific numbers. From economic theory, we know that one can optimize on this sort of planning issue by comparing marginal costs with marginal benefits and determining the point where the two are equal, the point where the sum of program cost and residual flood damage is minimized. The items pertaining include 1) program implementation costs by the responsible public agencies, 2) costs incurred by property managers in making their responses, and 3) residual flood damages. In balancing these costs, it is also necessary to recognize that an implementation program strong enough to bring everyone up to minimum standards may cause others to spend too much and that this cost tradeoff needs to be balanced too. At the present state of the art, we know too little about these cost functions to optimize on a target level of compliance, but perhaps we can weigh these considerations sufficiently well qualitatively to fix a reasonable target. The increasing number of nonstructural flood control programs around the country provides a growing base for collecting empirical data on what can be achieved.

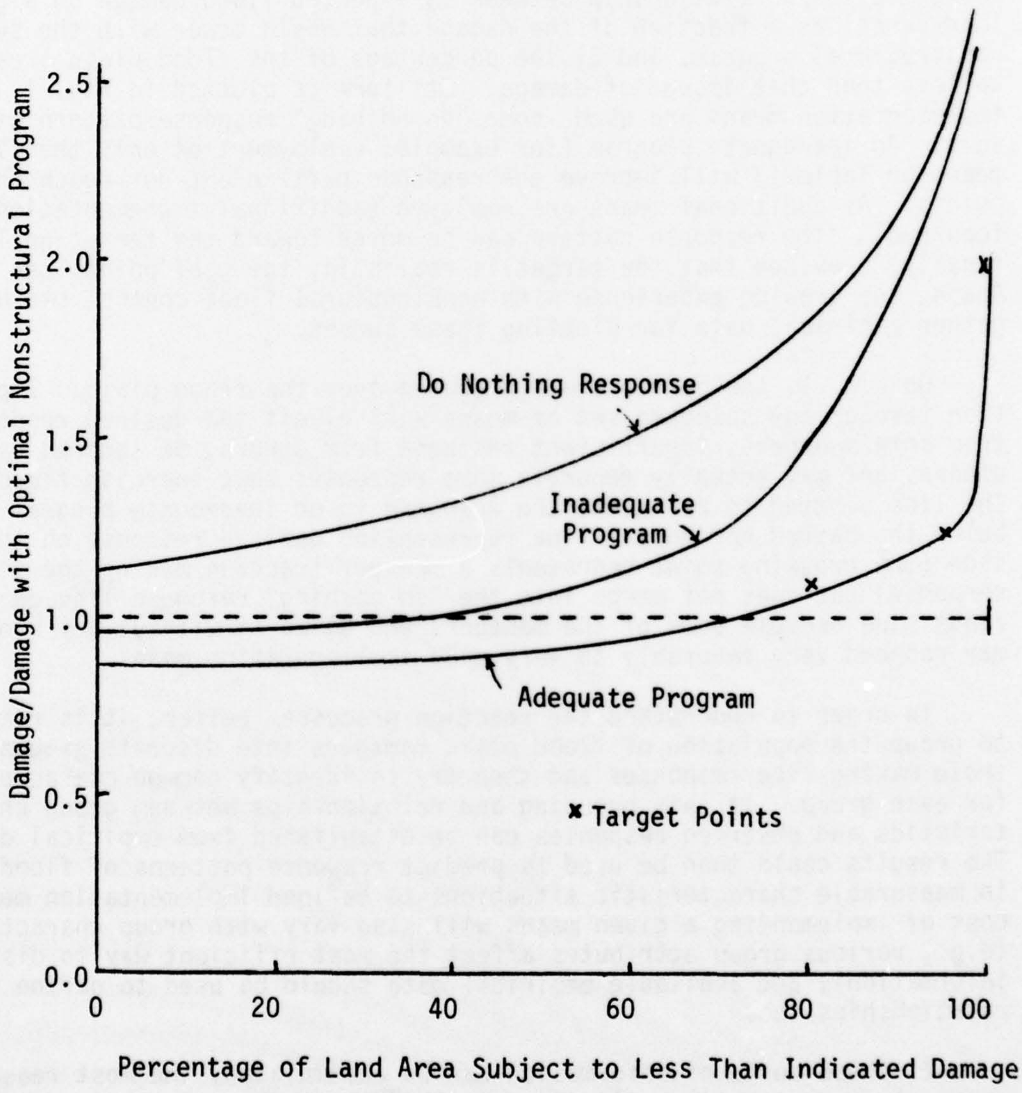
Once a target level of compliance has been defined, economic theory could still be applied to select a least cost combination of implementation means provided one can 1) estimate compliance and 2) estimate implementation costs. The first criterion used in the format for target compliance outlined above implies a relationship between 1) expected flood damage on a given land parcel as a fraction of the damage that would occur with the selected nonstructural program, and 2) the percentage of the flood plain area subject to less than that amount of damage. Its form is plotted in Fig. 1. If no implementation means are used, some "do nothing" response pattern will result. An inadequate program (for example, employment of only the first means on Table 1) will improve the response pattern but not reach the target points. As additional means are employed (additional implementation cost is incurred), the response pattern can be moved toward the target goals; and finally, provided that the target is realistic, the goal points can be achieved. Again, the growing experience with nonstructural flood control can be used to gather empirical data for plotting these curves.

On Fig. 1, the curves are aggregated over the flood plain. Implementation through any selected set of means will elicit the desired response from some managers, insufficient response from others, be ignored by still others, and may actually generate some responses that increase flood damage. The line plotted to represent the response to an inadequate program falls below the dashed horizontal line representing desired response on the left side (the crossing point represents a manager fraction making the desired response) but does not merge into the "do nothing" response line on the right side because some of the managers who do worst without any program may respond very favorably to very mild implementation means.

In order to understand the reaction processes better, it is reasonable to group the population of flood plain managers into discrete groups of those making like responses and then try to identify common characteristics for each group. If this grouping and relationships between group characteristics and observed responses can be established from empirical data. The results could then be used to predict response patterns of flood managers in measurable characteristic situations to defined implementation means. The cost of implementing a given means will also vary with group characteristics (e.g., various group attributes affect the most efficient way to disseminate information), and available empirical data should be used to define these relationships too.

If these sorts of information can be accumulated, the most reasonable approach to systematic application would be through a simulation model. The data would provide the probabilities of various responses from the defined situation characteristics, and Monte Carlo methods can be used to generate a manager response (or cost) for each situation. The results can be aggregated into a curve such as those plotted on Fig. 1. This procedure is particularly recommended for nonstructural measures because it gives an anonymity to the responses of particular individuals that is highly desirable for planning in a democratic society. Nonstructural programs are headed for real

Fig. 1. Conceptual Responses to Nonstructural Flood Control Programs



trouble if they ever become involved in opening what individual property owners do with their own property to the same sorts of public discussion now voiced on structural measures.

FACTORS AFFECTING RESPONSE PATTERNS

Engineers design structural measures from project specific information on topography, soils, geology, and other factors that they have long since learned must be taken into account in implementing a physical system that will function as desired in controlling flood waters at an acceptable cost. Those responsible for implementating nonstructural flood control programs simply cannot afford to overlook the importance of project specific information on factors relating to how well a nonstructural flood control program will function in preventing people from exposing themselves to flood damage. Today, we laugh on reading the Congressional debates over whether it would be worthwhile to fund the data gathering program of the U. S. Geological Survey or whether an engineer can design an efficient irrigation system in the field without topographic mapping and flow measurements.[1] It would be just as ridiculous to try to implement a nonstructural flood control program in 1976 as it would have been to try to implement a structural irrigation program in 1890 without project specific information. To go from principles to specifics, however, we need to determine what information is needed.

The information collection goal should be to make the best possible estimates of 1) how the managers of flood plain property will respond to the implementation means, 2) how the community will respond in its evaluation of the acceptability of the program as a legitimate use of taxpayer's money, 3) the cost of executing the implementation means, and 4) the finances and professional skills available to the government having jurisdiction over the flood plain. Even a superficial evaluation shows that flood plains vary on all four accounts. A program of implementation may work wonders on one watershed but fail miserably on another, and the collected information should be adequate for the task of predicting this in advance.

Four sets of factors that should be evaluated in comparing implementation means are outlined on Table 2. The first set is a list of the basic nonstructural measures and could be discretized on a much finer grid by defining various types of urban and agricultural land use or of flood proofing. The three attributes of the physical situation were those found most significant in a study that originally began by defining a much longer set.[2] In the same study, 18 hypothesized community attributes and 24 hypothesized attributes of the flood plain manager were reduced to the six most significant of each. Obviously, the state of the art is nowhere near sufficiently advanced for the attributes listed on Table 2 to provide a satisfactory list

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[1] U. S. Senate Report 928, <u>Irrigation</u>, 51st Congress, 1st Session, Serial No. 2707, 1891.

[2] James, L. D., "The Use of Questionnaires in Collecting Information for Urban Flood Control Planning," Environmental Resources Center Report No. ERC-0274, Georgia Institute of Technology, Atlanta, 1974.

Table 2. FACTORS AFFECTING RESPONSE TO IMPLEMENTATION MEANS

Attributes of the desired response

1. A more hazard-commensurate land use
   a. by reducing new incommensurate development
   b. by removing existing in commensurate development

2. Flood proofing protection of flood plain development
   a. of new development at the time of construction
   b. of already existing development

Attributes of the physical situation

1. Recent flood history in terms of the frequency at which flood damages occur and whether or not by chance a major flood has occurred recently.
2. Ease with which a layman can identify flood prone areas because of a distinct physical appearance.
3. Size, shape, and location of flood plain areas in that larger blocks of land become harder to leave idle as part of the landscaping of a development program.

Attributes of the community responsible for program implementation

1. Recognition of flooding as an important problem for the community as a whole.
2. Concern within the community over environmentalism in general and protecting flood plain ecology in particular.
3. Acceptance of the means as compatible with the value systems or political philosophies of the people in the community as a whole.
4. Financial and manpower resources available to the community for program implementation.
5. Willingness of the community body politic to raise taxes to undertake new programs of public benefit.
6. Philosophy of the people within the community as a whole on the responsibility of government to help out individuals in trouble.

Attributes of the managers of flood plain property

1. Time, ability, and inclination to take on the various measures.
2. Motivation for flood plain occupancy on a scale from being caught unaware at a site chosen for entirely other reasons to purposefully moving onto the flood plain, fully aware of the risk, in order to enjoy such benefits as natural areas and seclusion.
3. Understanding of and sympathy for the selected nonstructural measures.
4. Philosophy on individual rights with respect to what the government should or should not require.
5. Perceived personal benefits from implementation of the nonstructural flood control program.
6. Perceived personal losses from changes that would occur if the nonstructural program were implemented, particularly the loss of rights to develop flood plain property.

of independent variables for a working planning model for predicting response to the means used to implement a program of nonstructural measures. The intent is only to provide a reasonable starting point for quantitative analysis.

FACTOR QUANTIFICATION AND INTERPRETATION

Quantitative analysis requires specific definition of each variable so that it can be measured and a systematic measurement procedure that will give consistent results when independently applied to the same situation. The definition should capture the aspects of the variable that are most highly correlated with response, and definition should thus be refined to improve the predictions as modeling progresses. These tests of correlation and consistency were used in developing methodologies for quantifying each physical, community, and flood plain manager attribute listed in Table 2.[1] Specific definition of the physical factors permitted their measurement from streamflow records or topographic maps. The fourth community factor was defined so that it could be estimated from a qualitative assessment of the resources and capabilities of the staff of the community government. The other five community factors were defined for estimation by scaling responses to questionnaires answered by a random sample of the citizens of the community. All six flood-plain-manager factors were defined for estimation by scaling from questionnaires answered by the affected individuals classified into two groups according to whether their home or a business property is exposed to the hazard. The most important factor here is to exert special care in obtaining questionnaires from respondents representative of community opinion making and flood-plain-property-manager decision making. Each factor should be measured for the relevant population, and the results can be normalized on a 0 to 1 scale. Such an application has been published.[2]

A COMPREHENSIVE MODEL FOR PLANNING

A comprehensive flood plain management program should combine structural and nonstructural measures based on information on available implementation means and the results that they can reasonably be expected to achieve in the measured real-world setting as well as on what could be achieved if ideal flood plain management practices were universally followed. Fig. 1 provides a conceptualization for comparing real-world with ideal response. Table 3 summarizes the major tools required for comprehensive analysis. The present

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[1] James, L. D., "Formulation of Nonstructural Flood Control Programs," Water Resources Bulletin, Vol. 11, Aug., 1975, pp. 688-705.

[2] James, L. D., Benke, A. C., and Ragsdale, H. L., "Integration of Hydrologic, Economic, Ecologic, Social, and Well-Being Factors in Planning Flood Control Measures for Urban Streams," Environmental Resources Center Report No. ERC-0375, Georgia Institute of Technology, Atlanta, 1975.

Table 3. TOOLS FOR A COMPREHENSIVE NONSTRUCTURAL PROGRAM PLANNING FRAMEWORK

1. A model for selecting an optimal nonstructural program from economic. ecologic, and administrative considerations.

2. Systems for measuring the physical, community, and flood plain manager factors listed on Table 2.

3. Relationships for predicting the probabilities of the various responses that the manager of flood plain property might make given his measured attributes, the measured physical and community context, the specified implementation means, and the initial situation. As an example set of responses, an owner of undeveloped flood plain land may 1) keep his parcel undeveloped, 2) develop it in a conforming use, 3) develop it in a nonconforming use but flood proof, or 4) develop it in a nonconforming use. Obviously a larger set of more precisely defined responses would be a possibility for a more advanced model.

4. A simulation model for predicting the response pattern to a specified set of implementation means from measured factor values and available relationships.

5. A simulation model for predicting the cost of implementing a specified set of means from measured factor values and cost relationships.

situation is that the optimization models that have been developed assume an ideal response. Measurement systems and prediction relations are in the embryo state and could be developed much more quickly if a body of empirical data could be obtained on how managers of flood plain property are responding to nonstructural flood control programs in different contexts. Reactions to the means being implemented by communities in order to qualify for the flood insurance program need to systematically observed. The simulation models cannot be developed until the response relationships are more firmly at hand.

Table 4 outlines an 11-step program for using these tools in planning a nonstructural flood control program including both optimal measures and optimal means. The purpose of the outline is to provide a general framework for continued development of the methodology fully recognizing that modifications will be required as progress continues. The key features are 1) beginning from a "do nothing" curve as a base for quantifying what the implementation means have actually achieved, 2) considering the effectiveness of the implementation means employed in comparison with their costs, 3) specifying a target level of compliance and using empirical data to determine whether its achievement is realistic and desirable, and 4) providing an explicit decision-making framework for dealing with the question of what to do if nonstructural measures do not prove to be technically feasible as originally conceived.

APPROXIMATE METHOD

Current methodology, however, is not nearly this far advanced. One approximate strategy[1] is

1. To formulate a target nonstructural program including one or more of the four measures listed at the top of Table 2. Specific programs are possible for each subsection of the total flood plain.

2. To select the implementation means that seem most applicable to the chosen measures. For example, the dissemination of information on adverse ecological effects seems reasonable as a deterent of flood plain development but hardly seems a reasonable way to encourage people to flood proof existing buildings.

3. To select a few of the physical, community, and flood plain-manager factors that seem likely to be critical to the success or failure of each selected implementation means. For example, it seems reasonable to hypothesize that the dissemination of flood hazard information is most likely to be successful in motivating nonstructural measures if 1) the community recognizes its flooding problem as important enough to warrant a continued commitment to keeping the information dissemination program going, 2) the flood plain

[1]See James, "Formulation of Nonstructural Flood Control Programs," for its details.

Table 4. STEPS IN PLANNING A NONSTRUCTURAL FLOOD CONTROL PROGRAM

1. Determine the current land use and flood proofing within the area being analyzed and estimate the associated expected annual flood damages by parcel.

2. Use an appropriate model to select a target nonstructural program (a spatial pattern of hazard-commensurate land use and flood proofing of conforming uses) from economic, ecologic, and administrative considerations; and estimate the associated residual annual flood damages by parcel.

3. Combine the results of the first two steps to plot a "do nothing" curve normalized on the basis of the target program as defined on Fig. 1. This curve is likely to vary with the time since the last major flood; and by a more refined definition, the "do nothing" curve would be an average over the range of conditions expected within the planning period.

4. Select a target level of compliance for achieving the target nonstructural program.

5. Measure the physical and community factors for the flood plain being studied (or factor sets if the total study area exhibits physical diversity or crosses community boundaries).

6. Measure the flood-plain manager factors by survey methods that preserve the anonymity of all involved individuals.

7. Select an alternative combination of implementation means and employ the response-simulation model to generate a corresponding response curve.

8. Estimate the cost of the alternative from the cost-simulation model.

9. Adjust the combination of implementation means to match the target level of compliance more closely or to reduce cost, and repeat steps 7 and 8. Repeat the cycle as desired for improved results.

10. If the target level of compliance cannot be achieved at reasonable cost or without creating other implementation problems, lower the target as needed to reach a feasible zone.

11. With the implementation costs and the effectiveness (residual damages now known), return to the model for selecting a target nonstructural program to determine how the optimal combination of measures is affected. For example, structural measures may turn out to be more economical after all once the cost of implementing the nonstructural program is known. If the optimal program is substantially different, repeat steps 2 through 10 until the analysis stabilizes.

managers have the time, resources, and inclination to act on their own, and 3) the flood plain managers perceive significant benefit from the measures that they employ.

4. To measure the selected factors and note any results that suggest implementation difficulties. Major difficulties would suggest shifting to alternate implementation means, to alternate nonstructural measures, or from nonstructural measures to a structural program.

Such an approximate method is a significant improvement over ignoring project specific information on local physical and social conditions altogether, but it has several major drawbacks. Selection of the implementation means and the key factors is based entirely on judgments of reasonableness that must be made from minimal experience and no supporting empirical data base. No empirical data are available for use in deciding what numerical factor scores indicate severe enough implementation difficulties for shifting the program design.

APPLICATIONS OF THE APPROXIMATE METHOD

The approximate method outlined above was applied to the flood plains along three small creeks in metropolitan Atlanta, Georgia.[1] The first, Noonday Creek has a wide flat flood plain in a middle class residential area just beginning to experience rapid development most of which so far is located on the fringes of the 100-year flood plain and thus away from the stream. The economic analysis used to formulate a target nonstructural flood control program selected a program relying on the flood proofing of new buildings at the time of construction. The measured factors suggested that such a program would be in difficulty because neither the community nor the managers of flood plain property believed that they have a significant flooding problem and the latter group are unlikely to be willing to spending extra money for flood proofing at the time of development. A hazard-commensurate land use pattern would probably have a more favorable response because less immediate cash outlay is involved.

The second, Proctor Creek flows through a black neighborhood comprised primarily of older lower class homes but also containing a few newer homes in the middle class price range. The economic analysis selected a program relying on flood proofing the existing buildings. Damages were too low to justify either structural measures or evacuating the existing developed area. The measured factors showed that flood proofing was acceptable in concept because the people had been flooded often enough to know that they had a problem and to recognize that something should be done. The factors also showed, however, a population of flood plain managers whose low incomes would make it very difficult for them to finance flood proofing their homes and who had very little time, ability, and inclination to undertake flood proofing on a do-it-yourself basis. Financial assistance was thus identified as a key implementation means in this case.

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[1]James, Benke, and Ragsdale, op. cit.

The third, Warren Creek floods a row of middle class houses that back onto the flood plain. The economic analysis selected construction of a small earth levee between the backs of the houses and the creek as the least expensive program but showed flood proofing to be not far behind. In this case, the flood plain managers were all aware of the problem, perceived a need to do something, were inclined to do it, and had sufficient income to afford modest expenditures to protect themselves. From the point of view of implementation, this would be the easiest of the three areas in which to develop an effective flood proofing program.

SUMMARY

The purpose of this paper is to identify some fundamental questions on the implementation of nonstructural flood control programs for discussion and not to present answers. The state of the art is still a long ways from that. If studies have thus far established any one fact, it is that nonstructural measures are not always implementationally feasible; and therefore, project specific information should be obtained and analyzed for each flood plain for which the nonstructural approach is being seriously considered. It is far better to find out that a program won't work in a planning evaluation than through failures at the time of implementation. In order to do this, we must develop methods of analysis that can do a better job of identifying probable success. This paper has outlined some thoughts on how the analysis might be improved. I expect that this group can furnish ideas that can be used to improve it ever more.

REAL ESTATE POLICY IN NON-STRUCTURAL FLOOD CONTROL PLANNING

By

E. L. Ingram, Jr.[1]

Any discussion of non-structural flood control planning is necessarily intertwined with the whole issue of land use. Land use regulation has only recently come to the fore-front as an issue to be dealt with in a sound, balanced way. With the release of the Public Land Law Review Commission's Report in June 1970, a concerted effort to codify, and where possible, to simplify the public land laws was begun in earnest. Land use legislation has been wending its way through Congress for several years now, without having come to a final vote. This is partially because of the emotional reactions generated by such legislation. The proposed law would set up certain incentives if local jurisdictions made comprehensive plans concerning the use of land on a regional, and even statewide basis. The law would provide that where Federal lands are involved, their proposed use must be coordinated with the director of a National Land Use Policy Board. The fate of this legislation is still pending, but it seems certain that some type of land use law will be passed in the near future. Implicit in such legislation is the recognition that State Governments should get into the business of land use control and long-range land use planning. It is realized that there will be apprehension by those who believe in the traditional system of local control over land-use decisions. However, this may be unwarranted since appropriate local decisions will remain under local control. The difference is that land use decisions must be made with the recognition that they have implications beyond the particular town or county in which they are made. This means an integrated approach that will be of benefit to all.

It would be well to look at some of the case law in the field of land use regulation. Early in our history, the courts construed the taking clause of the 5th Amendment to the Constitution strictly, so that in order for an owner to receive compensation his property must have been actually taken in the physical sense of the word. No indirect or consequential damage warranted compensation. A new direction appeared in the early 20th Century, primarily promoted by Justice Holmes. In 1922, Holmes announced his famous rule in Pennsylvania Coal Co. v. Mahon: "The general rule at least is that while property may be regulated to a certain extent, if regulation goes too far it will be recognized as a taking." Thus, when a diminution of property values by regulation reaches a certain magnitude, a taking occurs. Based on this reasoning, the courts have continued to use a balancing test--a weighing of the public benefits of the regulation against the extent of loss of property values.

[1]E. L. Ingram, Jr., Chief, Acquisition Division
Directorate of Real Estate, Office, Chief of Engineers

The application of this balancing test has been left mostly to the state courts. In general, the courts seem to have established a "presumption of validity" for local regulations of land use, although in many states the presumption is easily rebutted. Consequently, the question of whether there has been a taking turns on the particular facts in a given case.

In this light, we should examine two fairly recent state court decisions in the area of flood plain zoning. In a 1971 case out of Michigan, a local flood plain zoning ordinance was struck down. (Sturdy Homes, Inc. v. Township of Redford, 186 NW 2d 43). In that case the Plaintiff brought an action to compel the Township to issue a building permit. The Township had refused since the property lay in an area designated as a flood control area. The court held that denial of the building permit was unreasonable and granted the requested relief. It pointed out that although there had been floods in the general area, plaintiff's land had never been flooded. The only use that he could make of the land was to build a detached single family house, and in doing so there was no danger to public health or safety from flooding. The Appellate Court upheld the lower court's decision, but took issue with the finding that flood plain zoning was confiscatory in that it constituted a taking of private property without just compensation. Rather, the test was one of reasonableness measured in light of its relationship to the public health, safety, morale and general welfare of the community as a whole.

The opposite view upholding a flood plain ordinance was the subject of a 1972 California case. (Turner v. County of Del Norte, 24 Cal. App. 3d 311). This was an action against the county brought by a sub-divider and other landowners alleging an inverse condemnation in that the zoning of their property under the flood plain ordinance amounted to a taking without compensation. The court held that the county was acting within the scope of its police power in enacting the flood plain zoning ordinance and there was no taking of property. The facts showed that there had been a prior history of extensive flooding of the land. The zoning regulations were adopted in 1965 and 1966. The ordinance prohibited permanent residences and commercial and public buildings, while allowing boating facilities, campgrounds, trailer parks and agricultural uses. The court pointed out the history of flooding and that anything built in the zoned area would be subject to being destroyed by floods, and endanger lives and health. Therefore, the ordinance was reasonable in relation to the health, safety, and welfare of the public.

Although the state of the law on land use cases is somewhat confused, one generalization can be drawn. There is a strong tendency on the part of the courts to approve land use regulations if the purpose of the regulation is statewide or regional in nature rather than merely local. Although the courts are supporting local land use regulations with a reasonable degree of consistency, they show an obvious preference for regulations having broad multi-purpose goals.

The aforementioned cases deal with local zoning powers which the Federal Government of course does not have. Consequently, where the Federal Government is directly involved in this type of flood prevention, it must do so by acquiring a controlling interest in the land, either outright in fee or with some restrictive type of easement. Under such a plan, all landowners affected would receive just compensation for the interest acquired from them.

Our policy in any type of land acquisition program is to purchase the land whenever possible through actual, practical and realistic negotiations. We operate under the provisions of Title III of the Uniform Relocation Assistance and Land Acquisition Policies Act of 1970, Public Law 91-646. The amount offered for the land is developed by an appraiser using standard appraisal methods, whose report is thoroughly reviewed by an experienced reviewing appraiser to insure that it is adequately prepared and consistent with other similar values in the area. The full amount of the appraised value so developed is offered to the landowner, who may accept or reject it, or bargain for some higher figure. If we cannot reach agreement with the landowner because we feel the price he is asking is too high, we must then resort to the Government's power of eminent domain. Condemnation proceedings are instituted with the filing of a Declaration of Taking. Along with this instrument, the Government deposits into court its estimate of compensation, which can be withdrawn by the landowner for his use pending the final outcome of the case. Title automatically passes to the Government upon filing of the Declaration of Taking, and the only issue remaining is the determination of just compensation. The Government may obtain possession of the property, but must give at least 90 days written notice before displacing the occupant. Public Law 91-646 also provides certain relocation assistance benefits designed to assist those persons whose property is being taken for a public use.

I have given you a general overview of our land acquisition policy. We might look at how this fits into the subject of non-structural flood control planning. Section 73 of Public Law 93-251 is a mile post in legislation and provides a mandate for the consideration of non-structural alternatives in flood control planning. I might point out at this time that the 1961 Survey Manual of the Corps, EM 1120-2-101, paragraph 1-76, provided that reports should discuss various practical methods of solutions to flood problems, including, either singly or in combination, flood plain regulation, evacuation and resettlement, and the usual traditional structural measures of increasing flood carrying capacity or control. One of the alternatives to a flood control structure would be to acquire the land or impose an easement thereon. The main consideration of this alternative would be the cost involved. If the area is developed to the point that the cost would be prohibitive in terms of other alternatives, land acquisition would not be the answer. However, such programs may often provide the best answer to accomplish the goal of effective flood control when weighed against all the issues, including the citizens' expectations and environmental considerations. Therefore, the consideration of land acquisition must be included in the planning of any flood control project. It should be pointed out that Section 73 requires that where a non-structural alternative is recommended, non-Federal participation from any local interest shall be comparable to the value of lands, easements, and rights-of-way which would have been required of non-Federal interests under Section 3 of the Act of June 27, 1936 (Public Law 738, 74th Congress), for structural protection measures, but in no event shall exceed 20% of the project costs. Thus, cost-sharing is comparable to traditional structural alternatives for local protection projects. The maximum non-Federal contribution of 20% is the average cost experience on traditional structural flood control plans.

Paragraph 9 of the draft ER on Non-Structural Alternatives in Flood Related Planning deals with real estate interests (ER 1105-2-____, 19 March 1976). It points out that we have the capability to acquire the necessary real estate interests for non-structural measures, and that land acquisition by the Corps would assure uniform procedures nationwide. The paragraph mentions aspects of non-structural measures other than acquisition which affect real estate. It states that in instances where flood insurance is required as a condition of Federal involvement, local interests will insure that flood insurance is acquired annually for each of the improved properties that remain in the project flood plain. The regulation requires that before construction of any non-structural measure such as flood proofing, raising, or relocation of a building to a new site, legal and enforceable contracts must be executed between structure owners and the local cooperating agency. In instances where a building owner does not desire that his building be raised, this building will be eliminated from the plan of improvement. Where buildings are to be relocated to a new site and the owner does not wish to relocate, the property shall be purchased. The regulation points out that care must be taken to insure that evacuated lands are used for purposes outlined in the management plan such as recreation, fish and wildlife, or open space. To insure that these lands are used in accordance with the management plan, the Corps will purchase the land, remove structures, restore the land, and convey the land to another Federal agency or to a state agency with the condition that it revert to the Federal Government if not used for the purposes outlined in the management plan. Where evacuation is recommended, a person may elect to live in his house for a term not to exceed 15 years. When a person selects this option, the Corps will purchase his property, but any benefits under the Relocation Assistance Act, the Flood Insurance Act, or the Flood Disaster Protection Act will be forfeited.

Thus far, there have been three projects where we have been involved on a planning basis for non-structural alternatives, but two of these have not been funded. All three were authorized by the Water Resources Development Act of 1974, Public Law 93-251. The first of these is to provide flood protection for Prairie due Chien, Wisconsin, a city of about 6,000 that is situated along the Mississippi River in a valley 1-1/2 miles wide. Approximately 42% of the town's area is developed, with potential for future development of another 40%. Local interests requested aid in developing a flood control plan, and Federal and State representatives expressed interest in the project. Floods in 1967 and 1969 stimulated the community drive for flood control. Wide support was given by city officials for a permanent evacuation plan that would allow prudent use of the flood plain areas, such as an expanded park system to complement the existing historical and water-based attractions within the community.

The only practical and economically justified solution to the flood problems at Prairie du Chien would be a project to flood-proof or evacuate and relocate business and residential structures in the flood plain. This would involve the purchase and demolition of approximately 48 structures, relocation of about 157 structures, raising and flood-proofing about 40 others, and management of the flood plain in a manner compatible with the objectives of the project. The project authorization requires that local interests furnish assurances of local cooperation, including Federal ownership of a flowage easement on lands in the design flood plain, and bear 20% of all project costs, presently estimated at $460,000.

The Charles River Watershed in Massachusetts is another example of a project being planned on the basis of non-structural alternatives. Like Prairie du Chien, the project is also authorized by Section 2 of PL 93-251. The planning studies showed that the natural valley water storage contained in the many swamps, marshes and other wetlands in the Charles River Basin modify the high and low flows of the river in the same manner as a reservoir, and provide a natural solution for the basin's growing flood control problems. Continuing urbanization threatens the wetlands, and without the storage they afford, flooding would become an increasingly serious problem. A combination of Federal and non-Federal actions to preserve the marshes, swamps and wetlands in their present state as natural floodwater detention areas is needed to reduce growth in flood losses and to safeguard natural open space. There will be Federal acquisition of lands and easements in 17 natural valley storage areas totalling 8,500 acres that are critical to the comprehensive flood reduction plan for the entire watershed.

Positive measures are necessary to assure that future flood loss is kept to a minimum. Of the methods available for flood damage prevention, Federal acquisition of regionally significant natural valley storage areas offers a manageable approach. It is compatible and complementary with local and state flood management actions. The plan proposed is one which would provide the opportunity for multiple use of the natural resources of the watershed.

All structural alternatives were found to be more costly than the recommended plan. Assurances will be required from local interests that:

a. Existing roadways, utilities, bridges, culverts, and any other improvements that might affect the drainage characteristics of the natural storage areas will not be modified or altered;

b. That local interests will adopt and enforce regulations to restrict development of flood plain lands; and

c. That they will operate and maintain the existing dams along the Charles River. In this project, unlike Prairie du Chien, the cost of lands and interests therein and annual charges are a Federal cost.

The first two of these projects were authorized in Section 2 of PL 93-251. The third one was picked up in Section 88 of the Act and modified the existing project for flood control below Chatfield Dam on the South Platte River, Colorado. The Secretary of the Army, acting through the Chief of Engineers, is authorized to participate with non-Federal interests in the acquisition of lands and interests therein and the development of recreational facilities immediately downstream of the Chatfield Dam, in lieu of a portion of the authorized channel improvement, for the purpose of flood control and recreation.

Federal participation is limited to the amount of savings realized by the United States in not constructing that portion of the authorized channel improvement below the dam, together with such share of any land acquisition and recreation development costs, over and above that amount, that the Secretary of the Army determines is comparable to the share available under similar Federal programs providing financial assistance for recreation and open spaces.

Land acquisition is limited to those lands deemed necessary by the Secretary of the Army for flood control purposes, and not otherwise reduce the local cooperation required under the project.

Non-Federal interests shall enter into a binding written agreement with the Secretary of the Army to prevent any encroachments in needed flood plain detention areas which would reduce their capability for flood detention and recreation.

The agreement must be consummated prior to the furnishing of the Federal participation authorized by the Act. Negotiations with local interests are under way and the local agency is presently negotiating for options based on land values approved by the Corps.

In conclusion I would emphasize that real estate acquisition policy in connection with non-structural alternatives to flood control is essentially the same as real estate policy used for traditional flood control projects. Once the decision has been made to use non-structural alternatives, the area defined, the estate established, our people will appraise and negotiate in the same manner as they do where a dam is being built. By these methods we are successful in purchasing over 80% of our land requirements, and there is no reason to believe that a new approach to flood control would indicate any less success. In fact, the non-structural approach may have more local support, leading to a higher percentage of purchase and less condemnation. At any rate, the Real Estate Directorate of the Corps of Engineers has the ability and stands ready to be an important part of this new thrust in the area of flood control.

SCREENING FOR NON-STRUCTURAL ALTERNATIVES IN THE SUSQUEHANNA RIVER BASIN

By

Harold L. Nelson [1]

In 1970, a Level B Comprehensive basin study was completed of the Susquehanna River Basin by the Federal agencies and the States of Maryland and New York and the Commonwealth of Pennsylvania. The flood control component of the early action plan consisted of five reservoirs and five local flood protection projects. Prior to implementation of any of these potential projects, Tropical Storm Agnes occurred which was the flood of record in most of the basin. As a result of the devastation wrecked by this flood, the Congress requested that the Corps of Engineers review the flood control recommendations contained in the comprehensive report and to determine whether the recommendations should be revised in view of this disasterous flood.

A review study was initiated in Fiscal Year 1974. Only traditional structural solutions were considered in the 1970 comprehensive study whereas non-structural solutions would need to be investigated in the review study because of the increased interest in these types of solutions by both the Congress and the affected public.

In the Susquehanna River Basin, there are about 300 communities in the flood plain along the main stem of the river and its major tributaries. Because it is a level B study, each community does not need to be examined in survey scope detail. Even to examine each community from a broad basin approach, however, would require a large amount of time, funds, and manpower which were not available. This paper describes the screening process which was developed to identify the communities with the highest potential for a non-structural solution to their flood control problem.

The methodology presented is based on a review of recent reports on the use of non-structural approaches and a pilot study on Jersey Shore, Pennsylvania. The various non-structural measures used in this study, the assumptions, and the methodology of formulating and evaluating non-structural plans are discussed in subsequent sections.

Pilot Study of Jersey Shore, Pennsylvania

In order to develop the screening process, it was felt that a small community should be analyzed in detail to determine which factors could best be used to screen for the communities where a non-structural approach would be feasible. Jersey Shore, located on the West

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[1] Assistant Chief, Planning Division, Baltimore District

Branch Susquehanna River, was selected because it is small community with about 400 flood plain residences, a commercial business district, and a light manufacturing industrial concern. It does not have an existing local flood protection project but is afforded some protection by four upstream reservoirs. The types of construction involved in the residences and the commercial business district is typical of other communities throughout the basin.

Methodology

During the evaluation of flood control measures for Jersey Shore, various non-structural alternatives to either lessen the impact of flood damages or reduce the flood hazard were considered in developing a non-structural methodology. The non-structural techniques evaluated include:

1. Flood Proofing
2. Permanent Relocation
3. Flood Insurance
4. Flood Forecast and Warning
5. Flood Plain Management

It became readily apparent during the study that only a portion of the alternatives could be evaluated quantitatively and this was possible only if several very general assumptions were made. In addition, the feasibility of the various alternatives was addressed only in economic terms and other considerations such as social, political, and environmental factors were not addressed. It was felt that these considerations could be addressed when potential economically feasible projects could be identified, but were not pertinent to the basic screening process. It is recognized, however, that these considerations are very important and must be addressed should any non-structural plan approach economic justification. With regard to economic evaluation, benefits were developed for reduciing flood damages from West Branch Susquehanna River flows only and not for the small tributary streams which flow through the town. However, flood damages caused by the small streams, although more frequent, are small when compared to the damages caused by river overflows.

To facilitate necessary data collection, community-wide and structures survey forms were prepared. Some of the data was available in office files, but the bulk of the data was obtained through a short meeting with knowledgeable local officials and a "windshield" field inspection. Available data includes identification, numbering, use, condition, size and lack of or presence of basement for each appraisal in the flood plain in the early 1960's, and hydraulic and hydrologic data such as sources of flooding, average flow velocities, duration of flooding, and depths of inundation for historical floods. The type of information obtained during the field inspection included type of construction; elevation of first floor referenced to the ground; the type, size and positioning of all building openings; structural condition of the building; changed conditions since the latest flood damage survey; and items which may effect non-structural solutions. Residential appraisals were "averaged" and a single general description for the entire community was utilized during the evaluation. Commercial, public and industrial appraisals did not lend themselves to a general categorizing procedure, however, and each structure had to be inspected individually. We met with local officials to collect information concerning location and flooding susceptibility of essential municipal facilities such as police, fire department, hospitals, etc., and the community's flood emergency program.

A discussion of the evaluation of each alternative to include assumptions and procedures follows:

1. Flood Proofing

Three distinct types of flood proofing measures were identified for consideration for residential appraisals. These were, (1) flood proofing of the building to the maximum possible level to essentially preclude floodwaters from entering the building's interior; (2) provision of a waterproof utility cell to house the furnace, hot water heater, and electric switchbox in the otherwise flooded basement; and (3) raising of the building above the flood level. Flood proofing "packages" reflecting the construction items and the related cost required for implementation of each alternative were assembled. The unit costs utilized were calculated on the basis of Federal participation in any eventual project and thus reflect Federal guidelines on wages.

It was recognized individuals or local contractors could possibly accomplish the work for a lesser cost. The first costs thus derived were expressed on an annual basis utilizing a 6-1/8 percent interest rate and a project economic life of 50 years. It should be noted that the 50 year project life may be a liberal estimate for many buildings due to their present age and condition. Annual costs for operation, maintenance, and replacement were not included as they were considered minimal.

For the "dry interior" flood proofing package, construction items included permanent blocking of basement openings, waterproofing of interior and exposed exterior basement walls, provision of a sump pump and electric pump and installation of an automatic check valve in the sewage lines. The effectiveness of the waterproofing by means of applying masonry paint or spraying a silicone stearate material on the walls is questionable at best; but was assumed satisfactory for this evaluation. Based on structural analyses made for the Lock Haven Survey Report, the maximum height of flood proofing was assumed to be three feet above the ground level. Since the first floor of most residences in Jersey Shore are two to three feet above ground level and it is questionable that the first floor of the predominantly wood frame houses could be made water-tight, flood proofing to the first floor level or three feet above the ground was considered to be the maximum possible level. The benefits generally realized under this plan would be the elimination of average annual damages that would otherwise occur in the basement.

The second method of residential flood proofing evaluated consisted of constructing a waterproof concrete block utility cell to house the furnace, hot water heater, and electric switchbox. The remainder of the basement could be utilized for storage but would be subject to normal flooding. The benefits for this plan would equal the damages prevented to the aforementioned utility items and were estimated to be from 9 to 25 percent of the total damages occuring in the basement depending on the residential classification.

The third and last residential flood proofing method considered was raising of the structure by raising the super structure and construction of an additional foundation wall to the design level. A maximum raising height of six feet was assumed based on a stability analysis made in connection with the Tug Fork Flood Control Report and the aesthetic values associated with higher raising. According to information contained in the Tug Fork Report, raisings of more than six feet would necessitate replacement of foundation walls with those of heavier cross section. A possible problem in raising which was identified but not addressed was access (stairways) to the houses particularily for those that are presently located directly adjacent to the sidewalk and street. Benefits attributable to this plan would result from the elimination of damages that would otherwise occur if the buillding was not raised.

Flood proofing of commercial and public service appraisals were treated somewhat differently than residences in that protection above the first floor level was assumed structurally practical to a height of six feet above ground level and raising up to this same height was not considered since this would undoubtedly cost more than flood proofing. The vertical limit on flood proofing is based on the Lock Haven Report. The components of basement and/or first floor flood proofing included permanent blockage of basement openings, temporary flood shields for first story doors and windows, a sump and electric pump, waterproofing of walls, and an automatic check valve in the sewage line. Benefits would equal the average annual damages eliminated.

Industrial appraisals in Jersey Shore were evaluated on an individual basis utilizing two general solutions, i.e., ring levee/floodwall or flood proofing. The ring levee/floodwall would be designed to act as a small local protection project, complete with closures and portable pumps to discharge interior drainage. Access to the industry would be maintained by driveways and railroad tracks if needed. The rational formula, Q=ciA, was used to estimate discharge capacities required for the pumps. Levels of protection up to the flood of record were considered and two feet of freeboard was used in levee and wall design. Unit cost curves for both levees and walls were developed for future use. Flood proofing techniques for industries were the same as those utilized for commercial buildings. Benefits were computed as the average annual damages eliminated up to the design level.

2. Permanent Relocation

Acquisition of flood plain improvements and property, demolition of the structures and evacuation of the owners was the second non-structural technique evaluated. This alternative was considered for residential, commercial, and public service appraisals only since cost estimates could be generated with existing data. Cost for industrial evacuation would, in all likelihood, have to be obtained from the local manufacturing leaders, thus creating the possibility of adverse public reaction to potential evacuation of key industries. Real estate costs for residences of the three generalized categories included market value of the properties and acquisition and resettlement costs. For the commercial and public service appraisals, the real estate costs were based on the maximum flood damage possible for each building based on our generalized stage-damage data. A lump sum cost of $6,000, which represents the minimum total estimated acquisition and resettlement costs for a residence was added to the maximum damage figure to cover these cost items for commercial and public properties. It is felt that the resulting first cost is conservative since items such as land costs and inflated property values due to locational advantages are not included in the maximum flood damage figure. Also, none of the estimates includes demolition or redevelopment (parks, playgrounds, etc.) costs which would be necessary to realistically implement an evacuation plan. The resulting first cost was expressed on an annual basis utilizing 6-1/8 percent interest rate and a 50 year project life. Benefits were taken as the average annual flood damages which would be eliminated for the entire range of flooding.

3. Flood Insurance

Initially, this non-structural alternative does nothing to reduce flood hazard or damages, but, rather, lessens the economic burden of flooding on flood plain occupants. Over the long term, however, the land use regulations required for participation in HUD's National Flood Insurance Program will effectively reduce the amount of existing flood prone development and associated damage potential and control future flood plain development. This "relocation by attrition" aspect of the flood insurance program has been strengthened by passage of the Flood Disaster Protection Act of 1973, P. L. 93-234. The Act provides that no Federal agencies or Federally backed financial institution shall approve any financial assistance for acquisition or construction purposes in flood hazard areas unless the community in which the area is located is participating in the National Flood Insurance Program. Due to the legislative requirements of the insurance program, existing development susceptible to damage by the one hundred year flood cannot be substantially improved without the owner acquiring flood insurance.

No attempt was made to evaluate flood insurance on a benefit to cost relationship since there are no overall economic benefits initially and future benefits accruing to "relocation by attrition" are difficult to quantify with any degree of accuracy.

4. Flood Forecast and Warning

Relatively short-term action taken as a result of a reliable and timely forecast and warning of an impending flood can significantly reduce the economic losses and human suffering that would otherwise be caused by the flood. The Federal-State River Forecast Service located in Harrisburg gathers rainfall, river stage, and weather forecast information and disseminates flood warnings to the news media and local authorities. From the 1970 Susquehanna River Report, the average warning time for Jersey Shore is 24-30 hours. If the local residents have faith in the warnings and act accordingly, it can be assumed that significant reductions in flood damages will be realized. The temporary relocation of readily transportable items out of the flood plain would result in twenty to thirty percent reduction, on the average, in urban residential flood damages in the Susquehanna Basin according to the 1970 report, "Flood Warning Benefit Evaluation, Susquehanna River Basin (Urban Residences)," by Harold J. Day, U. S. Weather Bureau. Mr. Day calculated that benefit-cost ratios ranging from 3.1 to 7.5 could be attributed to various flood warning efforts depending on location in the basin. The benefits he used were the reduced flood damages due to temporary relocation while the costs reflect the value of labor and materials necessary to remove and return the household items, as if a moving company was involved. It can be assumed similar results would occur with commerical, public and industrial appraisals. However, flood damage reduction estimates can vary greatly depending on such variables as age and health of residents, the availability of manpower, and the faith the local people place in the warnings. No new analyses of flood warning efforts were made for this study.

5. Flood Plain Management

Among the many flood plain management tools available to reduce flood damages are relocation, flood insurance, flood forecast and warning, and land control measures. All of these except the latter have been previously discussed. Land use controls to include zoning, subdivision, regulations, building codes, development policies, designated floodways, and encroachment lines attempt to mold the flood plain development in such a manner as to lessen the damaging effects of floods. These measures are obviously more applicable to future development than to existing structures. There is no straightforward way to evaluate economic justification of land use controls, but they are potentially valuable aids for communities as they seek to minimize their flood problems. In practice these measures are used with the flood insurance program to make a comprehensive package to deal with present and future flood damages.

Formulation

Using the methodology described above, benefit-cost ratios were calculated by computer for all residential appraisals for flood proofing and permanent evacuation measures. Using this information, zones of applicability can be generated to show where there is the potential of applying particular types of non-structural measures.

Because of the large variety of commercial, industrial, and public properties, it was necessary to manually compute benefit-cost ratios for each of these types of appraisals. The different types of structures and their uses did not allow a generalized cost or benefit function to be used. Each industrial appraisal was evaluated separately. For the commmercial and public properties, however, the appraisals were divided into categories of similar appraisals such as offices, service stations, churches, appliances, etc. The building with the highest potential average annual damage for each category was used as representative of that category. This procedure was felt to present the most favorable conditions for flood proofing. Also, block long groups of buildings were analyzed as a unit to minimize costs in determing if non-structural measures could be applied to an entire block.

Results

The application of the non-structural methodology showed that the non-structural measures were not economically justified for the residential and most commercial and public properties in Jersey Shore. Some individual structures including residential, commercial, public, and industrial appraisals did show that some form of flood proofing would be economically justified. However, on a community-wide basis, there was an overall lack of justification. It must be noted that other considerations might also prove those few economically justified cases to be impracticable.

Conclusions

On the basis of the pilot study for Jersey Shore, the following conclusions were reached:

a. The approach as applied at Jersey Shore can be used throughout the basin.

b. The level of detail used is the minimal level which would be adequate for plan formulation.

c. It is recognized there are deficiencies in evaluation of the structural and especially the social, environmental and political aspects of non-structural measures which will have to be addressed if a plan is economically justified for a community.

d. It is estimated that to do a non-structural analysis, once the methodology and procedure is finalized, for a community the size of Jersey Shore (5,000) would take approximately 5 man-weeks.

Screening Process

In view of the fact that there are several hundred communities in the Susquehanna River Basin with flood problems, it is not possible within time, money, and manpower limitations to evaluate each and every one on an individual basis.

In order to fairly and logically apply the non-structural approach throughout the Basin, all the communities must be screened to eliminate those where non-structural measures appear to be definitely not feasible. Maximum effort can then be spent on those communities which show the most promise for non-structural solutions to flooding problems. The screening methodology is outlined in Figure 1 and described below.

During the Jersey Shore pilot study, it was obvious that non-structural measures were not feasible for the community. A search was made for what would be a good indicator for a non-structural project. The location of the house in the flood plain became the indicator. The stage-damage relationship of each house is fixed as is the stage-discharge and discharge-frequency curves for each community. Using the typical house in Jersey Shore, it was determined that it would have to be located in the 10 year flood plain for the benefit-cost ratio to approach unity for any non-structural measure. This was verified for several other locations in the Susquehanna River Basin and compared favorably to the conditions at Prairie de Chien, Wisconsin, where flooding occurs every two years and a non-structural project has been authorized. Therefore, it was decided to use the 15-year flood as an indicator. Buildings located above this

FLOW CHART FOR
SCREENING PROCEDURE
NON-STRUCTURAL ALTERNATIVES

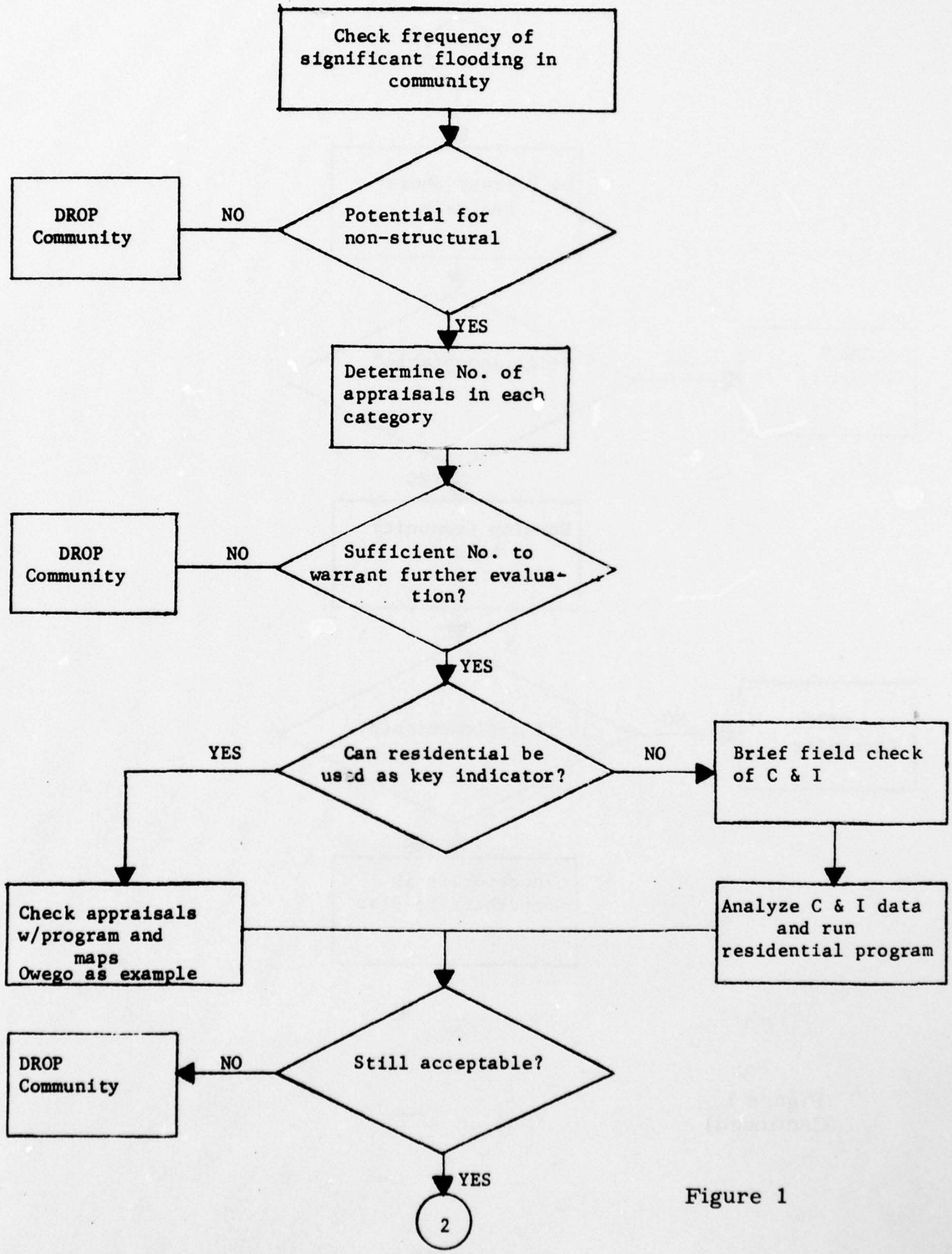

Figure 1

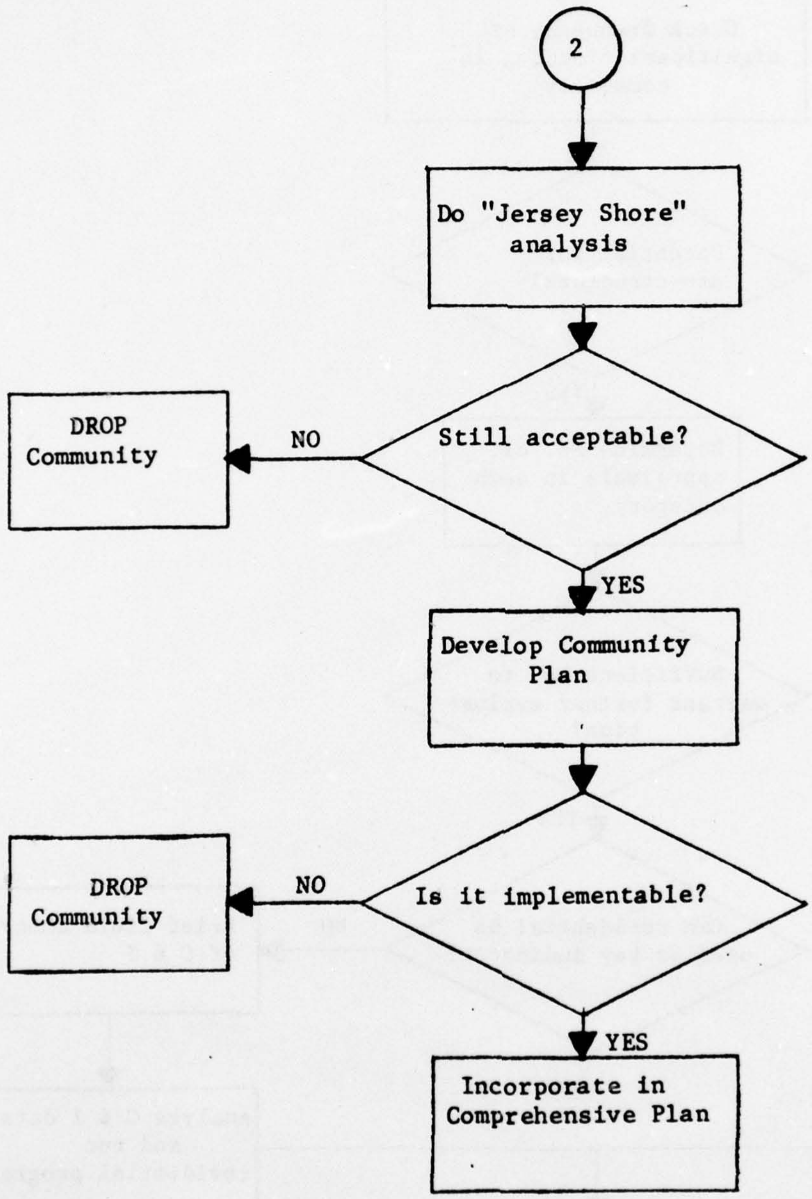

Figure 1
(Continued)

flood plain would not receive enough flooding to justify a non-structural approach.

The screening process starts by analyzing the stage-damage-frequency data for each community to determine its flood problem. Figure 2 is the form used in organizing this data. Three levels of flooding were used as indicators of flood damages. These levels were the flood of record (FOR), the flood that caused significant damages (approximated as 10% of the FOR damages) and the flood which caused first damage in the community. For each of these floods the dollar damages, the frequency of occurence in percent chance, and the percent of "flood-proofable" damage which is residential (PDR) were determined. The PDR is defined as the residential portion in percent of the total residential, commercial, industrial, and public damages which are the damages that can be reduced by a non-structural plan. Other damages to include transportation and utility losses cannot practicably be reduced by non-structural methods.

The first screening level eliminated those communities where the significant damage causing flood is no more frequent than the 15 year flood. Based on economic evaluations made for a hypothetical residential structure, the building had to suffer significant damage at the 15 year flood level or lower to justify non-structural flood reduction measures. It was assumed, therefore, that sufficient average annual benefits could not normally be generated to justify non-structural alternatives for a community unless significant damages could be expected to occur at least every 15 years. If a community had significant damage more frequently than the 15 year flood, it was then considered for further evaluation.

The second level of screening evaluates the number of appraisals in each community. Those communities with fewer than 25 appraisals did not warrant a more detailed evaluation. The communities which pass these first two tests would then be considered further in the third screening level.

In the third level, if more than 67 percent of the community's damages are residential (PDR) then an assessment of the economic feasibility of non-structural measures will be based on an analysis of the residential appraisals only. The residential appraisals are considered to be a key indicator for a community. For those communities where the PDR is less than 67 percent the commercial, industrial and/or public appraisals have to be evaluated further to determine the economic feasibility of non-structural measures. Pertinent data for residential structures is stored on magnetic tape and the economic feasibility of non-structural measures for residences is determined by a computer program. The analysis for the other categories which is required when the PDR is less than 67 percent requires a brief field trip to augment existing data. The data are

SUSQUEHANNA RIVER BASIN REVIEW STUDY

NON-STRUCTURAL ALTERNATIVES - SCREENING PROCESS

REACH & COMMUNITY	FREQUENCY-DAMAGE DATA FOR 3 FLOOD LEVELS									Eval. Further	Use Resid. Test	REMARKS
	$ 1st Damage			"Significant" Dam.			FOR					
	$/1000	Freq. %	PDR 1/	$/1000	Freq. %	PDR 1/	$/1000	Freq. %	PDR 1/	Y or N	Y or N	

Figure 2

1/ Percent of "flood-proofable" Damage which is Residential manually analyzed and combined with the computer analysis of residential appraisals.

The results of either method of analysis at this level are then placed on a community map to determine whether those structures which are feasible are located in one area or are scattered throughout the community.

On the basis of this screening level if a community still appears to have a non-structural program which is economically justified then it is further evaluated in a "Jersey Shore" analysis. At this analysis additional data on the particular flood problem in the community will be collected. Community officials will be contacted to obtain their input.

Again, if the analysis at this level shows that a non-structural plan for the community is still economically feasible, a more detailed analysis will be performed. Those communities which are determined to have an unacceptable economic situation are dropped from further consideration for a Federal non-structural plan.

For those communities which remain after the fourth level of screening, a community plan will be developed. In this analysis the non-structural measures which are economically feasible are refined further. Also at this time an assessment of the environmental, social and institutional effects of non-structural plan will be included in the analysis. Upon the completion of the analysis at this level, a determination will be made as to whether or not the community plan is still feasible and most importantly, whether it is capable of being implemented. Those communities which have an implementable non-structural plan will then be incorporated in the overall Susquehanna Basin flood control plan formulation.

CONSIDERATIONS FOR "NON-STRUCTURAL" FLOOD CONTROL PLANNING IN THE PACIFIC OCEAN DIVISION

By - John R. Pelowski[1/]

INTRODUCTION.

Historically, annual flood losses have continued to increase in spite of large amounts of money spent for planning and construction of flood control works. The Federal Government has invested over $9 billion for flood control projects since 1936. Non-Federal governments have invested additional millions. Currently, annual losses from floods are almost $2 billion. This trend has been recognized for many years. In the early 1960's, the Corps of Engineers initiated a program of flood plain management services intended to define and publicize potential flood hazards in order to discourage unwise use and development of the nation's flood plains. For various reasons, this program has been only partially successful and annual flood damages continue to mount. Ideally, definition of the flood hazard of a given flood plain prior to development would direct wise planning and subsequent use. In the real world this is not usually the case. The need and subsequent assignment of priorities for flood plain information studies, or flood control studies, is established after some development has taken place and a flood problem exists. The very term flood control, in its general usage, implies physical control of water in time of flood. Current factors of construction and land costs, social and environmental considerations, fish and wildlife concerns and the level of protection required in today's planning and design of urban flood "control" projects has made acceptance and economic justification of traditional flood control works difficult. Yet the nation's annual loss from floods continues to increase. Clearly, an alternative to total restriction of flood plain usage, or, on the other end of the spectrum, physical control of periodic overflows of our streams and rivers is necessary in planning for continued and future use of our flood plains. Non-structural methods of reducing damages from floods that allow continued existing use and future development of flood plain lands, depending on local factors, can fill this need; not as a clearly separated alternative, but in combination with other methods of physical and land-use controls.

The following paragraphs discuss physical and economic factors influencing planning for flood damage reductions in the Pacific Ocean Division. Examples of completed, authorized and planned projects using non-structural elements are described.

DESCRIPTION.

The land mass above sea level in Hawaii, Guam, and American Samoa is relatively small extending from sea level to as high as 13,000 feet above sea level. The land areas are characterized by steep mountains with deeply

1/ Chief, River Basin Planning, Planning Branch, Engineering Division, Pacific Ocean Division incised valleys with very steep slopes. Streams draining the valleys have (by mainland standards) very small drainage areas. These areas range from only a few square miles to a few hundred square miles. Because of steep slopes, climatic conditions, and proximity to the beaches and transportation systems, development is principally limited to the coastal plain from sea level and up the valleys to roughly 200 feet elevation. Much of these areas are necessarily the valleys and coastal plains subject to inundation from stream flooding or tsunami (tidal waves).

Annual rainfall ranges from less than 15 inches on the leeward side of the islands such as in Waikiki on Oahu, to the wettest place in the world at Mount Waialeale on the island of Kauai with annual rainfall of over 450 inches. Normally, rainfall is orographically induced as trade winds push moist air from the ocean up the steep mountain slopes. Very intense rain of over 25 inches in 24 hours can occur. It is these events that normally cause destructive flooding. Flood peaks rise in a matter of a few hours and flow with high velocity through the valleys and across the coastal plain to the ocean. Flood velocities range from 5 feet per second near the coastline up to 40 feet per second in the upper areas of the steep valleys.

Because of expanding economy and population, and limited buildable land, areas subject to inundation in Hawaii have, and will continue to be developed. This, in spite of the threat of damage from flooding, the existing requirements for flood insurance, and/or local land use regulations and building codes. While some years behind, the same condition can be projected for Guam and American Samoa. At this time, residential land, whether developed, or planned for development, is valued at $8 to $15 per square foot. Economic pressures will support continued development in areas subject to flooding. Economics, as well as the current, active concerns for visual aesthetics and environmental and social considerations, severely constrain development of purely structural flood control projects. Specific considerations of the applicability of non-structural solutions of flood problems in POD are addressed in the following paragraphs.

FLOOD DAMAGE REDUCTION BY NON-STRUCTURAL MEANS.

FLOOD PROOFING. Flood proofing of existing and future structures can, with some limitations, be very effective, depending on the location of the structure. The depths and velocity of potential flooding is the key. Basements are very uncommon. Most structures are either built "slab on-grade" (residential and commercial) or on stilts or pilings a few feet above the ground. It is obvious, in older areas, that the early residents of flood-prone lands were aware of potential depths of inundation. Recent floods approaching 100-year frequency, in rural areas, resulted in flood depths at or just below the first floor elevation. New structures built, particularly in the valleys, do not exhibit this awareness. Raising the first floor above potential flood levels is, and could be very effective in reducing substantial flood damages. In areas of high velocities, the effectiveness of flood proofing is constrained by economic considerations of providing waterproofing and particularly structural stability for the high velocities carrying debris and boulders. Damage to landscaping, automobiles or outbuildings would not be reduced.

ZONING, EVACUATION, AND ACQUISITION OF FLOOD PLAIN LAND. From social and economic considerations, elimination of use of flood plains is particularly undesirable. Limited available buildable land is one reason. While economics are important, there is a much more basic reluctance to relocation. Early Hawaiians, and subsequent peoples arriving and developing the economies and lifestyles of the islands have centered their activities by the ocean and in the nearby valleys.

FLOOD INSURANCE. Flood insurance is available, but relatively few policies have been issued. This is because of lack of knowledge of availability, or need for coverage. This is particularly evident in established areas. Recent subdivisions or condominium developments being sold in or near potential flood hazard areas require flood insurance. Flood insurance does nothing to reduce flood damages but spreads the cost of flood damage. Flood insurance, while potentially beneficial to the policy holder, contributes nothing to the reduction of damages by flooding.

FLOOD FORECASTING, WARNING, TEMPORARY MEASURES. The effectiveness of these measures is a direct function of time to react, coupled with a belief by the residents of the flood plain of the accuracy of the forecast or warning. This confidence is most often based on past experience. Flood plain residents in the unprotected reaches of the Mississippi, Ohio, or Missouri Rivers, and other major rivers and their tributaries, have days, and even weeks to prepare for high flood stages. This time allows for flood preparations such as floodproofing, sandbagging, or even construction of emergency levees or floodwalls, and evacuation of people and goods. In areas where the time from peak rainfall, to peak flood discharge, is a matter of hours, the primary aim of forecasting and warning is to save lives. In known critical urban areas in Hawaii, civil defense agencies, in cooperation with the National Weather Service and police have established plans for evacuation of people from flood-prone areas in time of heavy rainfall or possible tsunami. While lives can be saved, little can be done to reduce destruction of property.

"NON-STRUCTURAL" PROJECTS.

No strictly "non-structural" flood damage reduction projects have been developed in the Pacific Ocean Division. Four projects are described below that incorporate non-structural elements with traditional structural means to reduce flood damages.

KAWAINUI SWAMP, OAHU, HAWAII. This project, completed in the late 1960's, provides flood protection for Kailua Town on the windward side of the island (Figure 1). The project utilizes the natural flood storage of the swamp, located upstream of Kailua Town. In ancient times, the swamp was a natural lake, storing and discharging runoff from the mountains, and trapping sediment carried by the water. In time, the sediments filled the lake, reducing its storage capacity. Then came man, attracted by the area and its proximity to the sea. Kailua Town was developed between the swamp and the sea. Runoff from heavy rain storms was no longer stored in the swamp, but overflowed and flooded Kailua Town. The flood control project uses the existing storage capacity of Kawainui Swamp, increased by a levee on the seaward end, to store flood runoff for eventual discharge to the sea through a system of channel improvements and dikes. Construction of the project required that the City and County of Honolulu acquire and reserve about 700 acres for flood storage in the swamp. This land acquisition not only provides flood storage and preserves open space in a rapidly urbanizing area, but is also a valued sanctuary for wildlife, including some endangered species.

NAMO RIVER, GUAM. This project, authorized under Section 205 of the 1948 Flood Control Act, provides for a combination of traditional structural channel enlargement and lining with reservation, by zoning, of a flood flowage area to be used for open space or other uses compatible with the defined flood hazard risk (Figure 2). Of the approximately 35 acres required for this project, only about 8 acres are required for structural flood control features. The project will provide a high degree of flood protection for the developing coastal area on this part of Guam, and also preserve about 28 acres for open space use. Plans and specifications are essentially complete and the project will be completed when Federal and Government of Guam funds are available.

IAO STREAM, MAUI, HAWAII. Iao Stream flows past Iao Needle, a spectacular landmark and favorite tourist attraction above the town of Wailuku, Maui. From this scenic valley, Iao Stream traverses an area of residential, commercial, and agricultural development. While the area depends on Iao Stream for municipal, agricultural, and recreational water, periodic overflows have caused considerable destruction of property and the loss of 13 lives since 1916. In 1968, flood control improvements were authorized. Recent reformulation and design studies in cooperation with residents, commercial, agricultural, fish and wildlife interests, and the County of Maui have resulted in the development of a plan of improvement for flood control that combines structural improvements such as levees, channel widening, lining, drop structures, with reservation and zoning of agricultural land for flood passage (Figure 3). Maui County is highly dependent on its agricultural economy. Reservation of 55 acres for continued agricultural use of the total 70 acres required for flood control will provide for continuation of sugar production, protection for existing and planned future residential and commercial development. The $10 million project will be ready for construction in mid 1977. (The cross-hatched areas of Figure 3 represents land zoned for flood passage.)

AGANA RIVER, GUAM. An Interim Survey Report for flood control for the Agana River, Guam, was recently reviewed and approved by the Board of Engineers for Rivers and Harbors (Figure 4). The project, very similar to the Kawainui Swamp flood control project, constructed in Oahu, Hawaii, recommends that storage available in the existing Agana Swamp be increased by the use of levees and that outflow be controlled by channel improvements. The combination non-structural-structural improvements will provide SPF protection for the commercial and governmental center of Guam.

4 Incl
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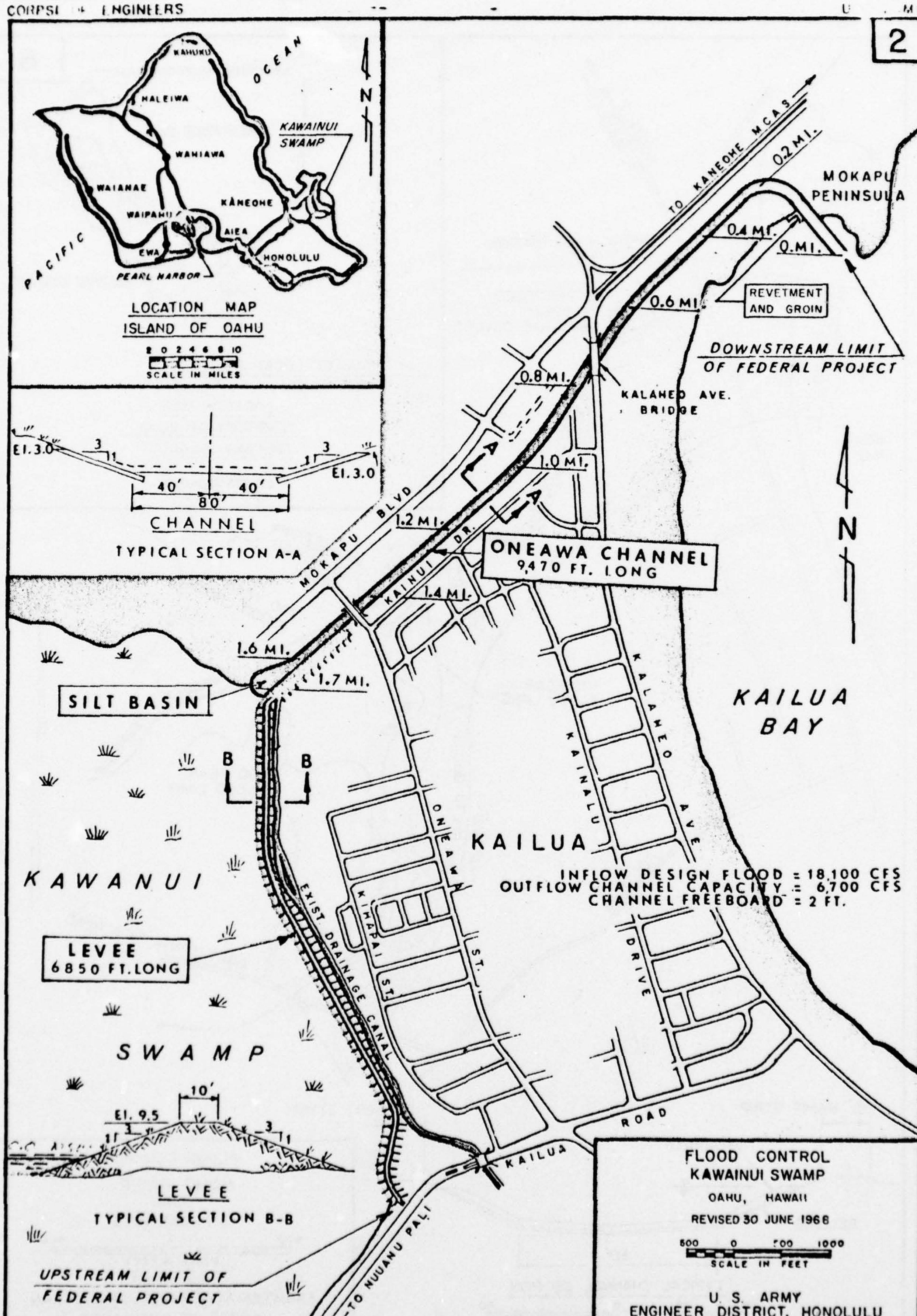

2
KAHUKU
HALEIWA
OCEAN
KAWAINUI SWAMP
WAHIAWA
WAIANAE
KANEOHE
WAIPAHU
AIEA
PACIFIC
EWA
HONOLULU
PEARL HARBOR
LOCATION MAP
ISLAND OF OAHU
0 2 4 6 8 10
SCALE IN MILES
N
El. 3.0
3
1
40'
80'
40'
El. 3.0
CHANNEL
TYPICAL SECTION A-A
TO KANEOHE M.C.A.S.
0.2 MI.
MOKAPU PENINSULA
0.4 MI.
0 MI.
0.6 MI.
REVETMENT AND GROIN
DOWNSTREAM LIMIT OF FEDERAL PROJECT
0.8 MI.
KALAHEO AVE. BRIDGE
A
1.0 MI.
MOKAPU BLVD
1.2 MI.
KAINUI DR.
ONEAWA CHANNEL
9,470 FT. LONG
1.4 MI.
1.6 MI.
1.7 MI.
SILT BASIN
KAILUA BAY
B
B
KALAHEO AVE
KAINALU DRIVE
ONEAWA ST.
KAILUA
INFLOW DESIGN FLOOD = 18,100 CFS
OUTFLOW CHANNEL CAPACITY = 6,700 CFS
CHANNEL FREEBOARD = 2 FT.
KAWANUI SWAMP
KIMAPAI ST.
EXIST DRAINAGE CANAL
LEVEE
6850 FT. LONG
10'
El. 9.5
LEVEE
TYPICAL SECTION B-B
KAILUA ROAD
UPSTREAM LIMIT OF FEDERAL PROJECT
TO NUUANU PALI
FLOOD CONTROL
KAWAINUI SWAMP
OAHU, HAWAII
REVISED 30 JUNE 1966
500 0 500 1000
SCALE IN FEET
U. S. ARMY
ENGINEER DISTRICT, HONOLULU
CORPS OF ENGINEERS

FIG 1

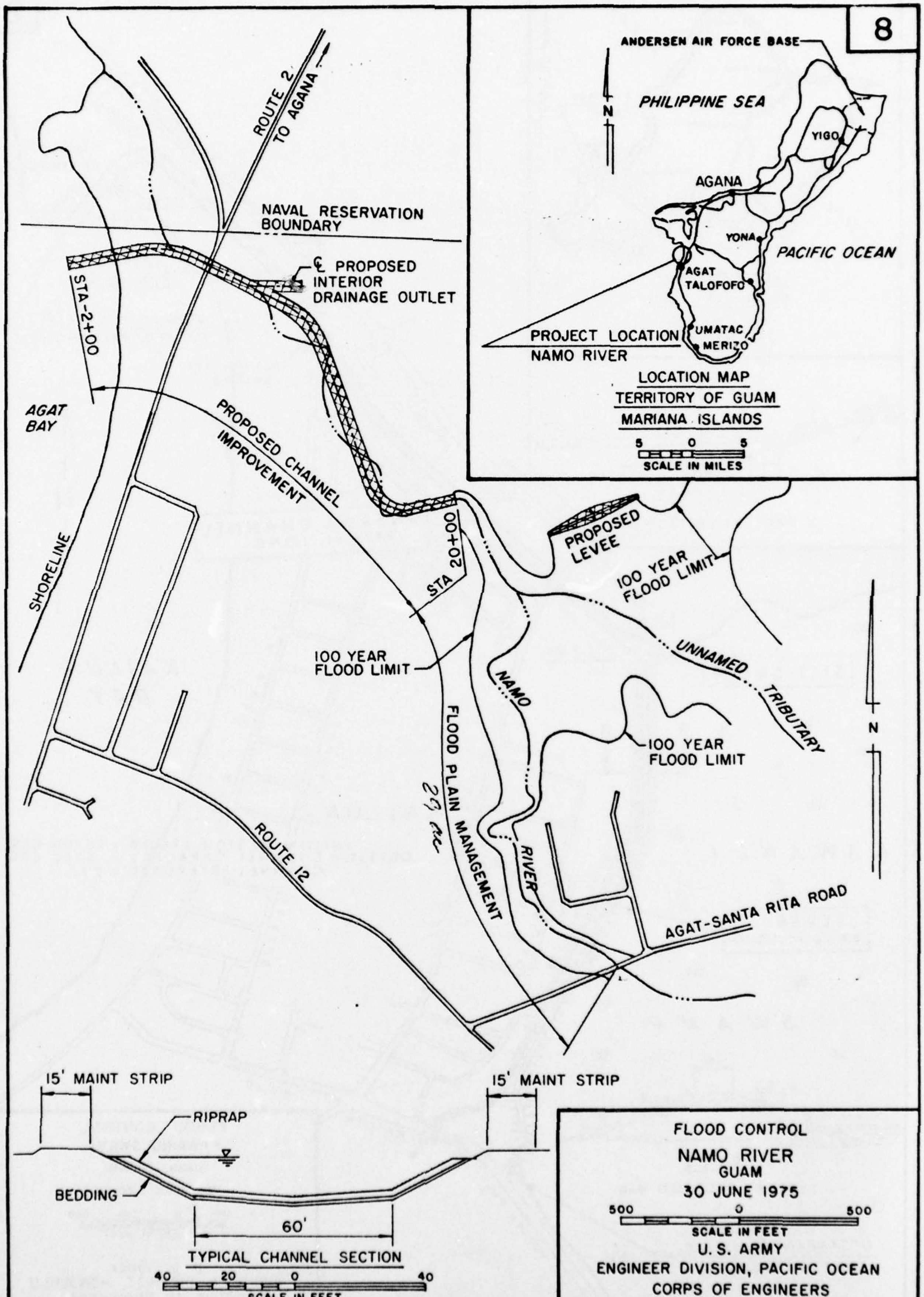
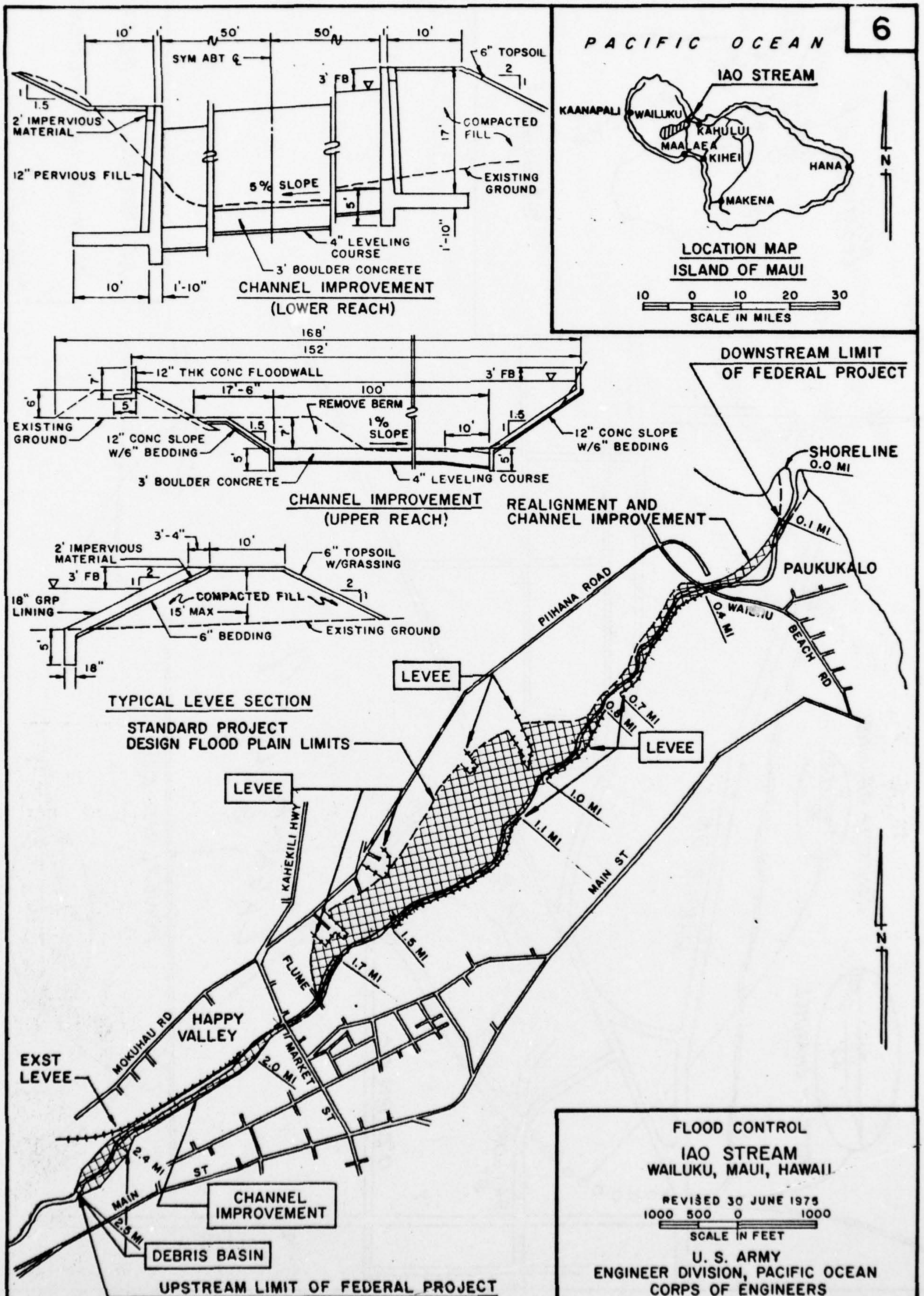
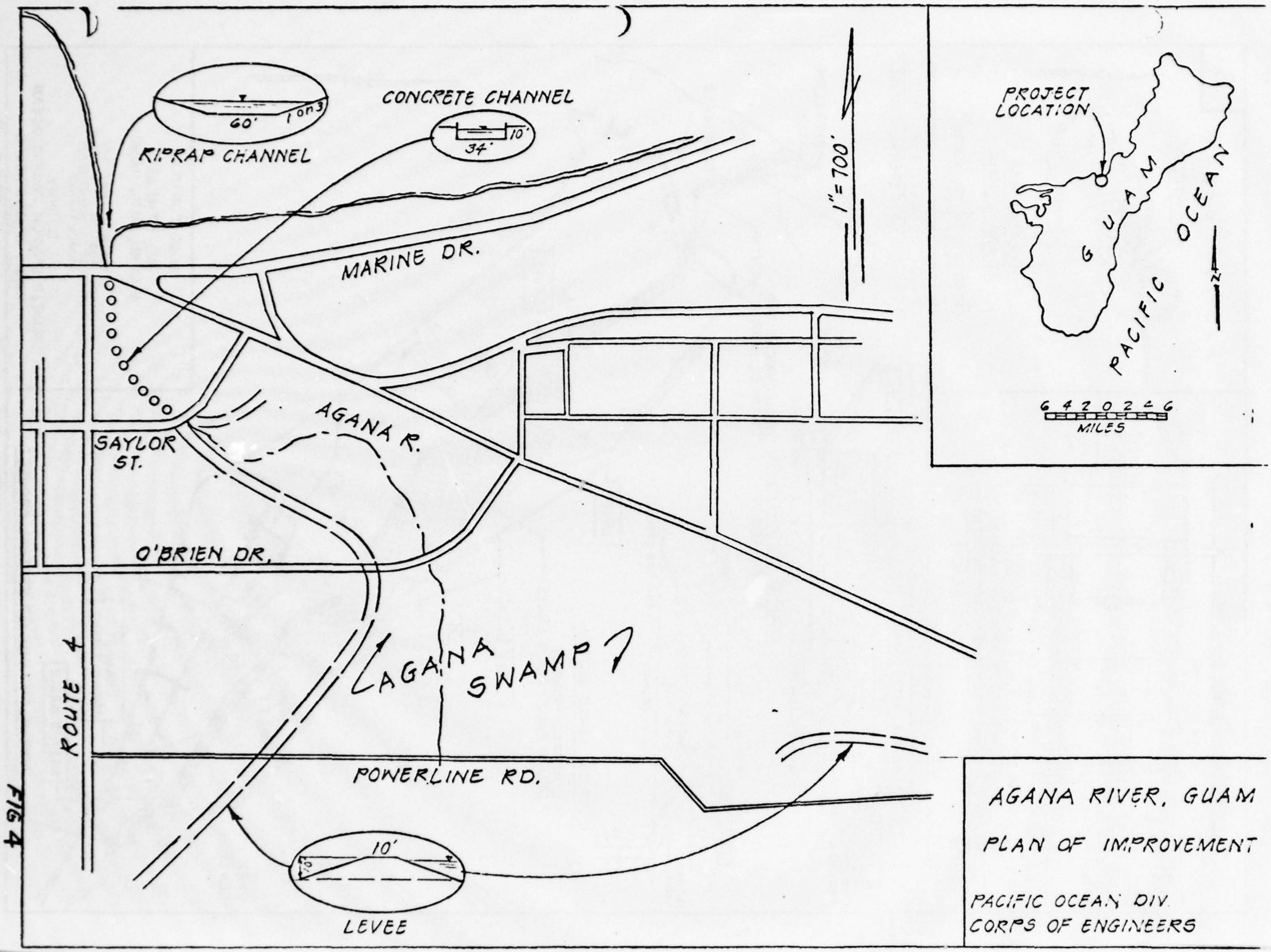

8
ANDERSEN AIR FORCE BASE
PHILIPPINE SEA
N
YIGO
AGANA
YONA
PACIFIC OCEAN
AGAT
TALOFOFO
UMATAC
MERIZO
PROJECT LOCATION
NAMO RIVER
LOCATION MAP
TERRITORY OF GUAM
MARIANA ISLANDS
5 0 5
SCALE IN MILES
ROUTE 2
TO AGANA
NAVAL RESERVATION BOUNDARY
℄ PROPOSED INTERIOR DRAINAGE OUTLET
STA-2+00
AGAT BAY
PROPOSED CHANNEL IMPROVEMENT
STA 20+00
PROPOSED LEVEE
100 YEAR FLOOD LIMIT
SHORELINE
100 YEAR FLOOD LIMIT
UNNAMED TRIBUTARY
NAMO
100 YEAR FLOOD LIMIT
FLOOD PLAIN MANAGEMENT
29 ac
ROUTE 12
RIVER
AGAT-SANTA RITA ROAD
N
15' MAINT STRIP
15' MAINT STRIP
RIPRAP
BEDDING
60'
TYPICAL CHANNEL SECTION
40 20 0 40
SCALE IN FEET
FLOOD CONTROL
NAMO RIVER
GUAM
30 JUNE 1975
500 0 500
SCALE IN FEET
U. S. ARMY
ENGINEER DIVISION, PACIFIC OCEAN
CORPS OF ENGINEERS

FIG 2



6
PACIFIC OCEAN
IAO STREAM
KAANAPALI
WAILUKU
KAHULUI
MAALAEA
KIHEI
HANA
MAKENA
LOCATION MAP
ISLAND OF MAUI
SCALE IN MILES
CHANNEL IMPROVEMENT
(LOWER REACH)
SYM ABT ℄
6" TOPSOIL
3' FB
2' IMPERVIOUS MATERIAL
COMPACTED FILL
12" PERVIOUS FILL
5% SLOPE
EXISTING GROUND
4" LEVELING COURSE
3' BOULDER CONCRETE
CHANNEL IMPROVEMENT
(UPPER REACH)
12" THK CONC FLOODWALL
REMOVE BERM
1% SLOPE
12" CONC SLOPE W/6" BEDDING
3' BOULDER CONCRETE
4" LEVELING COURSE
TYPICAL LEVEE SECTION
6" TOPSOIL W/GRASSING
18" GRP LINING
15' MAX
6" BEDDING
EXISTING GROUND
DOWNSTREAM LIMIT OF FEDERAL PROJECT
SHORELINE 0.0 MI
REALIGNMENT AND CHANNEL IMPROVEMENT
PAUKUKALO
PIIHANA ROAD
WAIEHU BEACH RD
LEVEE
STANDARD PROJECT DESIGN FLOOD PLAIN LIMITS
KAHEKILI HWY
MAIN ST
FLUME
MARKET ST
HAPPY VALLEY
MOKUHAU RD
EXST LEVEE
CHANNEL IMPROVEMENT
DEBRIS BASIN
UPSTREAM LIMIT OF FEDERAL PROJECT
FLOOD CONTROL
IAO STREAM
WAILUKU, MAUI, HAWAII
REVISED 30 JUNE 1975
SCALE IN FEET
U. S. ARMY
ENGINEER DIVISION, PACIFIC OCEAN
CORPS OF ENGINEERS

FIG 3



CONCRETE CHANNEL
10'
34'
60'
1 on 3
RIPRAP CHANNEL
MARINE DR.
1" = 700'
PROJECT LOCATION
GUAM
PACIFIC OCEAN
N
6 4 2 0 2 4 6
MILES
AGANA R.
SAYLOR ST.
O'BRIEN DR.
AGANA SWAMP
ROUTE 4
POWERLINE RD.
10'
LEVEE
AGANA RIVER, GUAM
PLAN OF IMPROVEMENT
PACIFIC OCEAN DIV.
CORPS OF ENGINEERS

FIG 4

A CASE STUDY
OF
NON-STRUCTURAL MEASURES
CONSIDERED FOR
SOUTHWESTERN JEFFERSON COUNTY, KENTUCKY
LOCAL FLOOD PROTECTION PROJECT

By
Ralph D. Reid 1/

INTRODUCTION

The flood prone problems of Southwestern Jefferson County were identified by historians of the early 1800's in their writings on the culture of the time.

"The whole of this plain (Ohio River flood plain) as we have before observed, is alluvial, and this fact shows to what depth the waters extended. But at the time, the owners of these hatchets were seated by this fire, where, I would ask, was the Ohio River?" - Dr. McMurtne's Sketches of Louisville, 1819.

As might be concluded from the above historical sketch, archaeological findings substantiate that other civilizations have occupied this land and used the adjacent Ohio River over the centuries.

The present occupants of the flood plain learned of the area's flood proneness first hand during a major Ohio River flood at Louisville in March 1964. Subsequent to the flood, resolutions were adopted by both houses of the Congress requesting consideration of flood control and allied improvements in Southwestern Jefferson County. A survey investigation was assigned to the Louisville District in June 1964, and a final report was submitted in February 1967. The plan proposed in the project document combined local flood protection works contiguous to and downstream from the existing protection works for Louisville, Kentucky, with a permanent lake that would support both general and fish and wildlife recreation. These improvements required 90,000 feet of earth embankment and 1,550 feet of concrete wall. Appurtenances included two pumping plants and thirteen drainage structures through the embankment. The

1/ Chief, Flood Plain Management Services, Planning Division, Louisville District, Corps of Engineers. Graduated with degree in Civil Engineering from University of Louisville, 1957; Master of Community Development, University of Louisville, 1973; Master of Engineering, University of Louisville, 1975.

embankments and walls were proposed to have a design level about three feet above the crest of the record 1937 flood which is consistent with the degree of protection provided by the existing Louisville flood protection project.

In transmitting the project report to the Speaker of the House of Representatives in June 1968, the Secretary of the Army recommended that during the preconstruction planning stage, the Chief of Engineers should review the size and scope of the proposed works and modify the plan as needed to achieve the most reasonable balance between structural works, flood plain regulation and a broad program of flood plain management. To properly consider this requirement, a special report on alternatives was undertaken to specifically develop recommendations for modification of the project plan as needed to achieve the most reasonable balance between structural works and non-structural measures.

PROJECT SETTING

General.

To fully understand the array of alternatives considered for Southwestern Jefferson County, one must first have some perspective in the locational process that examined the natural, socio-economic, and psychosocial linkage environments of the project setting. The physical planning for the project does not stand alone, but it is the product of relating the psychosocial goals and objectives within a framework of economic constraints and physical considerations. Primary features of the project environment are related in the paragraphs which follow.

Physical Features.

a. Location. The study area comprised the flood plain of the Ohio River, principally in Southwestern Jefferson County, Kentucky, lying downstream from the existing Louisville local flood protection project to Salt River about 15 miles down river. Maps of the project area are presented as Plates 1 and 2.

b. Streams. Principal drainage of the area is by two local streams, Lower Mill Creek and Pond Creek. Lower Mill Creek, with a drainage area of 17.4 square miles, flows generally parallel with the Ohio River through the center of the flood plain entering the Ohio River at the downstream extremity of the concerned flood plain. Pond Creek, having a drainage area of 125 square miles, flows along the eastern edge of the flood plain into Salt River, also at the southern extremity of the area.

c. Geology - Topography. The flood plain is an area of low relief characterized by a deep covering of Pleistocene outwash deposits of alluvium clay, silt and gravel. These deposits were washed from the ice sheet and deposited in the preglacial valley of the Ohio River. Thickness of these deposits range from 85 feet to 115 feet; underlying bedrock is New Providence shale, a soft clay shale. Surface soils consist of clay and silt, and these overlay the aforementioned outwash deposits.

d. Transportation Routes and Utilities. The principal highway in the area is U.S. 31W - U.S. 60, locally called Dixie Highway; this highway is served by a well integrated network of secondary roads. Lines of the Louisville and Nashville Railroad and the Illinois Central Railroad traverse the area. Utilities services in the entire sector, including gas, electricity and water, are generally available.

e. Economic Development. The historical beginnings of the extensive development in Southwestern Jefferson County, Kentucky, center about the organization and growth of Louisville. The fertile Ohio River valley southwest of Louisville was initially devoted to general farming, livestock raising and large truck gardens supplying produce to Louisville and other urban markets. With greater mobility afforded the population by the improvement of the automobile, surburban development began to encroach upon farmland along Dixie Highway near Louisville. Expansion of the Fort Knox Military Reservation, preceding and during World War II, resulted in additional scattered development in the area. A significant increase in population and shortage of adequate housing following World War I, together with changing mortgage concepts by financial institutions, further accelerated growth in the area.

f. Population and Economic Base. Statistics for Jefferson County excluding Louisville, indicated the area increased in population about 96 percent since 1930, from 355,000 to 695,000 persons. For the same period, the Southwestern Jefferson County flood plain increased from 2,000 to 53,000 persons or 2650 percent. The economic base of the area centers about the industry and commerce of Louisville, other portions of Jefferson County, and the military reservation at Fort Knox in adjoining Hardin, Bullitt and Meade Counties.

g. Projected Future Land Development. Some indications of growth and land use were obtained for the area from the local planning commission. In addition, other local groups with a specific projective interest in area development were contacted, and their data along with supplemental census data were used to develop growth estimates. Since the flood protection project was authorized in 1968, local interests have directed planning and development to some degree on the expectancy that flood protection similar to the Louisville local protection project would be provided. In 1965, organization of a riverport authority was started to foster industrial development in the Southwestern area with port facilities on the river. Options to purchase 2,867 acres of land for port development and use by related industry have been obtained. To properly consider detailed projections of future growth areas with and without the project, maps indicating the respective areas of growth expectancy were prepared.

PROBLEMS AND NEEDS

Real estate development in the United States has not been distinguished for its attention to the amenities of the living environment. The development of Southwestern Jefferson County has been no exception. There were few complications in assessing needs of this urban complex that could be addressed by the resolutions of the study and water resource legislation, as the water resource problems were generally confined to the flood potential of the area the need for outdoor recreation opportunities. In discussing the area generally, the flood hazard of the study area has been frequently alluded to. The comparatively rapid expansion of developments into the flood plain was stimulated by favorable topography and subdrainage which permitted economies in construction of buildings, streets, sanitary sewers and other utilities. Reluctance of lending institutions to finance construction in the lower areas provided a degree of restraint. However, much of the area at or above the level of a 1945 flood which was about 10 feet below the 1937 record flood has been developed. A recurrence of the record 1937 flood would cause an estimated $118,047,000 million dollars (1972) damage under present conditions of development. Average annual damage in all categories of property was estimated at $494,000.

For outdoor recreation consideration, Southwestern Jefferson County is situated within the heavily populated metropolitan area of Louisville and within ten miles of the populated center of the Fort Knox Reservation. Counties included in a zone of influence of Southwestern Jefferson County are Clark and Floyd Counties, Indiana and Jefferson, Meade, Hardin and Bullitt Counties, Kentucky. This area is projected to obtain a population of 2,200,000 people by the year 2010, an increase of more than 100 percent from the 1970 population of 950,000. The City of Louisville and Jefferson County have 146 parks and playgrounds involving about 6,550 acres; a significant part of this acreage is hilly forest land. There is no recent official visitation estimate; however, a 1966 count of swimming participants amounted to 2,600,000. An estimate based on Bureau of Outdoor formulae by local park staff indicates that land needs by 1990, based on a population projection of 1,166,000, will total 11,666 acres. In other words, an additional 5,000 acres would be required to reach the recommended standard by 1990. For the recreational area considered with the authorized level project, plans provide for additional land acquisition of about 2,000 acres.

ALTERNATIVES CONSIDERED AND METHODS OF ANALYSIS

General.

The fundamental dilemma of planning a water resource project in the urban area is deciding which organizing principles can or should be effective within the city to determine the allocation of lands, facilities and services and to arbitrate the proper interactions among persons. It is easy to generalize on the economic, environmental and social objectives that should be the goals of water resource planning. To give content to these generalities in terms of understanding the effects of the physical and environmental structure on the individual man or man as a creature in society, is a very difficult task. In the analysis of alternatives for Southwestern Jefferson County, it must pointed out that a levee project had already gone through the organizing and fundamentals stage and was authorized. In addition, there were few guidelines for analysis or treatment of non-structural measures.

Alternatives Considered.

Both the non-structural and structural measures were considered with a carefully planned strategy for minimizing or eliminating flood damage and providing outdoor recreation opportunities, using the strengths of the market place, existing legislation and the potential of the legislative process. There were numerous possible alternatives that could have been considered, but the basic idea was to consider each one on its own merit and then offer combinations as necessary. The individual alternatives considered and a summary explanation of the methodology involved is presented in the paragraphs which follow:

Do Nothing. In this treatment, the policy of two Presidents and several local leaders were quoted to build on the premise that the "Do Nothing" alternative was hardly viable if any reading of the people's views was possible. Reviewing the many urban problems of the area - the extended metropolis, fragmented geographic and functional units of government, differences in local government capabilities, the impact of urban change, preliminary demands of local government for services - together with the foregoing items of developmental consequence and the predictive potential of flood damage, to "Do Something" was considered most appropriate and consistent with the stated Federal water resource policies of Senate Document 97 and related policy guidelines. Several root questions were also explained under this alternative: Why do people live in Southwestern Jefferson County? and What lands are available to make a shift?

Evacuation. Aside from the economic data for several levels of evacuation, see Table 1, the technique of permanent evacuation is probably the least desirable of the corrective measures available for flood damage reduction. One has only to look at the lack of evacuation examples of any magnitude nationwide to conclude an aire of social unacceptability. Moreover, the current social resistance to the displacement of people by development generally would appear to substantiate the lack of public acceptance to permit the technical realities of an evacuation program. For an evacuation analysis, four levels of flood frequency in the area were studied, the 10, 50, 100 and a level equal to the design level of the authorized levee project. Some idea of the analysis procedure can be obtained by an examination of Table 1.

Flood Proofing. The adaptability and effectiveness of flood proofing as a flood control alternative for the Southwestern Jefferson County flood plain, as in most general cases, depends upon the stage of flooding, the uses of the flood plain, the relationship of flood proofing to other flood damage reduction measures, and the degree of safety required by the community.

Without specific consideration of the aforementioned constraints, the same four levels examined for evacuation were examined on a screening basis for flood proofing. At a 1-year frequency flood level damageable property is mainly confined to outbuildings and miscellaneous items which are not readily adaptable to flood proofing. For the frequencies of 50, 100 and the levee design level, flood proofing measures were infeasible with a maximum benefit cost ratio, 0.91 to 1.0 occurring at the 50-year level for industrial properties, see Table 2.

Zoning. Although this alternative was given a written treatment in our analysis, there are generally significant annual costs that can be attributed to the zoning process. As might be surmised from the paragraph on flood damages, the potential for flood damages in Southwestern Jefferson County is large, and it is growing. In viewing the reality of this situation, the staff of the Louisville District have been working with the local zoning agency to rewrite planning and zoning regulations to include flood plain zoning and more efficient land use policy. It is for note that both Louisville and Jefferson County are currently obligated to adopt flood plain and floodway regulations, as they have accepted the Federal Flood Insurance program. At this juncture, it is anticipated that acceptable regulations involving the following concepts will be involved: (1) Flood plain zoning ordinances, (2) Setback ordinances, (3) Ordinances controlling subdivisions, and ownership by a public agency of flood control right-of-way. On an estimated basis, it is believed that the type of zoning currently being considered could reduce future average annual damages by about 10 percent.

TAL 1

DATA FOR EVACUATION ALTERNATIVES

Frequency 1/	Present Units	First Costs 2/ (Dollars)	Annual Cost 3/ (Dollars)	Annual Benefit (Dollars)	B/C Ratio	Remaining Urban AAD (Dollars)
Residential						
10	0	0	0	0	-	0
50	1355	24,400,000	820,000	22,000	.03:1	6,000
100	2450	44,000,000	1,500,000	61,000	.04:1	8,000
Design Level	14285	256,000,000	7,680,000	420,000	.05:1	18,000
Public						
10	0	0		0	-	0
50	5	2,700,000	91,000	1,000	.01:1	0
100	9	4,860,000	165,000	1,000	.01:1	0
Design Level	52	28,080,000	951,000	3,000	.003:1	0
Industrial						
10	0	0	0	0	-	0
50	2	20,100,000	684,000	3,000	.004:1	0
100	2	20,100,000	684,000	4,000	.006:1	1,000
Design Level	2	20,100,000	684,000	10,000	.015:1	2,000
Commercial Units						
10	0	0	0	0	-	0
50	57	5,814,000	197,000	1,000	.005:1	3,000
100	102	10,404,000	352,000	4,000	.011:1	3,000
Design Level	410	41,820,000	1,417,000	23,000	.016:1	5,000

1/ Frequencies represent modified conditions with the present upstream reservoir program; the design level represents an average flood frequency of 1,000 years.

2/ Includes units only; no utilities, streets, or land for relocation; estimates based on field survey data.

3/ See Footnote 1/ - Table 2.

TABLE 2

DATA - FLOOD PROOFING ALTERNATIVES 1/

Frequency	Present and Future Use	Units Available For F.P.	Annual Costs	Benefits	Ratio	Remaining Urban AAD
	(Units)		(Dollars)	(Dollars)		
Residential						
10 Year	0/0	0/0	0	--	--	0
50 Year	1355/1355	675/675	459,000	21,000	.05:1	34,000
100 Year	2450/2450	1815/1815	2,120,000	88,000	.04:1	46,000
Design Level	17560/45500	2650/6825	8,744,000	209,000	.02;1	1,241,000
Commercial						
10 Year	0/0	0/0	0	--	--	0
50 Year	57/57	28/28	19,100	1,000	.05:1	7,000
100 Year	102/102	60/60	70,100	5,000	.07:1	9,000
Design Level	410/1000	60/150	194,100	11,000	.06:1	77,000
Industrial						
10 Year	0/0	0/0	0	--	--	0
50 Year	2/2	2/2	6,800	6,000	.88:1	0
100 Year	2/2	2/2	8,800	8,000	.91:1	2,000
Design Level	2/17	2/17	81,800	74,000	.91:1	16,000
Public Units						
10 Year	0/0	0/0	0	--	--	0
50 Year	5/5	5/5	9,700	2,000	.20:1	0
100 Year	9/9	9/9	17,500	2,000	.11:1	0
Design Level	52/105	52/105	146,800	9,000	.06:1	0

1/ Costs in this report are a composite of screening and survey scope levels of data refinements. First costs related to evacuation costing are based on real property and improvement estimates made during actual field surveys for appraisal of the flood damage potential. These same field surveys were utilized to develop an estimate, at each flood frequency, of the number of units available for flood proofing. Annual costs for evacuation were developed on a screening basis, and represent interest and amortization charges for real estate and improvements: as indicated in footnote 1 of Table 1, utilities, streets, and land for relocation are not included. Costs for flood proofing include fill material, reworking of masonary wells, plumbing, waterproofing, temporary housing, landscaping, and structure repairs. Benefits were obtained by separating units benefited from the data previously computed for the autorized levee.

Structural Solutions. The basic non-structural measures discussed in the previous paragraphs offered little potential as measures in themselves or for producing the multiplicity of services needed. In seeking some solution to the identified needs within the framework of water resource goals and in such a manner as to maximize the outputs with minimum investment, consideration was also given to the relative efficiencies and costs of more positive structural measures, primarily reservoirs and levees. The project area does not lend itself to immediate flood control by a major reservoir, as the area is flooded by the Ohio River overflow which has a drainage area of 91,170 square miles at McAlpine Dam, a navigation structure, just upstream. Numerous levee plans and alignments were studies.

COMPARISON OF ALTERNATIVES AND COMBINATIONS

In the evolving thought process of examining non-structural alternatives, each single-purpose alternative was initially viewed for their quantitative and qualitative response in solving or avoiding flood hazards in Southwestern Jefferson County. As indicated in the preceeding paragraphs, only levees and zoning offer some potential, the balance of the measures being infeasible. Thus, no combinations of non-structural or structural, other than the foregoing were considered other than observing and various infeasible levee of the individual measures and their relative lack of merit. With the potential flood plain ordinance previously discussed, it goes without saying that some flood proofing measures in flood fringe areas could be implemented for future development, especially in non-protected areas. Table 3 summarizes the non-structural and structural measures discussed and their comparative merits.

DISCUSSIONS - CONCLUSIONS

Considering the potential alternatives presented, it was found that the authorized levee plan modified by several alignment changes reduced average annual damage for the area by more than 90 percent, and it was economically justified. No other alternative measure competed to any degree with this performance. At the same time, about 2,120 acres of the total 26,240 acres are left outside the protection works, and these lands have ltile residual development potential. There is currently, assuming the levee in-place, an average annual damage potential of $40,000 outside the selected alignment with some potentail for growth. To provide protection for this segment, two concomitant measures are most applicable considering comprehensive land use plans for the area. These measures, flood plain zoning and flood proofing, would entail a basic rewriting of existing ordinances for the area. Corps of Engineer's staff has worked with a local committee with the objective of properly formulating ordinances to reduce the flood problem throughout the community.

TABLE 3

COMPARATIVE MERITS OF ALTERNATIVES

NON-STRUCTURAL

Do Nothing - The conclusions of the Do Nothing thesis are that the needs are too great; the Federal involvement in the metropolitan area is intense and, in part by way of fiscal lending policies, is responsible for the problem; and a shift of land use to flood free areas is not competitive and physically impossible.

Evacuation - Evaluation of four flood frequency levels, the 10-year, 50-year, 100-year and a design level, indicated general infeasibility at all levels.

Zoning - Has little merit along, but about 10 percent of the average annual damages could be eliminated with the array of local proposals currently under study.

STRUCTURAL

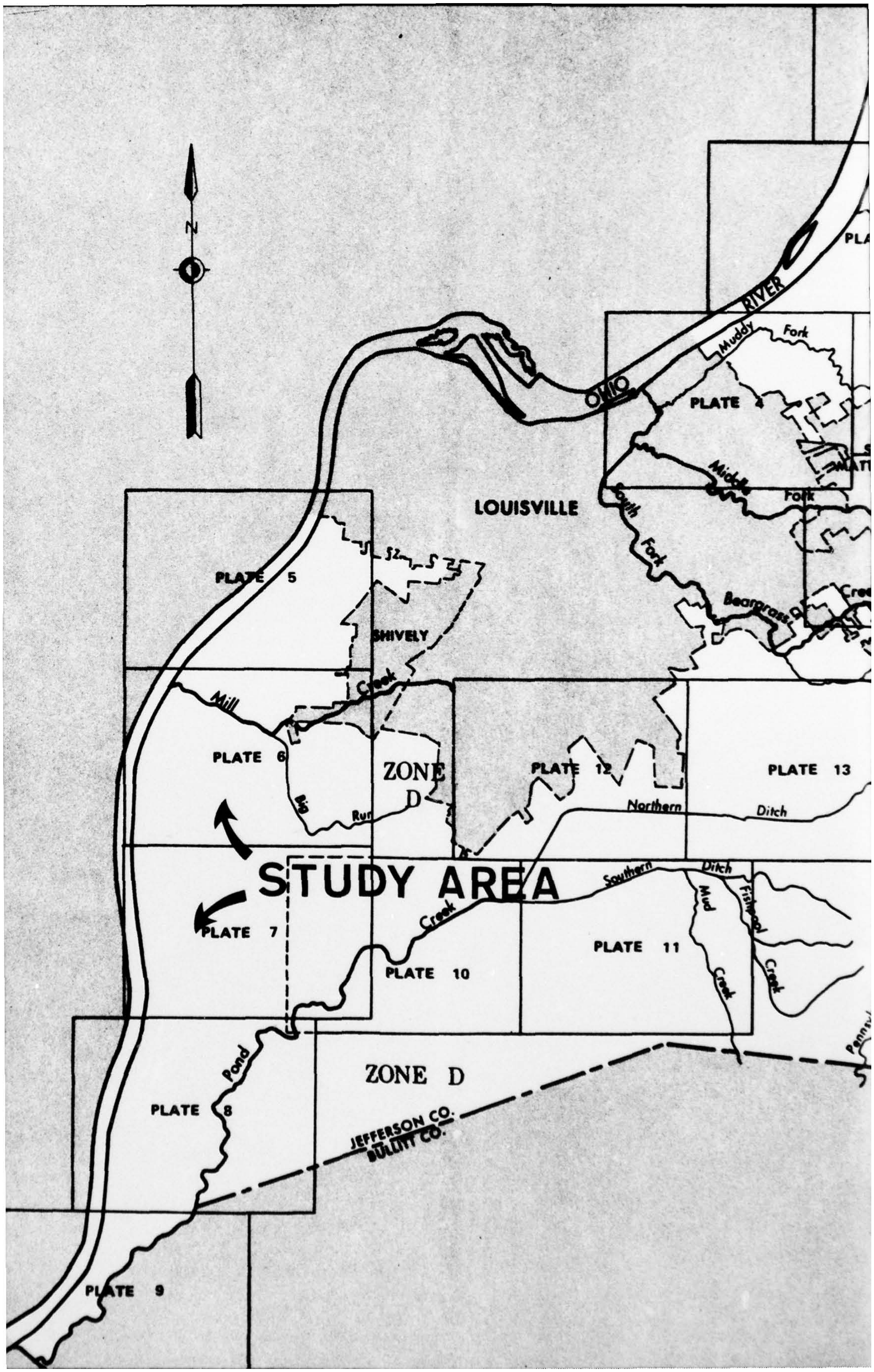
Major Reservoirs - Drainage area at Louisville too large for absolute control.

Levee - Only feasible measure.

COMBINATIONS

Levee/Zoning/Flood Proofing - Based on above findings involving an array of non-structural and structural alternatives, a levee with zoning and flood proofing of new development in flood fringe areas would offer an optimum combination of measures.

Our studies discussed in the foregoing pages, while demonstrative rather than precisely definitive, substantiate through a process of logic and mathematics where possible, that a viable solution to the flood problem and to some extent the need for added lands for outdoor recreation, was possible and most desirable. The plan of action, called for by the studies, recommended the basic project document levee plan with modifications found appropriate to proceed along with a community effort toward flood plain zoning and the flood proofing of existing structures outside the proposed levee where possible.


N
OHIO RIVER
Muddy Fork
PLATE 4
Middle Fork
South Fork
Beargrass Creek
LOUISVILLE
PLATE 5
SHIVELY
Mill Creek
PLATE 6
Big Run
ZONE D
PLATE 12
PLATE 13
Northern Ditch
STUDY AREA
Southern Ditch
PLATE 7
Creek
PLATE 10
PLATE 11
Mud Creek
Fishpool Creek
Pond
PLATE 8
ZONE D
JEFFERSON CO.
BULLITT CO.
PLATE 9

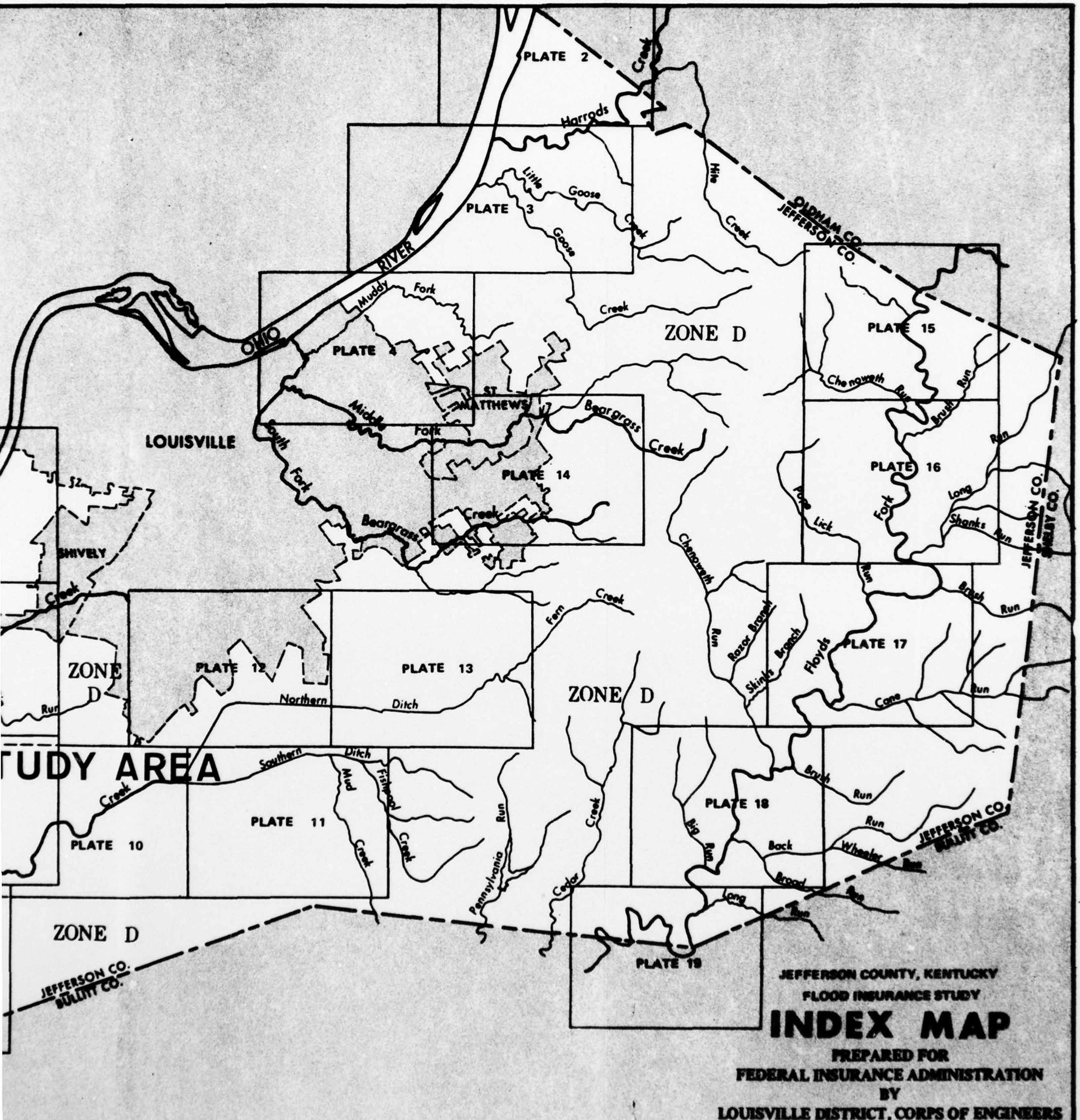
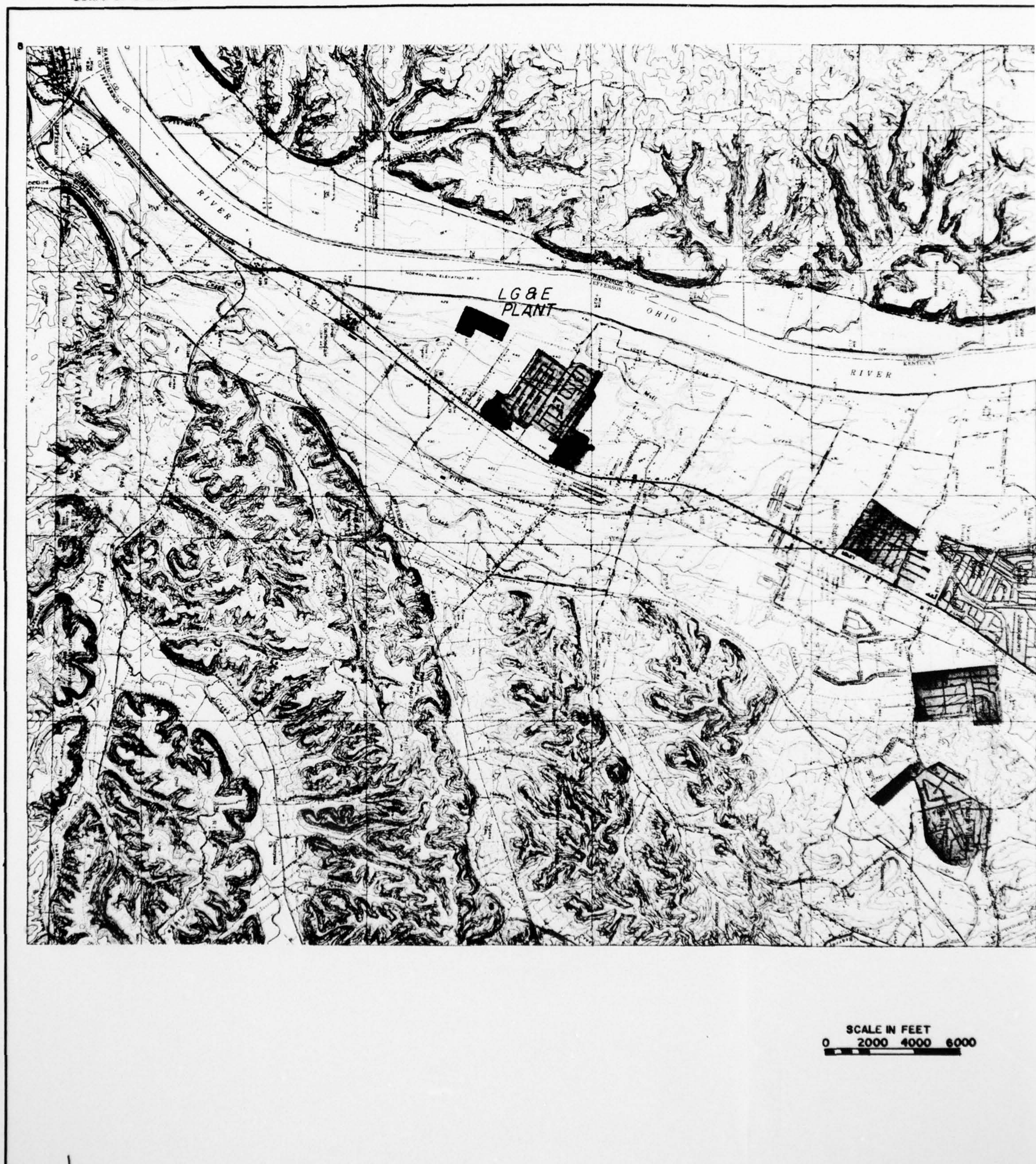


PLATE 2
Harrods
Creek
PLATE 3
Little
Goose
Creek
Hite
Creek
OLDHAM CO.
JEFFERSON CO.
OHIO
RIVER
Muddy
Fork
PLATE 4
ZONE D
PLATE 15
Chenoweth
Run
ST. MATTHEWS
Middle
Fork
Beargrass
Creek
LOUISVILLE
South
Fork
PLATE 14
PLATE 16
Brush
Long
Shanks
Floyds
Fork
Pope Lick
JEFFERSON CO.
SHELBY CO.
SHIVELY
Chenoweth
Razor Branch
Skinks Branch
Fern
Creek
PLATE 12
PLATE 13
PLATE 17
Cane
Run
ZONE D
Northern
Ditch
STUDY AREA
Southern
Ditch
Mud
Fishpool
Creek
Pennsylvania
Run
Cedar
Creek
PLATE 18
Big
Run
Back
Broad
Wheeler
PLATE 10
PLATE 11
PLATE 19
ZONE D
JEFFERSON CO.
BULLITT CO.
JEFFERSON COUNTY, KENTUCKY
FLOOD INSURANCE STUDY
INDEX MAP
PREPARED FOR
FEDERAL INSURANCE ADMINISTRATION
BY
LOUISVILLE DISTRICT, CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY
DECEMBER 1971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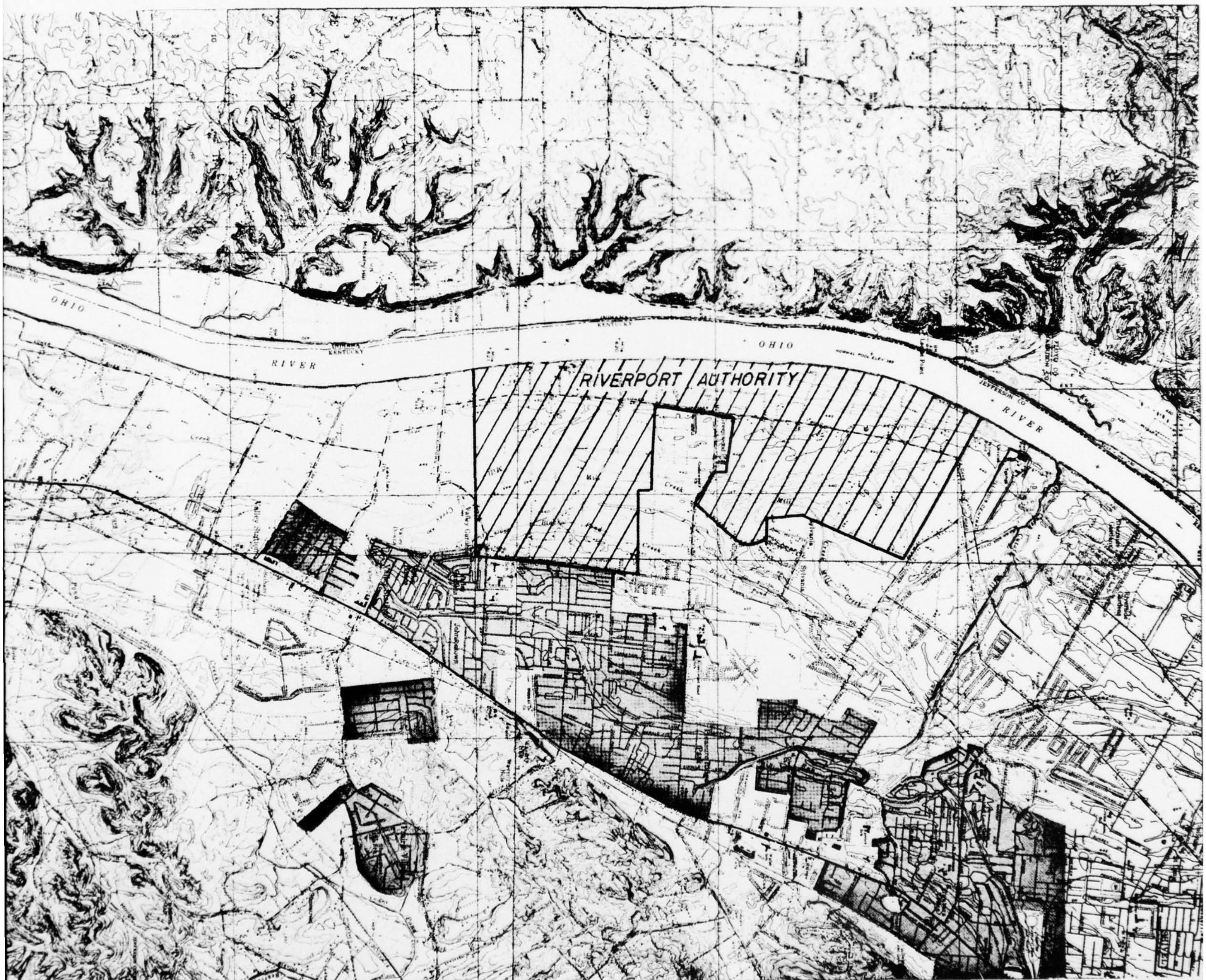

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SOUTHWEST JEFFERSON COUNTY, KENTUCKY
LOCAL FLOOD PROTECTION
SPECIAL REPORT
ON ALTERNATIVES
TOPOGRAPHIC MAP
SCALE AS SHOWN
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE, KENTUCK
OCTOBER 1972

2

PLATE 2

IMPLEMENTATION OF NONSTRUCTURAL MEASURES

SOME EXAMPLES

By

James E. Goddard[1]

INTRODUCTION

Congressional action of 1974 (P.L.93-251) added stronger legislative authority to earlier executive authority for a balanced approach to coping with flood hazards. Federal agencies were directed to consider nonstructural measures when planning projects involving flood protection. The legislation is to encourage the wise use of flood-prone lands, the preservation of open space, and the preservation and enhancement of the environment. To properly implement the broad approach, it is necessary to begin early in the planning process while solutions are still at the conceptual stage rather than wait until the plans are almost complete and then consider alternatives.

Purpose

Nonstructural and structural are the two common measures of flood plain management. Nonstructural measures can and should be used both alone or in partnership with structures. Structural measures should seldom, if ever, be used alone. Knowledge of the experiences with nonstructural measures will be very useful to those charged with implementing the broad national program. This paper discusses the implementation of various nonstructural measures at sites requiring variable solutions and presents the current status of certain nationwide actions. It also briefly discusses the implementation of combined measures.

FLOOD PLAIN REGULATIONS

The importance of flood plain regulations that lead to wise use of flood plains and their impact on the economy of our nation - - local, regional, and national - - is dramatically related to the following facts:

1. About 7 percent of the United States, excluding Alaska, is subject to inundation by the 100-year flood. That is more than 209,000 square miles or an area greater than the states of California and Ohio combined.

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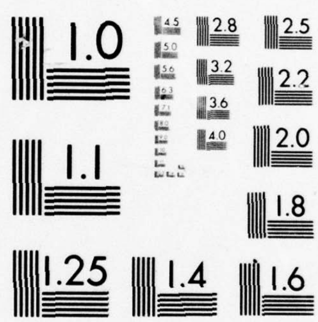
[1]Flood plain management consultant, Tucson, Arizona

AD-A052 607 HYDROLOGIC ENGINEERING CENTER DAVIS CALIF F/G 8/8
PROCEEDINGS OF A SEMINAR ON NONSTRUCTURAL FLOOD PLAIN MANAGEMEN--ETC(U)
MAY 76 K E MCINTYRE, G D COBB, F H THOMAS
UNCLASSIFIED HEC-SP-08 NL

2 OF 3
AD
A052607



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

2. One out of every six acres (16%) of urbanized areas is in the 100-year natural flood plain.

3. There are about 20,000 flood-prone communities and some 16,500 square miles of urban flood plains in the nation. That is equivalent to the states of Maryland and Hawaii combined or Massachusetts and New Jersey combined.

4. More than one-half (53%) of the Nation's flood plains in urbanized areas had been developed by 1973. That is an area of 8,800 square miles or more than the entire state of Massachusetts.

State regulatory programs

Recent studies made for the Department of Housing and Urban Development by John R. Sheaffer and associates of Keifer & Associates, Inc. included a survey of state and local regulatory practices for flood plains. That survey of all 50 states identified state regulatory practices as well as local practices for flood hazard areas. It found that 21 states have statewide regulations and 36 have model ordinances or other materials to assist local communities in managing flood plains. Forty-six - - all but four - - of the states are involved in the problem of hazard area land use control in one way or another.

Flood hazard mitigation requirements in most state regulations are based on Flood Insurance Administration (FIA) minimum criteria and the Water Resources Council (WRC) model code. They usually establish at least one district, the 100-year floodway, and frequently a second district known as the flood fringe. Within the floodway, virtually no permanent structures are permitted. No construction is permitted unless approval and/or a permit has been obtained from the appropriate state agency. Several states allow local governments to administer the review permits procedure as long as their criteria are consistent with state standards.

In the flood fringe the common practice is to permit the uses that would normally be permitted in the underlying zoning district, subject to certain flood hazard reduction measures. Structures and attendant utilities must be flood proofed or elevated to at least the level of the 100-year flood.

The most stringent regulations mandate that local governmental units adopt state minimum standards, or better, for land use practices in state-wide flood hazard areas. Indiana, Iowa, Kansas, Minnesota, Montana, Nebraska, New Jersey, New York, Ohio, Vermont, and Wisconsin have such standards. The remaining states regulate by operating a permit system which allows a case by case assessment at the state level, or they simply regulate certain river basins. For example, Massachusetts has regulations for the Assabet River and its tributaries and the State of Washington regulates 18 selected streams.

Seventeen of the 21 regulating states use the 100-year frequency. Indiana uses the flood of record if that is greater than the 100-year flood, Kentucky defines the floodway of the flood of record, and Colorado is proposing regulating areas above the 100-year flood elevation. New Jersey has revoked virtually all of the powers of the minicipalities to control land use in floodways and has mandatory state standards.

The remaining 29 non-regulating states reported a variety of activities. Many recognize statewide flood hazard areas and define a regulatory flood but have not established state regulations. Several are on the verge of adopting flood hazard area regulations and others are still studying the situation.

Local regulatory programs

The Corps of Engineers has issued about 1400 flood plain information reports covering some 3300 communities. More than 1400 of those communities have adopted new or have strengthened existing flood plain regulations. About 1200 additional communities are in the process of adopting similar programs.

In the Tennessee Valley, 99 of the communities with flood hazard areas have adopted effective flood plain regulations and others have adopted minimal type regulations.

The Federal Flood Insurance Administration has issued intermediate Flood Hazard Boundary Maps outlining hazard areas for 15,696 of the 20,000 communities that have flood hazards of varying degrees. Flood insurance studies that present the complete flood hazard situation have been issued for more than 600 of those communities and about 600 additional ones will be completed by mid-summer 1976. More than 1000 studies are expected to be completed the following year and perhaps 2000 annually thereafter. At the end of March 1976 the number of communities participating in the flood insurance program was 14,001, with 589 of them in the regular program.

The Federal insurance program requires, as a prequesite for insurance eligibility, that communities adopt flood plain regulations that meet or exceed minimum Federal criteria. Those criteria vary from minimal requirements to fully effective requirements, related to the availability of basic pertinent data. In accordance with these requirements, more than 14,000 communities have adopted flood plain regulations varying in effectiveness from minimal to fully effective. More than 1000 of those have fully effective regulations.

Allowing for duplication between the Corps, TVA, and FIA, there are at least 15,000 communities with minimal type of flood plain regulations or better. Of those, at least 2000 have fully effective regulations and nearly 2000 others are in the process of adopting them.

DEVELOPMENT POLICIES

Resistance to the extending of utilities and to the construction of streets will deter development in flood hazard areas. Street improvements elsewhere, schools, and other public facilities wield a soft-sell negative influence on flood plain exploitation and a positive leadership toward the safer, higher ground. Lincoln, Nebraska, adopted such an ordinance several years ago. Many knowledgeable communities have not adopted a formal ordinance but do consider this policy when making decisions.

TAX ADJUSTMENTS

Tax adjustments can encourage property owners to forfeit rights to use their lands as they wish or to continue use of the lands in a manner consistent with a proposed plan. It may include assessment on the basis of current use rather than potential use and deferred payment of taxes on land sold for development prior to public purchase. Tax abatements involve agreements by the owners to forfeit certain rights in return for a reduced tax assessment over a stated period of time.

Some states, such as Minnesota, provide abatements in return for the granting of public recreation rights. In Connecticut some woodlands are given special tax treatment for a period of twenty years to encourage planting of trees. Hawaii uses tax adjustments to accomplish orderly development and utilization of the state's resources as guided by a statewide plan. Where consistent with the plan, landowners may dedicate tracts to specific permissible uses for ten-year periods and thereby obtain a tax assessment at a value corresponding to such uses. Tax concessions encourage gifts or transfers of lands, if those lands are exempted from taxes and the owner is permitted to continue present uses until the land is needed.

Tax adjustments related directly to the flood hazards and for lands dedicated to recreation, agricultural, reservoir sites, conservation or other open space uses can be effective in preserving floodways along streams and shorelines. Tax evaluation of rural flood plain lands adjacent to developing urban areas and of open lands within the urban areas is commonly increasing. The increase finally reaches the point that the land no longer can profitably be used for farming or open uses. Appropriate tax adjustments prevent this.

This tax adjustment alternative has seldom been used for the abatement of flood damages or preservation of reservoir sites. Lack of understanding and support, intricasies of application, and public attitude have been discouraging factors. Several years ago the State of Florida considered legislation relative to tax adjustments but the program was not implemented. However, because of the changes in national policy concerning flood plain management and in the public approach, the true values of flood plain lands are beginning to be recognized. This will lead to revisions in the tax arrangements.

OPEN SPACES

Flood plain lands in many urban areas have been purchased or appropriate leases obtained for open space and recreational uses. Some communities have included the total flood plain along selected reaches of streams and others, such as Milwajkee, Wisconsin, have included the entire streams. Such uses must be coordinated with the recreational needs as stream locations are not generally spaced properly to best serve population densities.

Open space and recreational plans should always be given consideration, along with the overall development plan for the community, when planning a solution to the flood problem or preparing a watershed plan. Development along Indian Bend Wash in Scottsdale, Arizona, is an example.

WARNING SIGNS

The conspicuous display of signs indicating specific heights of floods can effectively inform inexperienced developers and prospective purchasers of flood conditions in the respective areas. Such action is not costly, but it is effective. Federal agencies use a modified type of flood warning signs along reservoir margins and along some streams. A few cities use flood marker signs for selected areas. The State of New Jersey has a statewide program but it has not been fully implemented. Minnesota and Wisconsin include signs in their shoreline management programs. Opponents claim such signs detract from the land values, thus indirectly admitting that they are effective in conveying flood information and alerting the public to the flood hazards.

FLOOD INSURANCE

Flood insurance is a major tool for flood plain management since it relates the cost of safe development to respective flood hazards. The Federal flood insurance program is also an effective instrument for getting communities to establish flood plain regulations. The number of communities in the program has been discussed earlier in this paper.

The Federal flood insurance program does not require nor effectively encourage insurance for developments located above the 100-year flood level. Yet there is a residual flood damage potential above that level. Flood insurance rates for structures above the 100-year level are so reasonable that all development in the flood plains should consider it.

Sound plans for developing in flood plains should include building structures above the 100-year flood level to be reasonably safe and then purchasing flood insurance to guard against possible major loss from larger floods. The insurance is not costly, because of the elevation of the building, but provides economic protection against the less-frequent and higher floods that may wreak major damage. This insurance can be compared with auto collision insurance where the owner pays a small annual fee to protect against the possible total loss of the car in a major accident.

Flood plain management plans should include recommendations and encouragement for flood insurance on all developments to be located in areas subject to flooding.

EVACUATION

Temporary evacuation is one of the oldest forms of nonstructural measures used by man. It is the only feasible solution to flood problems in certain areas. It has long been used as a supplementary measure along the Mississippi River and other major rivers as well as along sea coasts. It is more commonly used along small streams in urbanized areas. Examples are numerous and nationwide. Benefits are greatest where terrain and storm characteristics permit timely and reliable flood forecasting.

Efficient and effective evacuation depends on (1) knowledge of when and how much flooding and (2) an organized action to implement a plan of evacuation. Lack of the latter is often the cause of minimal effectiveness. This is now being given greater, though still too little, attention in state and local planning for flood damage alleviation. The State of Nebraska made an excellent start on a comprehensive program related to state and local plans to utilize forecast data - - but the program did not get far beyond the outline stage.

RELOCATION

Relocation of communities is an accepted practice when the communities are subject to inundation by new reservoirs. Such relocation has also been considered for some communities subject to frequent critical flooding. An example of the latter was a Corps of Engineers project along the lower Ohio River many years ago. However, at the time of that project the national policy only encouraged people and investments to move to higher ground that was purchased by the Federal Government. The project was only partially successful because most of the people did not want to leave their location although they knew they would be flooded again and again - - hopefully not too often. Later construction of a high bridge to replace the river ferry led to gradual relocation of most of the town.

Changes in national policy and greater public understanding now permit more forceful approaches to relocation. For example, the town of Klamath in northern California, after being washed away by a flood and rebuilt and then nearly destroyed again by another flood, was relocated on higher ground. Flood plain regulations were adopted to prevent further development in the old site and adjacent flood plains. Another more recent example is the proposed Prairie du Chen, Wisconsin, project along the Mississippi River, where much of the town would be moved to lands above the flood hazard.

FLOOD FORECASTING

The National Weather Service of the National Oceanic and Atmospheric Administration is responsible for preparing official forecasts and issuing public warnings for floods in all areas of the United States except the Tennessee River Basin where responsibility is shared with the TVA. Twelve River Forecast Centers cover 97% of the country, including Alaska. At a second level are River District Offices within the major river basins. Plans to extend a full forecasting service to other areas are being implemented.

The flood forecasting system is generally unsuitable for flash floods in smaller drainage areas. However, for many of those areas it is suitable and NWS uses three basic approaches to prediction and warning of flash floods.

One NWS approach is the Community Flash Flood Warning System. In this system a local official collects precipitation and streamflow reports and prepares a local forecast on his own initiative, using procedures furnished by NWS and equipment at local cost. He alerts the community.

A second approach is the Automatic Flash Flood Alarm which activates a warning in the community when the stream reaches a pre-set danger point. About a dozen of these systems are currently installed, including Wheeling, West Virginia; Green Brook, New Jersey; Rosman, North Carolina; and La Follette and Spring City, Tennessee.

The third and most widespread approach is the conventional Weather Warning which depends on the expertise of the local weather forecaster who issues a generalized warning of possible flash flood conditions.

Terrain and storm characteristics in many watersheds permit reliable and timely flood forecasts. Unfortunately, forecasts are of little value if there is no complementary plan to accomplish temporary evacuation, emergency flood proofing, or other measures. Public broadcasts of flood warnings seldom give explicit instructions on appropriate action to be taken. Appropriate plans for organization to utilize the forecast information are necessary, especially where life is endangered.

Well-known examples of forecasting and emergency action are the recent operation at Minot, North Dakota, and Operation Foresight of the Corps of Engineers and others for the upper Mississippi River Valley when record flood stages hit cities on the Mississippi, Red, and Souris rivers in 1970. Less important examples are noted annually throughout the nation.

The only solution, partial as it may be, for some flood problems is flood forecasting plus emergency action. For other flood problems it is appropriate as a supplementary measure. Cooperation of the NWS should generally be obtained and potential benefits of flood forecasting considered for applicable areas.

FLOOD PROOFING

Two good publications on flood proofing are John R. Sheaffer's "Flood Proofing : An Element In A Flood Damage Reduction Program" (1960) and Sheaffer's "Introduction To Flood Proofing" (1967) prepared for the Corps of Engineers and the Tennessee Valley Authority. Those briefly refer to sites throughout the

Nation where different types of flood proofing measures have been used. They also indicate designs and costs for some applications.

Flood proofing programs include both existing and proposed structures. Flexibility is inherent in this approach. It is used in conjunction with flood control structural measures, flood plain regulations, and flood insurance. It is also used separately for permanent, partial, or interim relief. However, it is more often considered a supplement to other measures rather than an alternate.

The Joseph Horne Department Store and the Pittsburgh Press newspaper buildings in the Golden Triangle of Pittsburgh, Pennsylvania, are excellent examples of flood proofing existing structures. The Gateway Center buildings and the Pittsburgh Hilton Hotel in the same area are examples of flood proofing new buildings as they are constructed.

The Horne Department Store was flooded to depths greater than eleven feet above the first sloor (more than 20 feet above the basement floor) during the 1936 flood. Following that flood, the store undertook a thorough flood proofing program. Aluminum bulkheads were designed to protect door and window openings. The bulkheads for the large show windows are suspended on overhead trolley rails for ease of movement from storage at the back of the show window space to cover the windows when needed. Massive bulkheads for the open loading dock areas are on hinges at the top so they can be swung up and stored horizontally. When floods threaten, they are lowered and bolted into place. Arrangements have been made to protect the large glass windows from the pressures of flood waters. Sump pumps are installed in the basement to handle seepage through the walls and elsewhere. Electric lines are brought into the building at high levels to assure power supply during floods. Counters and tables for displaying goods are mounted on wheels so they can be readily moved to upper floors, if necessary. And the Store was able to obtain flood insurance because of the thorough flood proofing to the height of the 1936 flood.

The Gateway Center buildings, Hilton Hotel, and newspaper building have similar aluminum bulkheads near each of the openings so they can be moved quickly and bolted into place. Some of the Center's openings are horizontal at ground level. The glass windows in the lower floor of the newspaper building were replaced by glass block. Valves on pipelines in the building are painted various colors in accordance with printed instructions for action during floods. The lowest floor of each Gateway Center building is concrete and is several feet thick to help overcome buoyancy during floods.

The basement of a church in an Appalachian Mountain resort town was being damaged by underground flows from upslope springs each time of heavy rainfall. There was seepage through the walls and at the junction of walls and floor as well as buckling of the basement floor in places. A narrow trench was excavated along the outside of the upstream walls, a porous layer of stone was installed below the elevation of the floor to act as a drain, and the trench was backfilled.

One of the motels in Gatlinburg, Tennessee, was built on a hillside with the floor above the 100-year flood level of the nearby stream. Sloping ramps were used because the public prefers ramps over many steps. Stores in a western Virginia town were similarly constructed.

Industries in many locations suffering from shallow flooding have raised large, expensive motors as much as two feet or more to prevent their being damaged from reoccurrence of the small floods. Other industries, such as a large one in Southwestern Pittsburgh and a Jacuzzi plant in California, have taken various actions to flood proof their existing investments.

Plans for a new $1.25 million school in Chattanooga, Tennessee, were revised so the structure floor would be above the 100-year flood elevation. The building was reoriented to take greater advantage of the topography and the structure built with the floor about two feet higher than originally planned. Cost of the changes was less than $25,000.

COMPREHENSIVE APPROACH

The experience of the twin cities of Bristol, Tennessee-Virginia, is an early though good example of the cooperative, multi-disciplinary approach to flood problems. The persistent flood problem that had retarded orderly development of the cities (hereafter referred to as Bristol) was solved as a part of the Tennessee Valley Authority's flood plain management program.

A joint Flood Study Committee (FSC) was appointed by the cities. That FSC enlisted the assistance of additional citizens and requested technical assistance from the Federal Government (TVA) and the respective states. Four subcommittees were formed to work with the Federal and state agencies in studying flood control, flood proofing, flood plain regulations, and urban renewal. The chairman of each subcommittee was selected from members of the FSC and each subcommittee recruited additional citizen members.

The final flood plain management program included two upstream detention reservoirs with a permanent recreation pool in one of them; recreation in each of the reservoir areas; channel enlargements along two principal streams through the cities; flood proofing of structures; professional guidance and assistance to individuals in flood proofing; revision of zoning ordinances, subdivision regulations, and building codes to include flood plain provisions; utilization of opportunities to assure improvements in other stream channels during new major highway construction; utilization of urban renewal opportunities to minimize flood damage; and action coordinated with the local plans for development.

Waterloo, Iowa, was not satisfied with the Corps' original plans for solving its flood problems. While reviewing the proposed flood control plans, the city realized it also had other urban deficiencies that were interrelated to the river and flooded areas. There was a blight belt that extended diagonally through the city on both banks of the river. There was unplanned and uneven growth in the area and a severe land mix of factories, homes, schools, and commercial facilities that presented safety and health factors. Quality of the river water was deteriorating from wastes.

Utilizing urban renewal assistance and with dynamic local input and impetus from local committees, a Federal-state-local cooperative comprehensive plan was prepared. It included river channel improvement, water quality improvement, levees and wall, land fill of a large area for industrial and recreational uses, a scenic river front drive, bridges to improve traffic conditions, greater water surface for water recreation, extended public park areas, a recreation center that was flood proofed and also serves as a reach of flood wall, a low-flow dam to maintain permanent water level in the river, mosquito abatement, a flood plain management policy, and a rebirth of a strong municipal spirit. This could not have been accomplished unless the local input and effort had not been closely coordinated with the Corps of Engineers efforts.

In St. Bernard Parish east of New Orleans, Louisiana, the land is low marshland, typically about 1.5 feet above sea level. The lowlands, extending inland from 20 to 50 miles, are subjected to severe hurricanes and flooding. The Corps of Engineers study indicated that diking the areas was not economically justified and recommended flood proofing of structures and emergency evacuation along with other effective flood plain regulations. New buildings were to have their lowest floor at least 12 feet above sea level (10 feet above the ground). Many buildings with attractive architectural designs have been constructed accordingly, including the Sebastian Roy School, San Pedro Pescador Church, Grand Isle Library, and U.S. Coast Guard Station.

A shopping center in Knoxville, Tennessee, followed advice of a Federal agency concerning the local flood hazard. The available site in the desired section of the city was on the flood plain of a winding creek. The creek channel was relocated and improved, the buildings were constructed with the floors above the 100-year flood elevation, the parking lot was left low and was paved to act as an improved overflow section during flood periods, and the entire swampy overgrown area was thus transformed into a useful attractive site.

Oliver Springs, Tennessee, is an example of a broad program involving the cooperative efforts of the community, counties, state agencies, area railroads, and Federal agencies. Planning for the multipurpose program was triggered by severe flooding.

The program includes an improved stream channel with some relocation, a public housing project, urban renewal, new water and sewer systems, school improvements, an industrial park, highway relocation, recreation facilities, renovation of the downtown business district, flood plain provisions in the zoning ordinance and subdivision regulations, flood proofing of buildings, and official awareness or future improvements. Local committees provided the focus for Federal-state-local cooperation in the project.

INFORMATION AND GUIDANCE FOR IMPLEMENTATION

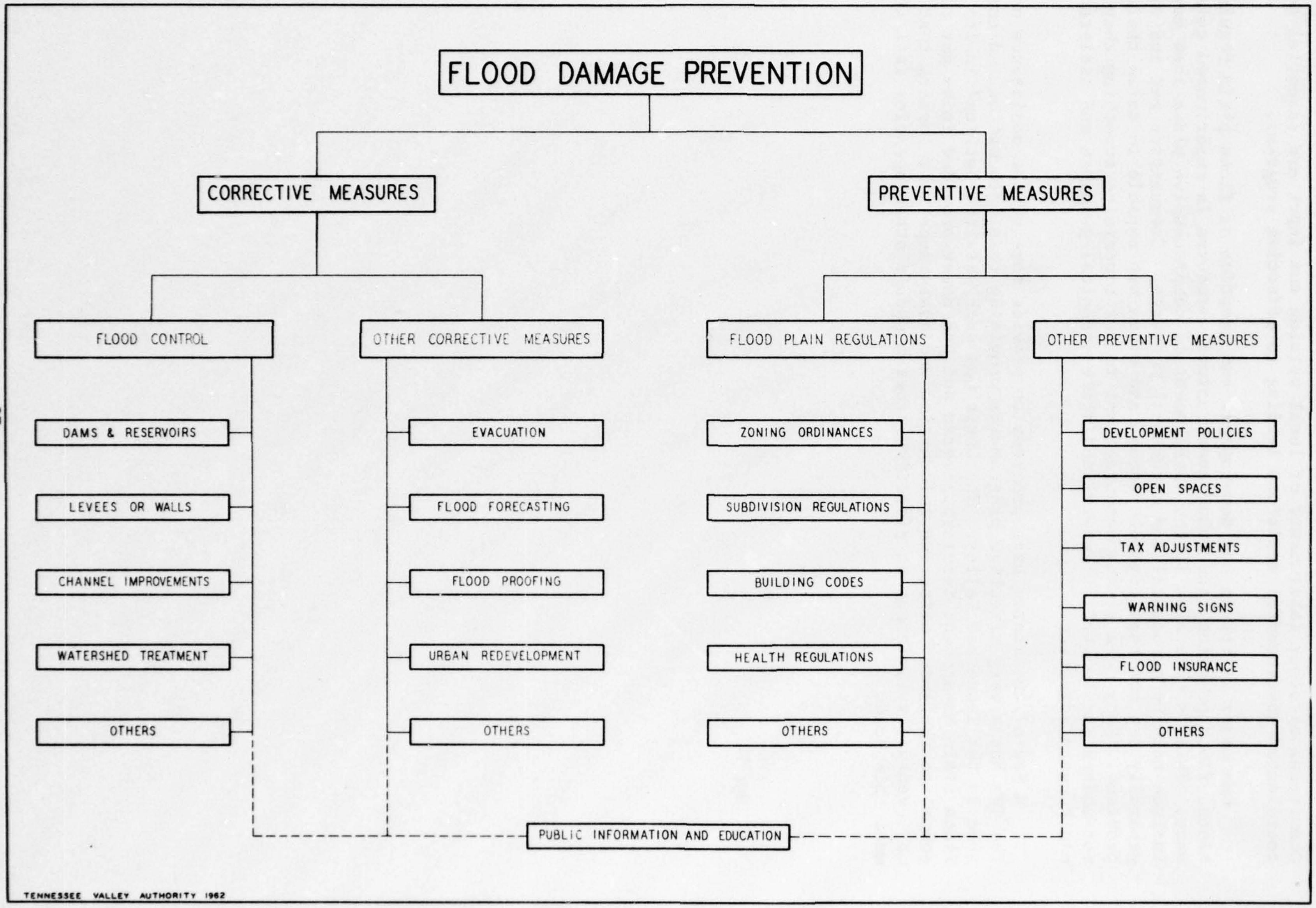
Changes in our society have led to a greater insistence of individual expression on specific projects and specific decisions of governments. It behooves program planners and managers to provide ample and understandable information that will permit informed opinions. Such information programs need to be organized at all levels of government - - local, state, and Federal.

Committees or other instruments of local opinion and input are essential to coordinated governmental decisions leading to effective programs.

One major factor in the development and adoption of flood plain regulations, flood proofing, and other nonstructural measures is experienced guidance. This is true also in the development of comprehensive plans that may include both nonstructural and structural measures. Communities and individuals generally are not knowledgeable enough and often not capable to solve their problems. Many need strong encouragement to act concerning something they do not understand too well. Federal and state technical guidance and assistance can be very effective.

A few of the states have programs to provide some of the assistance needed. The TVA has a very effective program for providing this information and assistance in the Tennessee Valley. The Corps has such services outlined in its Flood Plain Management Services program but has never provided funds nor personnel to implement effective information and assistance. It appears that FIA may eventually implement an effective program should other agencies fail to meet this need.

5 May 76


FLOOD DAMAGE PREVENTION
CORRECTIVE MEASURES
PREVENTIVE MEASURES
FLOOD CONTROL
OTHER CORRECTIVE MEASURES
FLOOD PLAIN REGULATIONS
OTHER PREVENTIVE MEASURES
DAMS & RESERVOIRS
LEVEES OR WALLS
CHANNEL IMPROVEMENTS
WATERSHED TREATMENT
OTHERS
EVACUATION
FLOOD FORECASTING
FLOOD PROOFING
URBAN REDEVELOPMENT
OTHERS
ZONING ORDINANCES
SUBDIVISION REGULATIONS
BUILDING CODES
HEALTH REGULATIONS
OTHERS
DEVELOPMENT POLICIES
OPEN SPACES
TAX ADJUSTMENTS
WARNING SIGNS
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OTHERS
PUBLIC INFORMATION AND EDUCATION
TENNESSEE VALLEY AUTHORITY 1962

EXPERIENCES WITH NON-STRUCTURAL MEASURES IN THE NEW ENGLAND DIVISION

By

LAWRENCE J. BERGEN[1]

Presentation at the Seminar on Non-structural Flood Control Measures

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[1] Chief, Policy and Long Range Planning Branch, Planning Division, New England Division, Corps of Engineers

Over the past several years, the New England Division has used several non-structural approaches to flood management problems and has found different approaches to be useful in different situations. In one area, the Charles River watershed, acquisition was successful, in another, the Pawtuxet River watershed, the Flood Insurance program was the most effective, and in the third, the Connecticut River Basin, the Flood Insurance program together with relocation and acquisition may be the answer.

Experiences with non-structural measures within this division could be grouped into two categories - those measures which prevent flood damage; and those which address existing damages.

To illustrate our success with various non-structural measures I would like to discuss three different studies in three different basins: (1) the Charles River Watershed Study; (2) the Pawtuxet River Flood Control Study; and (3) the Connecticut River Basin Study.

The three basins are different in many ways - size, shape, degree of urbanization and hydrologic characteristics. The Pawtuxet and the Charles are about the same size - 300 to 400 square miles - both rural in the upper watershed and highly urbanized in the lower watershed, but each has different hydrologic characteristics. The Connecticut River Basin, by contrast, does not have the same patterns of urbanization nor similar hydrologic characteristics and it is also a much larger basin - over 10,000 square miles. Also the Connecticut River Basin Study was a comprehensive (Level B) study while the other two were survey reports (Level C).

The Charles River watershed can be subdivided into three parts - the upper, the lower and the middle. The lower Charles extends from Boston Harbor to Moody Street, Waltham, and is highly urbanized. The middle Charles extends from Moody Street to South Natick Dam in Natick and contains established suburban communities. The upper Charles extends from South Natick Dam to the headwaters in Hopkinton, Massachusetts and is a rural area, rapidly changing to suburban in character.

The watershed is hourglass in shape - it is about 31 miles long and about 15 miles wide and extends from Hopkinton in a long meander about 30 miles to Boston Harbor. In the lower portion, the watershed is heavily urbanized, nearly all paved over by development and conducive to both tributary and main stream flash flooding. Near the mouth of the river there is a large impoundment created by a dam built in 1910. It is locally referred to as the Charles River Basin or just "The Basin". By contrast, the middle and upper watershed are now experiencing a major transformation in character with extensive areas being urbanized in nearly all towns. In recent years the lower Charles has been subject to severe flooding. During the record flood of August 1955, damage amounted to an estimated 5.5 million dollars. A repitition of this flood in 1971 dollars would cause over 12 million dollars in loss. This flooding is caused by the rapid run-off from built-up areas of Cambridge and Boston. Storm water from upstream of Moody Street, Waltham contributes very little to the lower Charles flooding. All of the flooding comes from the lower watershed. Peak levels in the lower Charles are reached four hours after a major rainfall, whereas flows from the upstream areas reach the basin three to five days later. This condition of little upstream influence on downstream flooding is primarily due to the natural valley storage areas of the middle and upper watershed.

Throughout the middle and upper watersheds, flood damage at the present time is not extensive. The relatively low flood damage experienced is attributable principally to the extensive marshes and swamps along the Charles and the principal tributaries upstream of Newton.

The primary flood problem in the lower Charles River results from the high degree of urbanization which causes intense run-off in a very short period of time and the fact that the Harbor high tide is higher than the Basin level. Aggravating the situation was a lack of control of the water level of the Basin in which the run-off collects.

Our studies of the lower watershed problem were completed in 1968, with the recommendation for construction of a multiple-purpose dam in the vicinity of the mouth of the river and the dam will include three navigation locks, a large pumping station and the foundation for an overhead traffic viaduct. When we were completing our study of the lower Charles, the 1968 flood occurred in the Charles. This flood approximated the 1955 flood which was the flood of record in eastern Massachusetts and the flood enabled the Charles River study team to observe what was happening in the numerous wetlands in the middle and upper Charles River. This was the beginning of what was to be the final report's recommendation for the over-all Charles River flood control management proposal.

The Charles River Study final report demonstrated that the natural valley storage contained in the many swamps, marshes and other wetlands in the Charles River watershed modifies high and low flows in the same manner as a reservoir or system of reservoirs and also provides a natural solution for the watershed's growing flood control problem.

Continuing urbanization threatens the wetlands and without storage afforded by the wetlands, flooding would become an increasingly serious problem. The report concluded that a combination of Federal and non-Federal actions to preserve the swamps and wetlands in their present state as natural flood water detention areas is needed to reduce growth and future flood losses and to safeguard open space. Recommended was the Federal acquisition of lands or easements in 17 natural valley storage areas, totaling some 8,422 acres that are critical to the comprehensive flood reduction plan for the entire watershed.

The unchecked momentum of municipal growth is threatening the flood safety of the Charles River communities which are downstream. The development continues to encroach on wetlands, reducing the total acreage and the storage capacity. As urbanization spreads and pavements and drainage systems replace vegetated areas, storm run-offs are much faster and the saturation capability of the land is exceeded. The importance of natural valley storage has always been recognized but there are very few occasions in which their preservation could be recommended as an effective means of flood management. This is probably the most important point to remember about the recommendations for natural valley storage area acquisition. The three essential ingredients that are required are first, there must be extensive natural valley storage areas present; second, there must presently be little or minor flood damages; and third, the loss of the natural valley storage areas must be imminent. This third requirement also makes implementation of our study recommendation urgent. Massachusetts, for instance, State-wide is losing its wetlands at a rate of 1 percent per year, but within the Boston area the rate is much higher. We anticipate that over half of the Charles River watershed wetlands will undoubtedly be gone in about 20 years time.

The question was raised "What will the acquisition of natural valley storage areas do that flood plain zoning won't do?" The purpose of flood plain zoning is to protect life and property against near future flooding and to contribute to protection against long term flooding. Emphasis in flood plain zoning is on promoting proper use, rather than prohibiting use. Numerous communities have adopted flood plain zoning based on a given flood with a certain elevation. In the Charles the flood plain is dynamic and elevations which are acceptable for development today will be in the future flood plain.

The New England Division concluded in the April 1972 Charles River Report that natural valley storage in the watershed has considerable flood control value, sufficient to justify the acquisition of wetland areas in lieu of building flood control structures. The Water Resources Development Act of 1974, Section 2, Public Law 93-251 authorized Federal action through the Corps of Engineers in preserving upstream natural valley storage areas, consisting of about 8,500 acres of swamp, marshes and other wetlands. Congress appropriated funds in fiscal year 1975 to initiate preacquisition planning, technically termed Advance Engineering and Design. Our current studies relate to updating and refining hydrologic data and economic analysis necessary for this non-structural method of flood protection.

The Pawtuxet River watershed within the State of Rhode Island is similar in size to the Charles River watershed with only slightly more than 200 square miles of drainage area. The basin area is made up substantially by seven communities, however, the bulk of the population is in the three downstream communities of West Warwick, Warwick and Cranston and primarily in the latter two.

The Pawtuxet River watershed has experienced many outstanding floods which resulted in rather moderate flood damages. However, uncontrolled urbanization coupled with extensive commercial industrial development and the introduction of a major interstate highway system has markedly changed the flood damage potential. For example, new complexes and interchanges have been built, largely along what were once vacant low-lying areas. The natural valley storage provided by those vacant areas modified earlier flood stages but no longer continues to do so; consequently with recurrence of past record floods, the effects of this urbanization will be felt in higher flood stages.

Another significant factor is the location of two reservoirs on the two major upstream branches, the north and the south, which form the Pawtuxet River at the upstream end of the three lower communities. In the past, major floods have occurred at times when the water levels in these two reservoirs were low, consequently, a significant amount of the flood run-off was stored in the two reservoirs. In the future, storage within the reservoirs and the resulting dampening effect cannot be counted on. To give you an example of the urbanization that has taken place recently, it is estimated that in the last ten years approximately 10 percent of the natural valley storage was lost through development. Studies indicate that as a result of loss of natural storage and increased run-off rates, future flood levels at this location could be at least one to two feet higher. Other upstream flood plain areas are presently undergoing similar land changes, and similar increases of flood levels will occur throughout the basin. It is likely that a recurring flood of the size of past record floods would inflict major losses.

As part of our study of alternative measures, many non-structural elements were considered in the initial phases of the study as possible flood control alternatives. These included, relocation, urban redevelopment, flood proofing, flood plain zoning, national Flood Insurance program and others. The conclusion was that non-structural approaches could be used effectively to prevent or minimize future damages and in some areas, to alleviate existing losses.

A program for relocation of all flood-prone structures presented an opportunity to remove domestic, commercia, industrial establishments from the flood plains to the secure areas free from potential flooding and to set aside those vacated areas for parks, open space and other passive uses. For those major damage areas protected by the considered project, this alternative would have been impractical, because of the existing high degree of development. It would have had a social and economic impact on families, business and industrial establishments and would have been inconsistent with the urbanization process of the area. From an engineering and economic viewpoint, such a measure would have been prohibitively costly and would have caused undue hardship.

Generally, an urban renewal program would be an effective measure for flood blighted areas that cause a continual drain on the economic life and welfare of the community and that usually do not lend themselves to other methods of regulation and control. Except for a few isolated areas, the lower end of the Pawtuxet River could not be classified in that category. Generally, it is an area heavily urbanized and served by a modern elaborate highway and railroad system. Therefore, an urban renewal program for these revitalized areas did not appear acceptable, particularly when more practical measures were available.

Flood proofing was considered in substantial detail, particularly along the main stem of the Pawtuxet River, and it was felt that it could be effective where depths of flooding do not exceed two to three feet and where the structure has the ability to withstand hydrostatic pressure. The age of many of the structures being threatened by potential flooding along the lower end of the Pawtuxet River would not lend themselves to flood proofing. The depths of flooding are such that flood proofing of existing structures would not be an effective measure for the lower Pawtuxet without some sort of supplementary structural measures. Also it would be very difficult to achieve and to administer because of the complex pattern of land use regulations and building codes which would require major community cooperation in those heavily built-up urban areas. For these reasons, flood proofing was not a workable alternative to the recommended structural measure, which was a major diversion project; however, with the reduction in flood stages by that major diversion tunnel flood proofing could become a viable supplement in many fringe areas of the flood plain.

The intent of flood plain zoning would not be to protect life and property against existing flood loss potential as much as to prevent the flood potential from worsening in the future. The emphasis would be placed on promoting wise use rather than prohibiting use. In the case of the lower Pawtuxet River where the flood plains are already moderately developed the effectiveness of zoning would be limited to the declaring existing development a non-conforming use, thereby curtailing expansion in the future. However, combining flood plain zoning with structural measures and stipulating that certain zoning constraints would have to be established with implementation of a definite structural plan would provide a balanced plan to reduce present damages and to insure wise use of the flood plain.

The national Flood Insurance program was considered but it should be noted that the maximum liability coverage would be limited to $100,000 each for the structure and the contents. In the lower Pawtuxet, a large percentage of flood losses would be sustained by structures beyond this limited coverage.

Therefore the Flood Insurance program would not provide total flood protection to the urbanized area, particularly because of the many diversified industrial establishments located on the lower Pawtuxet. Flood insurance should be used as an important component along with structural and non-structural measures in the total basin flood management plan.

Various other methods, such as flood forecasting, subdivision regulations and/or building codes were also considered and were determined to be complementary to the considered structural measures rather than alternatives to them. Therefore, the principal focus of the study shifted to a combination of structural and non-structural elements as the most favorable course of action to be pursued. As it turned out, the recommended plan for the Pawtuxet River watershed consists of a major diversion tunnel, approximately two miles long, from a point on the main stem of the Pawtuxet River just upstream of the major urbanized lower basin out to Narragansett Bay, coupled with two local protection projects, one around a residential area in Warwick (Norwood) and the other around an urbanized industrial area in Warwick. These structural measures would be supplemented by the Flood Insurance program along the main stem of the river, and also along the tributaries. There is also the recommendation for flood control storage to be included in the water supply reservoir plan on the South Branch to be built in the future.

PAWTUXET RIVER BASIN - NON-STRUCTURAL COSTS

House relocation $23,000

24' x 34' w/basement and relocation within same area

Raising home		w/Floodproofing	
1'	6,600	3,900	10,500
2'	7,800	3,500	11,300
3'	8,900	3,200	12,100

Flood proofing cellar

1'	3,500
6'	3,600
7.5	4,200

The Connecticut River Basin is a large basin, by contrast, with a large watershed area which extends through four States and encompasses over 11,000 square miles. There are local areas of the basin that are affected by urbanization but the Corps problem on the Connecticut River Study was to look into basin-wide flood management. In this particular basin, basin-wide flood management was not really significantly affected by urbanization.

As background, the Connecticut River Basin has had a basin-wide flood management plan for almost 30 years, ever since the Congressionally authorized plan of 1938. That plan called for the construction of dikes around the seven major damage centers along the lower main stem of the river, together with the construction of twenty large upstream reservoirs.

When the plan was first proposed, the dikes were built almost immediately. Initially, only five reservoirs were constructed, although eleven were added later. At present, the system is still seven reservoirs short of the originally proposed level of protection, and there is little likelihood that these reservoirs can ever be built - primarily because of political opposition. Because the seven reservoir alternative lacks support, the recent Federal/State supplemental study sought to accomplish most of the remaining needed protection through non-structural means. In the process, several levels of non-structural protection were investigated. These studies into non-structural measures were actually not done by the Corps but by the New England River Basins Commission with the Corps providing hydrologic and flood damage input.

The Commission considered three different alternative levels of non-structural measures. The maximum level was equivalent to the protection provided by the seven flood control dams recommended by the Corps. Two lower levels of protection were also considered. Analyses were made of the three alternative approaches for the six cities around which there are existing local protection projects and in addition, for ten other communities which have major damage problems.

Program A was designed to provide a non-structural alternative which would prevent an increase in the flood loss potential for events up to the SPF. Existing flood losses would be prevented in the flood plain below the elevation of the 100-year event. In other words, structures within the 100-year floodline would be cleared or flood proofed. New structures between the 100-year floodline and the SPF would be flood proofed. The insurance program would be modified to require a property owner to take insurance if he was below the SPF floodline. Land use controls would extend to all flood levels up to the SPF.

Program B was even more ambitious. This program was to have provided virtually the same level of protection that would be provided by the alternative local protection project; that is to prevent all losses from any flood up to the

SPF. Existing structures below the SPF line would be either removed or flood proofed; new structures would be flood proofed to the SPF. As in Program A, the flood insurance program would be modified to require property owners who are located below the SPF to carry insurance.

Program C, a compromise program which was recommended in the "River's Reach" was developed when it became evident (to NERBC) that Programs A and B could not achieve economic viability or public acceptance. Program C would be accomplished on a community specific basis under some general guidelines. Development would be prohibited in the floodway (NERBC used a 20-year flood to approximate the floodway). All existing structures that do not have to be in the floodway would be removed. Structures that have a strong locational advantage by virtue of being in the floodway would be flood proofed to the 100-year floodline. Residential structures, between the 20-year and the 50-year floodlines would be removed from the flood plain at the owner's option. New structures and existing structures that present a hazard would be flood proofed up to the 100-year floodline. The flooding potential of properties in the flood plain will be determined and this information will be disseminated to the public.

It could not be demonstrated that any community-wide Program C effort was economically justified. A rather crude benefit/cost assessment indicated that a Program C effort in a total of 18 communities has a B/C ratio of 0.9.

The "River's Reach" has recommended that level "C" studies be undertaken on a trial basis on several of the more promising communities in the basin. It is felt that the level "B" studies done to date do not prove or disprove the viability of a non-structural approach. NERBC feels that the recommended level "C" studies would also provide a vehicle to demonstrate "Section 73" of the 1974 Water Resources Act. Assuming that the level "C" studies do in fact prove that non-structural techniques provide: the optimum; and a viable solution, recommendations for cost sharing will be made under the provisions of Section 73.

RECOMMENDED PLAN - CONNECTICUT RIVER BASIN

1. Plan for areas behind the 6 existing dikes

    - Flood warning improvements
    - Raising the dikes to SPF level (in either 4 or all 6 of the communities)
    - Flood Insurance - expansion from 1 percent to SPF
    - Relocation and flood proofing - where economical

2. Plan for areas outside the 6 existing dikes

    - Consider local protection (including small dams)
    - Improve and expand flood warning and community preparedness
    - Consider relocation and flood proofing:
        - up to 20-year flood level reserved for floodway and open space
        - 20-year to 50-year permit only flood proofed non-residential structures
        - 50-year to 100-year permit only flood proofed structures

3. Prevent loss of natural valley storage and encourage wise use of flood plains

    - Regulate flood plains through Flood Insurance Program with State leadership
    - Acquire and preserve flood plain land as open space
    - Maintain agricultural use of flood plains
    - Guide growth away from flood plains

NON-STRUCTURAL PLANNING ALTERNATIVES

THE

SOUTH ATLANTIC DIVISION'S EXPERIENCE

BY

Shelton R. McKeever[1]

INTRODUCTION

Flood control planning procedure guidelines to give strong consideration to non-structural alternatives have been issued rapidly within recent years. This strong emphasis has been placed on non-structural alternatives in the absence of definite criteria. This, most likely, is due to a lack of past experience on which to establish tangible guidelines as we now have in our evaluation procedures for structural alternatives.

The most common analysis for flood damage reduction results in the recommendation for structural improvements. Until recently, only a cursory analysis was given the non-structural alternatives. This has changed somewhat with the issuance of the policy to give first consideration to these alternatives. Even now, we see recommendations for either structural or non-structural measures. Planning should abolish the concepts of "structural" and "non-structural" solutions and adopt what has been called the concept of "Flood Damage Prevention Planning". Only by applying this concept can we fully recognize and analyze the problem to give full consideration to both measures and, tailoring the formulation to the situation, come forth with a recommendation that best solves the problem.

OVERVIEW

This paper summarizes the experience of the South Atlantic Division in the evaluation and applicability of non-structural alternatives. By presenting this experience, it is hoped that we will gain more insight to flood control planning by realizing that a best solution may involve a mixture of various techniques or that it may involve either "structural" or non-structural" techniques.

Table 1 shows a list of selected projects with the B-C ratio of various alternatives.

[1] Civil Engineer in Flood Plain Management Services Branch, Planning Division, South Atlantic Division.

TABLE 1

ECONOMIC COMPARISON OF ALTERNATIVES

PROJECT	MAJOR ALTERNATIVES CONSIDERED	AVG. ANN. COST	AVG. ANN. BENEFITS	B-C RATIO
1. Simmons Creek	1. Concrete lined channel	$ 12,480	$ 27,520	2.2
	2. Floodproofing	6,140	29,185	4.8
2. Black River	1. Channel improvement	6,692	10,398	1.6
	2. Floodproofing	-	-	0.8
3. Scotts Creek	1. Floodproofing	37,600	28,800	0.8
	2. Channel improvement	55,000	64,220	1.2
4. Leith Creek	1. Floodproofing	45,200	23,500	0.5
	2. Channel improvement	16,700	22,200	1.3
5. Reedy Creek	Zoning of flood plain & building codes	None	None	None
6. Nicodemus Slough	Purchase Flowage Easements	185,000	?	-
7. Fisheating Creek	Flood plain purchase and raise a highway	61,000	61,000	1.0
8. Bay Gall Creek	1. Zoning			
	2. Floodproofing	Slab structures cause F.P.Problems		
	3. Flood plain evacuation	23,600	48,300	2.0
	4. Reservoirs			
	5. Channel improvement	51,510	82,810	1.6
	6. Levee			
	7. Clearing & snagging			
9. Brooklyn Branch	1. Evacuation (10-yr)	13,510	29,110	2.2
	2. Channel improvement	17,118	32,020	1.9

Problems in giving full consideration to all alternatives can be attributed to:

- A lack of understanding the non-structural approach.
- The history of not funding non-structural projects.
- A lack of adequate formulation and design methodologies.
- A lack of acceptance by local officials and the public.

A point to keep in mind in considering non-structural measures is there are intangible considerations other than property damage which motivate flood plain residents to seek structural solutions to their flood problems. As an example, we have worked with a county in Georgia through our FPMS program to develop a structural design to protect all structures against a 100-year frequency flood. The county, at their expense, is in the process of constructing this project. As a rough estimate, the BC ratio for the project is 0.4. This indicates that local governments sometime give little consideration to the cost where political and social influences are strong and where there are ample funds available. However, if bonds are needed, the support is weak and the public votes down the referendum. Also, there is a general willingness on the part of the public to accept structural solutions whereas they have a somewhat negative attitude on accepting non-structural solutions. This is demonstrated in Table 2 which summarizes the results of an opinion poll of flood plain residents.

TABLE 2

FLOOD PROTECTION PROJECTS

FLOOD PLAIN RESIDENTS RESPONSE (1)

ALTERNATIVE	ACCEPT	OPPOSE
CHANNEL ENLARGEMENT	100%	0%
RETENTION RESERVOIR	80%	20%
RAISE HOUSE 5 FEET	22%	78%
PERMANENT EVACUATION	67%	33%

(1) Ref. 1

SUMMARY OF EXPERIENCES

It is not uncommon for flood control feasibility studies to find that no structural improvements can be recommended, especially when there is sparse or scattered development in the flood plain. Even in areas where development is heavy, there are usually no suitable upstream reservoir sites due to development, and channel improvement is expensive because of major relocation and construction problems. In these cases, non-structural recommendations have been made. The most common alternatives are:

- Floodproofing
- Evacuation
- Flood Insurance

Appendix 1 presents one of our more detailed non-structural analyses which included evaluations of floodproofing, dikes, raising structure on pilings, and moving the structures.

EVACUATION

This has been the most successful and desirable technique. In cases where channel improvement is not practical due to relocation and construction problems, permenant evacuation of houses through purchase and demolition has been found to be the most practical non-structural alternative. A problem in using this technique is that only a limited portion of the damages can be eliminated. Our formulation indicates an evacuation design between 5 and 15 years which means there is considerable residual damage for the less frequent floods. Figure 1 demonstrates a typical evacuation plan that, after project formulation of a five-year design, there is considerable residual damage. The social impact of such a plan is adverse in that it disrupts the community life, displaces people from this settled area, and if only temporarily, places many inconveniences on those people affected. The political impact has been generally negative. However, the elected officials in some of our larger cities have begun to endorse this alternative. Table 3 shows the results of a questionnaire for public officials on the question of flood plain evacuation (Ref. 1).

The average annual cost of permanent evacuation of a structure is in the range of $2,250 based on a structural value of $30,000 (Ref. 1). Table 4 shows a breakdown of this cost.

FIGURE I

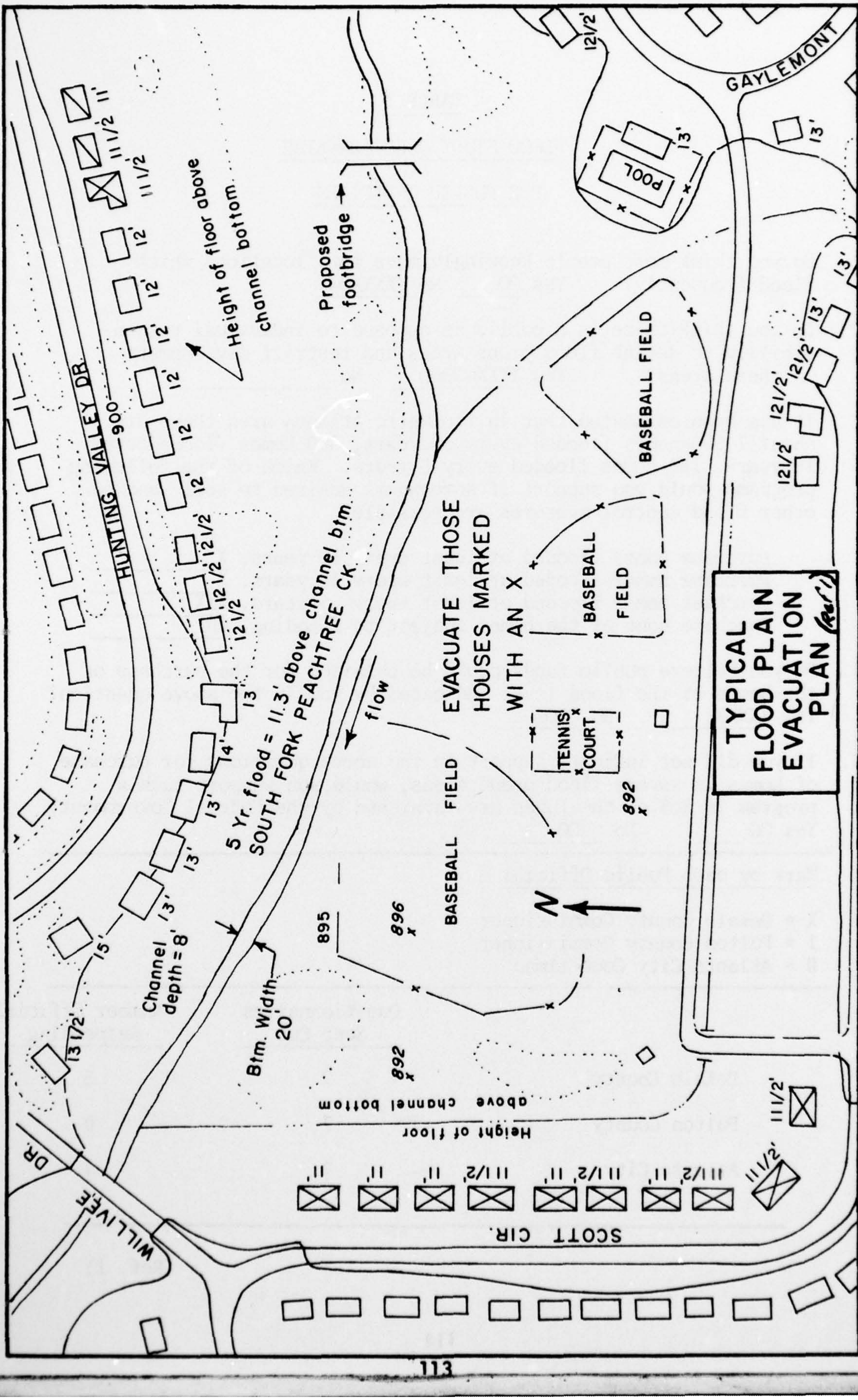
TYPICAL
FLOOD PLAIN
EVACUATION
PLAN
EVACUATE THOSE
HOUSES MARKED
WITH AN X
HUNTING VALLEY DR.
GAYLEMONT
SCOTT CIR.
WILLIVEE DR.
SOUTH FORK PEACHTREE CK.
5 Yr. flood = 11.3' above channel btm
flow
Proposed footbridge
Height of floor above channel bottom
Channel depth = 8'
Btm. Width 20'
BASEBALL FIELD
BASEBALL FIELD
BASEBALL FIELD
BASEBALL FIELD
TENNIS COURT
POOL
N
900
895
896
892
892

TABLE 3

FLOOD STUDY QUESTIONNAIRE

FOR PUBLIC OFFICIALS

1. Do you think most people knowingly move into locations which flood frequently? Yes 00 No XXXXX00

2. Do you think there is a public as opposed to individual responsibility to define flood prone areas and restrict development in these areas? Yes XXXX00000 No ____

3. It has been estimated that in the Metro Atlanta area there are about 1,550 homes flooded every 50 years, 380 homes flooded every 10 years, 130 homes flooded every 5 years. Which of the following programs would you support if homeowners desired to sell, and no other flood control measures are feasible?

   Purchase homes flooded at least every 50 years. X
   Purchase homes flooded at least every 10 years. X
   Purchase homes flooded at least every 5 years. XXX
   Purchase none of the homes subject to flooding. 00

4. Do you believe public funds could be obtained for the purchase of the homes at the flood level indicated by you in the above question? Yes XXXXX No 0000

5. If you did not indicate support in the above questions for purchase of homes in severe flood prone areas, would you support such a program if 80% of the funds are furnished by the Federal Government? Yes 00 No 00

Mark by each Public Official

X = DeKalb County Commissioner
1 = Fulton County Commissioner
0 = Atlanta City Councilman

	Questionnaires Sent Out	Number Officials Responding
DeKalb County	7	5
Fulton County	7	0
Atlanta City	7	4

(Ref. 1)

TABLE 4

AVERAGE ANNUAL COSTS

FOR

PERMANENT EVACUATION

Use typical brick veneer house 1500 ft.^{2} with 2-1/2' crawl space.

1975 value = $30,000

Economic Cost

Purchase price of house	=	$30,000	
Land Value	=		$7,500 (1)
Acquisition cost	=	1,500	
Demolition and cleanup (misc)	=	2,000 (3)	
		$33,500	
Engineering and Contingencies		2,000	
		$35,500 (2)	
Discount rate effective July 1975	=	6-1/8%	

Annual cost = $35,500 at 6-1/8% for 50 years.

Annual cost = $35,500 x 0.063444 = $2,252.00

(1) Land value is part of financial cost but not economic cost. Real land value is probably less than $7,500 and is retained, and remainder given to homeowner represents benefit to homeowner.

(2) Additional $5,000 not shown provides funds for homeowner to obtain suitable equivalent housing.

(3) Revised from $4,000 as was estimated to indicate actual contractor's cost.

(Ref 1)

FLOODPROOFING - In cases where modifications of the channel are not feasible due to sparse or scattered development, it is found that floodproofing is the most economically responsive solution. However, care should be exercised in making a recommendation especially for residential areas.

While floodproofing is a means of reducing flood damages, it is not a desirable solution for use in residential areas. Many of the homes affected by flooding are slabs on grade which precludes raising the structures. Using levees to floodproof individual property would be unslightly and also expensive due to the necessity for providing interior drainage. However, this technique has been employed by several individual property owners. They have either built walls or constructed levees around their property. If careful throught and engineering went into the design and construction, this was successful. However, many land owners neglect such things as hydraulic loading, interior drainage, materials selection, and flap gates in sewer and drainage pipes. As a result they sustain an increase in damage.

Floodproofing techiques are most effective utilized by commercial and industrial developments, especially if they are occupied 24 hours a day and have the resources to implement this technique. Floodproofing in conjunction with flood warning procedures is most effective on the larger streams where time to flood peak will give the occupants ample opportunity to seal any openings and/or activate emergency procedures. Figure 2 shows a plan view of an industrial complex where the recommended plan called for floodproofing (Ref. 2). Table 5 shows the major floodproofing measures to be implemented.

An example of the details of floodproofing an individual structure is furnished in Table 6.

TABLE 5
SIMMONS CREEK (1)

Floodproofing measures. The major floodproofing items considered in this report are doors, windows, outside walls, and air vents that provide ventilation under buildings. The structural quality of the buildings was checked to determine that they would withstand the pressure that would be applied by a major flood.

1. Doors. The most feasible door floodproofing would be the installation of a steel door, opening outwards, with a gasket seal around the inside of the door between the door and the doorframe. The water pressure exerted on the door, combined with the gasket seal, would provide a watertight door.

2. Windows. It was found that bricking-up was the most economical floodproofing measure for windows. The windows would be bricked-up to the desired height with two rows of brick, one on each side of the window, with mortar filler in between.

3. Walls. The outside walls would be cleaned of all foreign material and painted with two coats of silicone waterproofing material. A 2-foot freeboard was considered sufficient for wall waterproofing.

4. Ventilators. All ventilators under buildings and in basements would be closed with brick to prevent flooding by water entering under the building.

(1) Ref. 2.

FIGURE 2

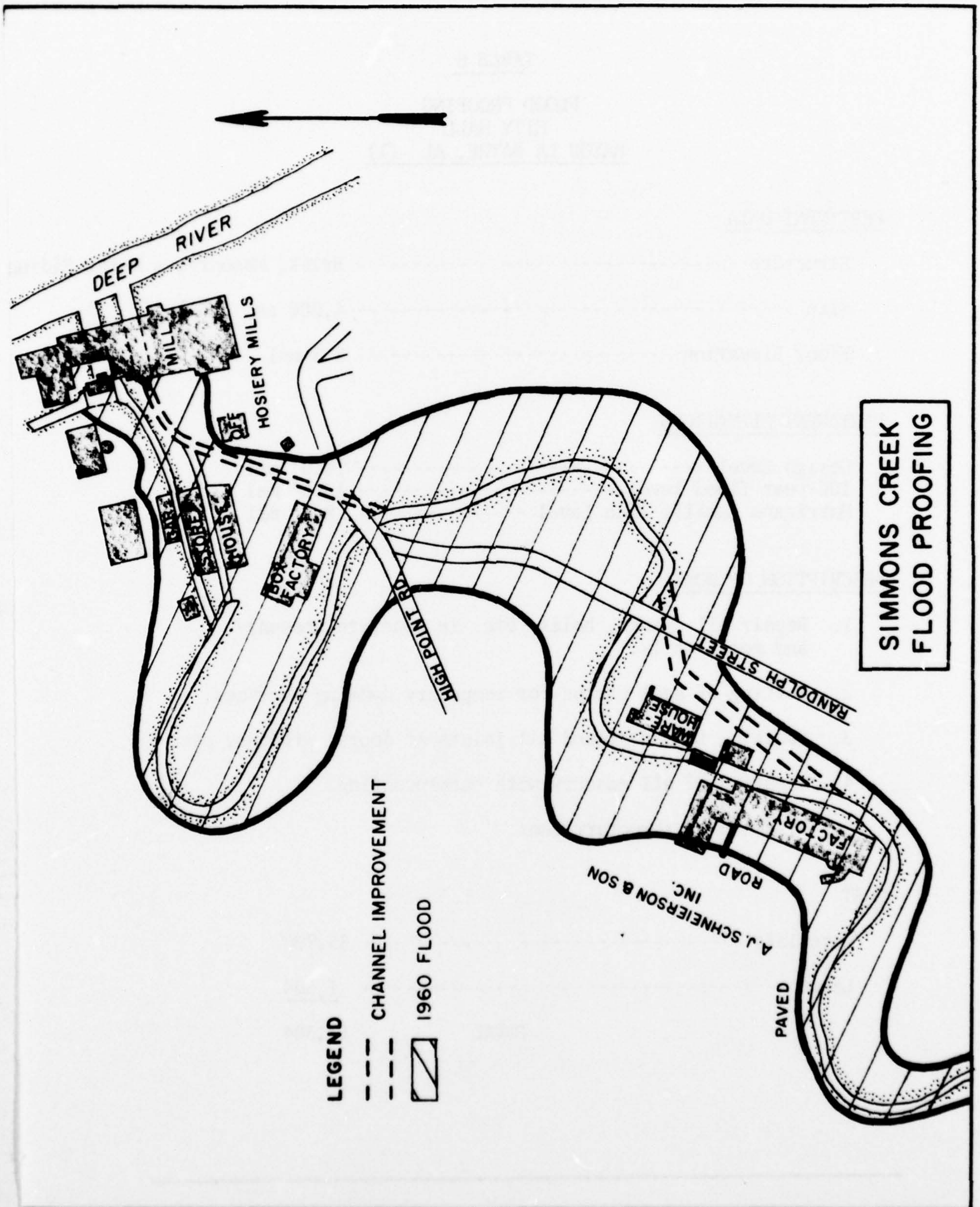
SIMMONS CREEK
FLOOD PROOFING
DEEP RIVER
MILL
HOSIERY MILLS
STORE
HOUSE
BOX FACTORY
HIGH POINT RD.
RANDOLPH STREET
WARE HOUSE
FACTORY
ROAD
A.J. SCHNEIERSON & SON
INC.
PAVED
LEGEND
CHANNEL IMPROVEMENT
1960 FLOOD

TABLE 6

FLOOD PROOFING
CITY HALL
BAYOU LA BATRE, AL (1)

PERTINENT DATA

Structure	Brick, Masonry, & Metal Siding
Size	4,900 sq. ft.
Floor Elevation	8.5 msl

PERTINENT ELEVATIONS

Design Level	10.0' msl
100-year flood level	13.5' msl
Hurricane Camille Tide level	8.5' msl

DESCRIPTION OF WORK

1. Repair all cracks, holes, etc. in concrete, masonry, and metal walls.
2. Setting of seal strips for temporary damming surfaces.
3. Caulking in and around all joints at doors, windows, etc.
4. Treating of all masonry with waterproofing.
5. Erection of temporary dams.

COST

Materials	$5,790
Labor	1,594
TOTAL	$7,384

(1) Reference 3.

FLOOD PLAIN REGULATIONS - This alternative has no immediate impact on flood damages but the long range potential is a very important consideration as witnessed by the basis for the Federal Insurance Program. This alternative is most effective for undeveloped areas which are subject to development pressure.

The full potential of using regulations is not being utilized. Areas can be zoned with exceptions for non-conforming uses which can be phased out at the end of the structure life or can be evacuated as funds become available. To gain acceptance, it is important that property owners be granted financial relief, such as tax breaks, an increase in development density, etc.

A weakness in this alternative as used by the Federal Insurance Program is that regulations are based on existing hydraulic conditions. The regulations should be based on future hydraulic conditions if development is to be kept out of areas subject to future flooding. In other words, regulations for future development should be based on the future conditions. Table 7 shows an example of the effectiveness of the flood insurance program. However, note the future increases in damages.

TABLE 7

FLOOD DAMAGE COMPARISON
FOR
FUTURE DAMAGE
WITH FLOOD PLAIN REGULATIONS (1)

Evaluated Condition	Exp. Annual Damages
1. Existing Land Use - No Regulations	$ 1,500
2. 1990 Land Use - No Regulations	$1,033,300
3. 1990 Land Use - FIA Regulations	$ 19,300

(1) Reference 4.

From the standpoint of the individual property owner, the flood insurance program is an alternative that can be applied to recover a portion of his damage. However, it is impossible to recover all damages, both tangible and intangible through the insurance program. This program does not reduce flood damage but simply spreads the damage to all policy holders and to the public. In fact, due to administrative cost, the costs of floods are increased by this program. However, the heart of this program is that it demands that flood plain regulations be adopted that result in a minimizing of future construction (thus damage) in flood hazard areas.

CONCLUSIONS

Table 8 summarizes in general terms our experiences in the applicability of various non-structural solutions. This table reflects the opinion of the author on rating the solutions on a scale from 1 to 10 based on economic, political, environmental, and social conditions.

TABLE 8

APPLICABILITY OF NON-STRUCTURAL ALTERNATIVES

	Location	Non-Structural Measure		
		Flood Proofing	Evacuation	Regulations (Flood Insurance)
I.	Drainage Areas less than 100 sq. miles			
	Industrial	10	0	0
	Commercial	8	2	2
	Residential	2	6	5
	Undeveloped	-	-	7
II.	Drainage Areas 100-400 sq. miles.			
	Industrial	10	0	0
	Commercial	9	2	2
	Residential	4	7	6
	Undeveloped	-	-	8
III.	Drainage Areas greater than 400 sq. miles.			
	Industrial	10	0	0
	Commercial	10	2	2
	Residential	5	8	8
	Undeveloped	-	-	10

FLOOD PROOFING - In general, flood proofing has been found to be most effective for industrial flood damage reduction in most areas due to the amount of flood damage and the availability of resources and manpower to implement this technique. For commercial buildings this has proven to be a good technique especially if used in conjunction with flood warning procedures. Thus, it is more effective for streams with larger drainage areas. For residential protection, this is the least desirable technique especially for the small drainage areas where flash flooding is experienced. We have seen examples of good flood proofing techniques, but these are greatly outnumbered by techniques that involve poor design or require swift emergency actions by the property owner.

EVACUATION - This has proved to be the best non-structural technique for residential area flood damage reduction. This completely eliminates the damage potential below the design level but still leaves residual damages above this level. Due to changes in the hydraulics, this technique is less desirable along streams with small drainage areas. Due to the investment, evacuation of industrial and commercial developments has been found to be almost impossible.

REGULATIONS - Regulations, especially those required by the Federal Flood Insurance Program, are most effective for residential development, or undeveloped areas along streams which have large drainage areas. There is some danger involved if regulations are based on existing hydraulic conditions. This would cause new development to locate above the present 100-year flood but hydraulic changes during the life of the structure may subject the property to more frequent floods. To some extent, the flood insurance program encourages residents to remain in their house and to improve and increase their investment, thus increasing the flood damage potential. Due to the large investment, high cost of flood insurance, and the desire of industry to locate near water, regulations are not effective for this type of development. For the cost and investment reasons, this also applies to commercial development.

GENERAL - In general, no matter which non-structural technique is implemented there is an inherent danger in that they are based on a fixed design, such as a 100-year flood design. Such a technique tends to overload development at the elevation just above the 100-year flood, thus making conditions for a disaster whenever the much larger floods occur. The true path to achieving what the structurally oriented and the non-structurally oriented are trying to achieve - prevent flood damages, there will have to be a joining of minds to arrive at the best solution to the problem, whatever that might be. In other words, our planning should be directed to a path of "Flood Damage Prevention".

APPENDIX 1

ANALYSIS OF TYPICAL NON-STRUCTURAL FLOOD DAMAGE

REDUCTION MEASURES

Crabtree Creek, Raleigh (1)

4 April 1976

Bldg Type-Construction	Bldg Market Value in $1,000	Design Flood-Ht Above Lower Floor	Type of Non-structural Measure [1]	Results: Cost [2] in $1,000	Results: Benefits in $1,000	Remarks
Apt Bldg - Brick						
8 Lower Apts	60	20yr-1.1'	Flood Proof	6.0	2.9	
		50yr-3.4'	Flood Proof	20.0	9.6	
		100yr-5.0'	Flood Proof	27.0	14.4	
Apt Bldg						
3 Bldgs 12 Apts	180	100yr-9.5'	Earth Dike L=1,800 ft	63.0	275.0	Only 3 Bldg W/major damages to basement contents
		50yr-8.2'	Earth Dike L=1,650 ft	44.0	244.0	
		20yr-6.8'	Earth Dike L-1,500 ft	36.0	184.0	
Residence Split level	20	100yr-8.3'	Raise on Pilings	25.0	63.4	
		100yr-8.3'	Move Bldg	22.0	63.4	
		50yr-6.4'	Raise on Pilings	20.0	61.6	
		50yr-6.4'	Move Bldg	22.0	61.6	
		20yr-4.2'	Raise on Pilings	14.0	56.8	
		20-100yr 4.0' plus	Flood Proof	N/P	-	Not possib structur-ally W/4' water W/O major stru tural alte ations.

(1) Ref. 5.

ANALYSIS OF TYPICAL NON-STRUCTURAL FLOOD DAMAGE

REDUCTION MEASURES

Crabtree Creek, Raleigh

4 April 1976

Bldg Type-Construction	Bldg Market Value in $1,000	Design Flood-Ht Above Lower Floor	Type of Non-structural Measure[1]	Results in $1,000 Cost[2]	Results in $1,000 Benefits	Remarks
Residence 1-Story	12	100yr-6.5'	Raise on Pilings	13.0	20.0	
1-Story	25	100yr-1.8'	Flood Proof	8.0	1.3	
1-Story	25	20yr-1.3'	Flood Proof	7.0	8.0	
2-Story	25	50yr-0.8'	Flood Proof	1.7	1.1	
1½-Story	20	20yr-0.7'	Flood Proof	2.1	10.0	
2-Story	18	20yr-1.3'	Flood Proof	3.6	5.1	

1. All measures were carried 1.0 to 1.5 feet above design flood elevation.

2. Costs do not include operation and maintenance expenses.

ANALYSIS OF TYPICAL NON-STRUCTURAL FLOOD DAMAGE

REDUCTION MEASURES

Crabtree Creek, Raleigh

9 April 1976

Commercial Bldg Type-Construction	Bldg Mkt Value in $1,000	Design Flood Ht Above Floor	Type of Non-structural Measure[1]	Results in $1,000 Cost[2]	Results in $1,000 Benefits	Remarks
Restaurant	68.0	100yr-1.1'	Flood Proof	6.1	5.3	
Warehse W/ unloading facilites & refrig compartments	350.0	100yr-1.4'	Flood Proof	67.5	28.2	Total L Bldg= 810' W/18 large drive-in doors; floor 5' above ground
Warehouse	8.0	20yr-2.3'	Move Bldg	6.1	10.6	
Bonanza Stk Hse Typical type & size	92.5	50yr-1.0'	Flood Proof	3.2	2.5	
Pizza Hut Typical type	33.0	100yr-3.4'	Flood Proof	15.3	6.8	
		50yr-1.9'	Flood Proof	7.1	3.4	
		20yr-0.3'	Flood Proof	1.7	0.3	
Brick Bldg	10	100yr-3.1'	Flood Proof	15.3	1.3	Area = 3,500 sq. ft
		50yr-1.6'	Flood Proof	6.7	0.4	
Aluminum W/ steel frame	60	100yr-4.6'	Flood Proof	25.1	11.5	Area = 2,700 sq ft
		50yr-3.1'	Flood Proof	13.1	7.7	
		20yr-1.5'	Flood Proof	4.9	2.7	
Hardees Rest Typical type	150	100yr-3.2'	Flood Proof	14.3	17.4	
Arby's Roast Beef Typical type	50	100yr-4.9'	Flood Proof	21.4	29.3	
		50yr-3.4'	Flood Proof	13.2	20.3	
		20yr-1.8'	Flood Proof	8.5	7.1	

Commercial Bldg Type-Construction	Bldg Mkt Value in $1,000	Design Flood Ht Above Floor	Type of Non-structural Measure [1]	Results Cost [2] in $1,000	Benefits in $1,000	Remarks
Office Bldg Aluminum W/ steel frame	30	100yr 4.8'	Flood Proof	23.0	18.8	Area = 9,000 sq ft
		20yr 1.7'	Flood Proof	11.5	7.4	
Block W/brick facing Bldg has 5 businesses operating	30	100yr 2.4'	Flood Proof	21.2	3.9	Area = 5,500 sq ft
		50yr 0.9'	Flood Proof	6.6	1.3	

1. All measures were carried 1.0 to 1.5 feet above design flood elevation.

2. Costs do not include operation and maintenance expenses.

REFERENCES

1. Investigation of the Feasibility of and the Optimum Level for Permanent Flood Plain Evacuation - by Frank B. Mallette, August 1975 - A Special Research Project Presented to the School of Civil Engineering at Georgia Tech Institute of Technology.

2. Simmons Creek Detailed Project Report, Randleman, NC

3. Flood Proofing, City Hall, Bayou La Batre, Alabama, March 1973

4. Oconee Pilot Study - Trail Creek Test, by the Hydraulic Engineering Center, September 1975.

5. Crabtree Creek, Raleigh, N.C. Detailed Project Report

REVIEW OF THE BAYTOWN, TEXAS EVACUATION PLAN

By

Carl O. Foley[1]

INTRODUCTION

The Board of Engineers for Rivers and Habors was established by an act of Congress in 1902 to provide an independent review of planning reports submitted by Corps of Engineers field offices. Although the Board is a part of the Corps, it is outside the operational chain of command and provides advice, views and recommendations to the Chief of Engineers. A survey report for flood control at Baytown, Texas was recently reviewed by the Board. The recommended solution to the problem by the Galveston District Engineer, permanent evacuation of the flood plain, is unique in many ways. The purpose of this paper is to discuss the policy issues addressed by the Board in their review.

The Recommended Plan

The city of Baytown, Texas is located 20 miles east of Houston. The area is characterized by large petrochemical industrial complexes as well as scenic residential development adjoining Galveston Bay and its esturaries. The study area is one of these residential communities adjoining Burnett, Crystal and Scott Bays. The homes are subject to hurricane and tidal flooding. The problem is compounded by a general land subsidence caused by extensive groundwater withdrawals for agricultural, industrial, and municipal uses in the Houston metropolitan area. The vulnerability of this area to flooding increased significantly in recent years as the subsidence became more pronounced. Several waterfront homes have been abandoned with standing water on the first floor. The Galveston District

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[1] Project Engineer, Board of Engineers for Rivers and Harbors, Fort Belvoir, Virginia

investigated a number of structural solutions but all lacked economic justification. The only viable solution appeared to be permanent evacuation of residential properties. The recommended plan of improvement would evacuate 448 homes in the 50-year flood plain with relocation assistance for the residents. The evacuated lands would be used for recreation or other passive uses. The $17 million plan would have a benefit-cost ratio of 1.3 and there is no apparent opposition by the people who would be affected.

National Flood Insurance Program

The impact of the National Flood Insurance Program was a factor in the Board's deliberation of policy issues. A little history and background on this program would be appropriate.

In 1972, the Water Resources Council published a report stating that annual flood damages in the United States exceed $1 billion annually in spite of enormous private and Federal investments for flood protection. The Federal investment alone, since 1936, has exceeded $7 billion. If these numbers are reasonably accurate, it would appear that a different approach may be needed to solve the nation's flood problems.

The National Flood Insurance Act of 1968 provided a different approach, subsidized flood insurance for people who live in flood plains. The program was voluntary and very few people took advantage of it. Only two home owners in Wilkes Barre, Pennsylvania, for example, had flood insurance at the time of Hurricane Agnes in 1972. The Flood Insurance Act was amended by the Flood Disaster Protection Act of 1973. The Federal share of the insurance cost was increased but there were strings attached to make flood insurance almost mandatory. Flood plain occupants cannot qualify for any other Federal financial assistance including most home mortgages unless they have flood insurance and their community participates in the program. To qualify for the program, the affected community must prevent any new development in the flood plain that isn't protected against at least the 100-year flood. In effect, the program would subsidize existing flood plain development and prevent any future development subject to significant flooding. When existing flood plain structures deteriorate, they will not be replaced, and flood damages will gradually decline over time. In my opinion the flood insurance concept is basically sound. There have been political repercussions due to the mandatory overtones of the program and the adverse impacts on the economy of many communities. There are problems and inequities that will have to be worked out if the program is to be successful. But it does appear to be a step in the right direction.

Federal Interest

The recommended plan for Baytown was considered by the Board of Engineers for Rivers and Harbors in January 1976. Federal interest in this plan was discussed at some length. It was clear that the plan would not have been economically justified without land subsidence, a local phenomenon caused by a disregard for the consequences of groundwater withdrawals over a long period of time. Is there a Federal interest in solving this problem? The Board concluded that there was a Federal interest primarily because of the National Flood Insurance Program. Future subsidies through this program are expected to be greater than the market value of many flood prone homes in the recommended plan. It's cheaper for the Federal government to acquire these homes rather than continue to pay flood insurance claims. Another important fact was the establishment in 1975, of a Coastal Subsidence District, with authority to restrict groundwater withdrawals and control future subsidence.

The next question raised by the Board was more difficult to resolve. Why should the Corps of Engineers acquire these homes? HUD is responsible for the Flood Insurance Program. They would appear to be the logical Federal agency to implement the plan. Section 1362 of the Flood Insurance Act appears to provide this option. However, this section of the act has never been funded. Even if it were funded the wording would have to be changed in order to purchase the homes at Baytown. Section 1362 provides that real property covered by flood insurance may be purchased if damaged substantially beyond repair by a flood. This has been interpreted to mean repairs caused by a given flood which are at least 50% of the market value of the structure. The homes at Baytown have not been subjected to devastating damages from a single flood. Damages occur frequently and the home owner, in two instances, has received cumulative payments over a five year period that exceed the market value of the structure. The Board concluded that the Corps has a longstanding responsibility for flood control and could implement the plan if directed to do so by higher authority.

Flood Insurance Benefits

Average annual benefits were calculated by the conventional flood damage reduction methodology. A parallel benefit analysis was presented in the report using reduction in flood insurance costs as a measure of the benefits. Since flood insurance costs are really a measure of flood damages, the benefits should be approximately the same by either method. However, the benefits shown in the report for reduction in flood insurance costs were nearly double the benefits calculated by the conventional method. Flood insurance costs were based on stage-damage relationships shown in a 1974 report by the National Flood Insurers Association. Much of the data was based on actual flood insurance claims processed from all parts of the country. The damages experienced at Baytown are not at all representative of the values shown in the Flood Insurers report. The stage-damage data used to calculate benefits by the conventional method were obtained during a recent damage survey and were clearly more reliable. The benefit analysis based on reduction in flood insurance costs was disregarded by the Board. The methodology is sound but adequate data that is site specific in not currently available.

Degree of Protection

Permanent evacuation of the 13.5-year flood plain would maximize net benefits. This includes 392 homes having a first floor elevation at least 10 feet below the elevation of the standard project hurricane. The recommended plan would extend evacuation to the 50-year flood plain and to about 56 additional houses.

The district gave several reasons for selecting the 50-year plan. Home owners located above the 50-year flood line were generally opposed to evacuation. On the other hand, there appeared to be near unanimous support from the people located below the 50-year flood line. The recommended plan was economically justified even though it did not maximize net benefits.

All flood plains described in the district report were based on projected ground elevations. It was assumed that groundwater withdrawals will be terminated in the next couple of years. However, an additional two feet or so of land subsidence will occur due to gradual consolidation of soil layers. Future subsidence will probably occur in pockets, the entire flood plain will not sink at a uniform rate. Therefore, the number of houses which will eventually end up in a given flood plain can only be estimated at this time. The district's position was that the optimum plan should be expanded to include all houses where there is a strong probability that flood insurance subsidies will be excessive. If the optimum plan, based on projected ground elevations, were implemented and it was determined at some future date that 50 or so homes should be added to the project, study costs alone would be almost as expensive as the value of the additional homes to be acquired. In other words, lets make sure we solve the problem once and for all.

The Board accepted this rationale for recommending the 50-year plan. The final decision regarding where to "draw the line" should be delayed until post authorization studies are near completion.

Topographic surveys at that time and the desires of the people affected, on a block-by-block basis, will have to be carefully evaluated. Permanent evacuation of all structures in the projected 50-year flood plain would appear to be the best solution, based on present knowledge and survey-scope level of detail.

Cost Sharing

Section 73 of the 1974 Water Resources Development Act appeared to open the door for 20-80 cost sharing for so-called nonstructural measures which would include the Baytown evacuation plan. However, Section 80 of the same act calls for a restudy of the Principles and Standards including a study of appropriate Federal and non-Federal cost sharing for water resources projects. The Water Resources Council members have agreed to defer specific cost sharing recommendations for nonstructural measures until the Section 80 study recommendations have been formulated. As a result, Corps field offices have been advised not to make specific cost sharing recommendations for nonstructural plans. Survey reports can be processed, on a selective basis, through the early stages of Washington-level review while the Section 80 study is underway. When an Administration policy for cost sharing has been formulated, an appropriate endorsement can be added without changing the district's report.

The Baytown report recommended that non-Federal interests share in the cost of the recommended plan in accordance with cost sharing provisions being developed under Section 80 of the 1974 Act. The Board made a similiar recommendation in their report. They concluded that since the Administration has not yet developed a cost sharing policy for nonstructural measures, this issue would have to be deferred, and perhaps covered in the report of the Chief of Engineers.

Conclusion

Evacuation plans as a solution to flood problems will never be a major program by the Corps of Engineers. Very few areas of the country are susceptible to average annual damages large enough to ecomonically justify this solution. The problems at Baytown are unique and so is the recommended plan. The report still has to pass through several levels of review in Washington. It will be an interesting case to follow.

ANALYSIS OF RELATIONSHIP OF FEDERAL FLOOD INSURANCE WITH EVACUATION PLAN FOR BURNETT, CRYSTAL, AND SCOTT BAYS AND VICINITY, BAYTOWN, TEXAS

By

Frank G. Incaprera [1]

INTRODUCTION

A feasibility report was prepared and submitted by the Galveston District on flood control plans for a portion of Baytown, Texas. The unique problem in the study area is that 5 feet of land subsidence has occurred over the past 30 years and the subsidence is expected to continue. The residential developments adjacent to the bays are becoming vulnerable to inundation more frequently. The type of levee systems that could protect the area is costly and the structural plans considered have been estimated to be economically unfeasible. Almost all of the properties located in the study area are covered by the flood insurance program, which is administered and subsidized by the Flood Insurance Administration which is a Federal agency in the U. S. Department of Housing and Urban Development. Claims have been paid almost on an annual basis ever since the insurance program was initiated. The future subsidies paid through the flood insurance program are expected to be greater than the market value of the homes located in the study area. The removal of these payments of claims is considered to be in the Federal interest because the largest share of the payments are funded through the subsidy program sponsored by the Flood Insurance Administration. The homes are demolished in the proposed evacuation plans; thereby the claims for repairing inundation damages are removed and the payments of claims are no longer required. The evacuation plan provides a least-cost method for reducing government expenditures. The purpose of this paper is to show the relationship of the Federal subsidy in the Federal Flood Insurance program with the evacuation plans.

The analysis of the relationship of the Federal flood insurance program with the nonstructural evacuation plans presented in the

[1] Civil engineer and economist, Economic and Social Analysis Section, Galveston, District.

feasibility report on the Baytown study was made in three phases. The initial phase was made to determine the cost of the flood insurance plan. The second phase covers the comparative costs for providing the flood insurance program or evacuating the flood plain. The third phase provides the conclusions that can be drawn from this examination.

COST OF FLOOD INSURANCE PLAN

The costs for flood insurance were determined for properties located in the study area and for properties located in the several flood plains used for delimiting the areas included in the various evacuation plans. The costs for implementing the flood insurance program as administered by the Flood Insurance Administration (FIA) are based on the Federal subsidies which are determined from actuarial rates, premiums paid by the public, and costs for operating the flood insurance program. Separate analyses were made for structural properties and contents and are shown on tables 1 and 2, respectively. The actuarial rates used in the analyses are taken from the "Flood Insurance Manual," which was prepared by the National Flood Insurance Association, 160 Water Street, New York, New York 10038, dated July 1974. The rates used in the cost analysis for structural properties (residential) are in FIA Elevation Rate Table III, Section A, on page R10 and the rates used in the cost analysis for contents are in FIA Elevation Rate Table III, Section C, on page R18. The actuarial rates in the Flood Insurance Manual are based on aggregations of average annual damage estimates prepared for many regions of the country. The premium rate used in table 1 for the private sector cost for structural property is \$0.25/\$100 of structure value, and the premium rate used in table 2 for the private sector cost for contents is \$0.35/\$100 of contents value. These rates were adapted from rate table 1 on page R-3 of the Flood Insurance Manual. According to FIA reports, sixty percent of the premiums collected go to the trust fund for claim payments and forty percent is used for operational costs of insurance firms. An average value of $17,000 was used in the insurance cost analysis for the unit value of all structures and an average value of $8,500 was used in the insurance cost analysis for the unit value of all contents, regardless of location. The average annual Federal cost for administering the flood insurance segment of FIA's total mission was estimated by dividing one-fourth of the annual appropriation ($20,000,000) by the number of policies in force in 1974 (385,000). The average annual cost for administering each insurance policy was thus estimated at $13. This value is used in the cost analysis for structures only and is not duplicated in the cost analysis for contents. A summary of the insurance costs for structural properties and contents for houses located at the various elevations in the study area is shown in table 3.

Homeowners' Deductible.- The flood insurance policy requires the homeowner be responsible for the first $200 of claimed damages or for damages that equal 2 percent of the total property value, whichever is the least. The actuarial values are developed on an average annual basis and the deductible is based on a single-incident occurence; the two values are not comparable. To separate the private cost of the deductible from the actuarial values, it would be necessary to restructure the stage-damage relationships used in making the actuarial rates and reevaluate the actuarial rates. To evaluate the potential net effect of the deductible, a sample check was made of a structure located 11 feet below the 100-year flood plain elevation. A structure at this elevation is typical of about 50 percent of the structures in the study area. Assuming $200 deductible, it was determined that the distribution of cost, based on the revised actuarial rate, would be 4 percent for the private share and 96 percent for the Federal share. This check indicates that the net effect of including the deductible, as opposed to excluding the deductible in the analysis of the flood insurance costs, amounts to revising the distribution of the private and Federal costs of the flood insruance program from 2 percent and 98 percent, respectively. Accordingly, since the overall cost of the flood insurance program is not changed, the analysis ignores the deductible in the interest of simplicity of comparison

COMPARATIVE COSTS FOR FLOOD INSURANCE AND EVACUATION

An aggregated summary of the private, Federal, and total costs, for implementing the flood insurance for structure and contents in the study area is shown in table 3. The total cost of implementing the flood insurance program for properties located within the areas of each evacuation plan was determined by summarizing the total annual costs for the structures located at every elevation below the design elevation, as shown in table 4. Comparisons of these costs with the costs for implementing the evacuation plans proposed in the feasibility report will show that the insurance program is more costly than the implementation of any of the evacuation plans. The comparisons are shown below:

Evacuation plan

Design	Elevation (feet, MSL)	Annual cost for insurance program	Annual cost for evacuation plans
SPH	19.0	$3,124,200	$1,813,000
100-yr	17.0	3,109,800	1,458,000
50-yr	15.5	3,098,300	1,261,000
25-yr	13.5	3,094,100	1,200,000
13.5-yr	10.0	3,082,200	1,098,000

Flood Insurance Cost for Property Excluded from Evacuation Plans: The recommended plan in the subject report was selected from an array of alternatives which included various levels of evacuation ranging from the 13.5-year flood plain to the Standard Project Hurricane flood plain. Using conventional methods, the costs and benefits associated with each alternative were evaluated and the net benefits computed. In comparing alternatives, only those costs associated with evacuation and relocation were considered. The principal annual costs related to the Federally-subsidized flood insurance program for areas located above the proposed designs were extracted from the attached table 3, and are estimated as follows:

Design for evacuation plan	Annual insurance cost for area located above the proposed designs
13.5-year	$42,000
25 -year	30,100
50 -year	25,900
100 -year	14,400
SPH	0

The Federal portion of the flood insurance costs shown above are estimated at $20,400, $11,100, $8,400, $3,500 and zero dollars, respectively. When considering the provision of the insurance program for the properties located above the elevations for the various evacuation plans as being complementary to the various evacuation plan, the percentage increase for adding the insurance costs to the cost of the evacuation plans is small. For example, the incremental costs for providing insurance for the properties above the elevation of the recommended plan for the 50-year design as compared to the cost for evacuation is only two percent ($25,900/$1,458,000). In view of the relatively small value of the incremental insurance cost for properties located above the elevation to be evacuated, the effect of including this cost in the overall benefit-cost evaluation presented in the feasibility report would be negligible.

Residual Damages for Evacuation Plans: The cost of the insurance program is reflected in the benefit analysis by the residual damages associated with each evacuation alternative. The residual damages for the various evacuation plans can be determined from the reduction of flood damage estimates shown in table D-12, page D-17 of Appendix 1 of the feasibility report, by subtracting the values for the reduction of flood damages for the lesser design from the SPH design. The estimates of the residual damages for the evacuation plans are as follows:

Design for evacuation plan	Estimate of residual damages
13.5-year	$24,000
25 -year	12,000
50 -year	3,000
100 -year	800*
SPH	0

*The value for residual damages for the 100-year plan were taken from working papers; the $800 value does not appear in table D-12 because of rounding numbers in the report to the nearest $1000.

Comparison of the residual damages with the cost of the flood insurance program for properties located outside the various evacuation plans, which are shown in paragraph 4, reveals that the cost of the insurance progarm is higher. This is due to the administrative costs for conducting the insurance program and to FIA's use of aggregated regional stage-damage data instead of local stage-damage data in developing the actuarial rates.

Total Federal Cost: It may be considered that the total Federal cost is the combination of the Federal evacuation cost of the recommended evacuation plan prepared by the Corps of Engineers and the cost of the Federal subsidy for the flood insurance program which is administered by FIA for properties located between the limits of the area within the SPH flood plain and the evacuated area. For example, the total Federal annual cost for the recommended 50-year design would be $1,026,200, which is estimated as follows:

Federal annual cost for 50-year evacuation plan:

$16,980,000	x	.80	x	.07364	=	$1,000,300
(Total 1st cost)		(Fed share)		(I&A factor)		

Total Federal annual cost for flood insurance for properties located outside the evacuated area (paragraph 5)	=	25,900
Total Federal annual cost		$1,026,200

CONCLUSION

The above methodology describes the distributions of costs for implementing the flood insurance program. The analysis is based on using the actuarial rates in the Flood Insurance Manual. The benefits for the evacuation of property below the 50-year flood plain based on the reduction of flood insurance costs as shown in the survey report are estimated at $2,350,000 and the benefits for the reduction of flood damages are estimated at $1,094,000. The reason for the imbalance is that the unit average annual damages used to construct the actuarial rates are based on input from various regions of the country while the average annual damages used in the reduction of damages analysis are specifically for the study area. The FIA is planning to publish a manual soon with actuarial rates based on historical data on flood damage settlements, a process similarly used for wind and fire insurance; the average annual damages concept is being abandoned. Regardless of what method is used to develop the actuarial rates, the annual costs to FIA, based on a long-term analysis, should approach the average annual damages normally evaluated in survey projects, plus operations costs. The net cost to the national account when evaluating in terms of the cost of the flood insurance program can be determined by adding the cost of $0.10/$100 of structural value and $0.14/$100 of personal property value, to represent the insurance company's operating cost, and adding $13 per structure for FIA overhead, to the average annual damages evaluated for the property being evaluated. That portion of the insurance premium that is dedicated to the funds for paying claims is not included, primarily to avoid duplicating the claim costs already represented in the average annual damages.

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TABLE 1

ANALYSIS OF FLOOD INSURANCE COSTS-STRUCTURES
(BURNETT, CRYSTAL AND SCOTT BAYS AND VICINITY, BAYTOWN, TEXAS)

Elevation feet (MSL)	Elev. above & below 100-yr flood plain (feet)	No. of houses (aggregate)	No. of houses (incremental)	Actuarial Rate ($/$100 value) Private	Fed	Total	Operations and taxes Private 1/	Fed 2/	Unit net cost per $100 Private 1/	Fed 3/	Avg. value of house unit	Total value of houses	Total annual costs Private	Fed	Total
19	+2	690	150	.15	.00	.15	.10	13.00	.25	.00	$17,000	$2,550,000	$ 6,400	$ 2,000	$ 8,400
17	0(100 yr)	540	84	.15	.08	.23	.10	13.00	.25	.08	17,000	1,428,000	3,600	2,200	5,800
16	-1	456	8	.15	.19	.34	.10	13.00	.25	.19	17,000	136,000	300	400	700
15	-2	448	20	.15	.34	.48	.10	13.00	.25	.34	17,000	340,000	900	1,400	2,300
13	-4	428	36	.15	.68	.83	.10	13.00	.25	.68	17,000	612,000	1,500	4,700	6,200
10	-7	392	1	.15	1.51	1.66	.10	13.00	.25	1.51	17,000	17,000	(43)	300	300
9	-8	391	11	.15	1.87	2.02	.10	13.00	.25	1.87	17,000	187,000	500	3,600	4,100
8	-9	380	13	.15	2.33	2.48	.10	13.00	.25	2.33	17,000	221,000	600	5,300	5,900
7	-10	367	11	.15	2.88	3.03	.10	13.00	.25	2.88	17,000	187,000	500	5,800	6,300
6	-11	356	22												
5	-12	334	3												
4	-13	331	58												
3	-14	273	273 }	.15	24.85	25.00	.10	13.00	.25	24.85	17,000	6,052,000	15,100	1,517,600	1,532,700
											Totals		$29,400	$1,543,300	$1,572,700

1/ Based on value per $100 increments of house value.
2/ Average FIA operations cost per structure.
3/ Federal cost includes values below per $100 plus $13 per each structure.

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TABLE 2

ANALYSIS OF FLOOD INSURANCE COSTS-CONTENTS
(BURNETT, CRYSTAL AND SCOTT BAYS AND VICINITY, BAYTOWN, TEXAS)

Elevation feet (MSL)	Elev. above& below 100-yr flood plan (feet)	No. of houses (aggregate)	No. of houses (incremental)	Actuarial Rate ($/$100 value)			Operations and taxes ($/$100 value)		Unit net cost per $100 value		Avg. value of contents per house unit	Total value of contents	Total annual costs		
				Private	Fed	Total	Private	Fed 1/	Private	Fed			Private	Fed	Total
19	+2	690	150	.21	.12	.33	.14	-	.35	.12	$8,500	$1,275,000	$4,500	$1,500	$6,000
17	0(100 yr)	540	84	.21	.28	.49	.14	-	.35	.28	8,500	714,000	2,500	2,000	4,500
16	-1	456	8	.21	.51	.72	.14	-	.35	.51	8,500	68,000	200	300	500
15	-2	448	20	.21	.78	.99	.14	-	.35	.78	8,500	170,000	600	1,300	1,900
13	-4	428	36	.21	1.49	1.70	.14	-	.35	1.49	8,500	306,000	1,100	4,600	5,700
10	-7	392	1	.21	3.17	3.38	.14	-	.35	3.17	8,500	8,500	(30)	300	300
9	-8	391	11	.21	3.90	4.11	.14	-	.35	3.90	8,500	93,500	300	3,600	3,900
8	-9	380	13	.21	4.82	5.03	.14	-	.35	4.82	8,500	110,500	400	5,300	5,700
7	-10	367	11	.21	5.94	6.15	.14	-	.35	5.94	8,500	93,500	300	5,500	5,800
6	-11	356	22												
5	-12	334	3												
4	-13	331	58												
3	-14	273	273 }	.21	49.79	50.00	.14		.35	49.79	8,500	3,026,000	10,600	1,506,600	1,517,200
											Totals		$20,500	$1,531,000	$1,551,500

1/ Average FIA operations cost included with flood insurance cost analysis for structures, which is shown on table 1.

25 Feb 75
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TABLE 3

SUMMARY OF FLOOD INSURANCE COSTS
STRUCTURES AND CONTENTS
(BURNETT, CRYSTAL AND SCOTT BAYS AND VICINITY, BAYTOWN, TEXAS)

Elevation (feet,MSL)	Elev. above & below 100-yr flood plain (feet)	No of houses (aggregate)	No of houses (incremental)	Total annual costs		
				Private	Fed	Total
19	+2	690	150	$10,900	$ 3,500	$ 14,400
17	0(100-yr)	540	84	6,100	4,200	10,300
16	-1	456	8	500	700	1,200
15	-2	448	20	1,500	2,700	4,200
13	-4	428	36	2,600	9,300	11,900
10	-7	392	1	(73)	600	600
9	-8	391	11	800	7,200	8,000
8	-9	380	13	1,000	10,600	11,600
7	-10	367	11	800	11,300	12,100
6	-11	356	22			
5	-12	334	3			
4	-13	331	58			
3	-14	273	273	25,700	3,024,200	3,049,900
				$49,900 ↓ (2%)	$3,074,300 ↓ (98% of total costs)1/	$3,124,200

1/ $3,074,300 ÷ $3,124,200

25 Feb 75
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TABLE 4

AVERAGE ANNUAL INSURANCE COSTS FOR PROPERTIES LOCATED WITHIN AREAS OF VARIOUS EVACUATION PLANS

Evacuation plan (design elevation)	Private cost	Federal cost	Total cost
100-yr	$39,000	$3,070,800	$3,109,800
50-yr	32,400	3,065,900	3,098,300
25-yr	30,900	3,063,200	3,094,100
13.5-yr	28,300	3,053,900	3,082,200

INDIAN BEND WASH GREENBELT
A CITY OF SCOTTSDALE, ARIZONA ACHIEVEMENT

BY

CHARLES RUIZ, PE [1]

INTRODUCTION

A project for flood protection on Indian Bend Wash, Maricopa County, Arizona, was authorized by the Flood Control Act of 1965. The authorized plan of improvement provided for the construction of a concrete-lined channel about seven miles long, starting at the Arizona Canal and extending southward to the Salt River. The rights-of-way for the channel section would have ranged in width from 170 to 180 feet.

The Los Angeles District reformulated and developed a modified plan of improvement (Plate 1) that was recommended and approved in the General Design Memorandum - Phase I, dated October 1973. The recommended combination structural-non-structural plan includes the confining of Indian Bend Wash flows into a seven-mile long floodway, 480 to 1,100 feet wide, from the Arizona Canal to the Salt River. The Corps' participation is limited to the construction of the inlet and the outlet channel portions of the floodway. Also, recommended is Federal participation in recreational development. No Federal participation in the construction of flood control features is recommended within the greenbelt floodway between the inlet and outlet channels. It is this 1,227-acre greenbelt floodway reach that is being managed by the City of Scottsdale.

Purpose

The purpose of this paper is to briefly examine the City of Scottsdale's past actions in the development of the highly acclaimed and nationally publicized greenbelt floodway. By examining these past actions, key factors are identified, which have aided the City in achieving a viable non-structural flood control measure. Two associated problems are also presented.

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[1] Civil Engineer, FPMS, Planning Division, South Pacific Division

The City of Scottsdale's enthusiasm, total commitment and agressive leadership are the primary reasons why the dynamic greenbelt floodway program is a success. This success can be judged by the casual observer. A drive along the greenbelt will reveal the day and night attraction for the recreational facilities, the land value enhancement inherent in the adjacent properties, the new resident fish and waterfowl, the adjacent private developments incorporating this same greenbelt concept, and the integrity of the City, where the adjacent greenbelt boundaries are accessible from both sides.

Significant Events

Between 1965 and 1967, three significant events took place that prompted the City to explore non-structural solutions for the frequent flooding problem. These were:

1965 Maricopa County Bond Issue Defeat - The revenue from this bond was to provide the means to accomplish the local cooperation requirements specified by the Flood Control Act of 1965, authorizing the project for flood protection along Indian Bend Wash. The authorized project was a seven-mile long concrete channel. The voters of Scottsdale overwhelmingly voted against the Bond Issue and contributed to its County-wide defeat. The voters were against concrete channelization.

El Dorado Park 1966 Development - The City with the assistance of the Bureau of Outdoor Recreation developed a 55-acre park in the flood plain area. The success of this development demonstrated that recreation uses of flood hazard lands was a viable community goal.

City Permit Denial Overturned - The City came to the realization that a flood plain ordinance was needed in order to legally control encroachments. A mobile home development was permitted to be located in the flood plain, despite City efforts to argue for its denial.

Actions Taken By The City

With the above turn of events, the City embraced the greenbelt floodway concept and undertook the following actions:

1967 Feasibility Report - The City contracted Water Resources Associates, Inc., a consultant, for a flood control feasibility report that found the greenbelt floodway feasible and that provided the basic plan the City is pursuing today.

1968 Flood Plain Ordinance - The City adopted a strict flood plain ordinance which has since been strengthened in the 1974 Amendment. This ordinance provides the legal means for enforcement and management and does not allow for development to increase the future 100-year flood water surface elevation (30,000 c.f.s.). The City regards the provision, where the responsibility to comply is shifted to the developer, as important. The City considers this ordinance as the fastest means by which a floodway can be achieved.

Community Support - The City staff went into the community and conducted discussions on alternative flood plain management measures. The City formed "Forum Committees" to insure public participation. The City found the public supportive of the greenbelt floodway concept.

Nature interrupted the City's actions with a storm and flood in June of 1972. The measured discharge was 20,000 c.f.s. at Indian Bend Road on Indian Bend Wash. This flood was significant because the magnitude approached the present 100-year discharge of 27,000 c.f.s. The City found that bridges were an essential item to be added to the greenbelt floodway plan because the dip-crossings under flood conditions prevented access of emergency services vehicles.

1973 Scottsdale Bond Issue - The voters then passed a $10 million bond issue by a 7 to 1 margin. The City was uncertain that Federal funding would be made available and therefore the City was prepared to pursue the greenbelt floodway development on its own.

1973 Evacuation - With HUD urban renewal funds the City evacuated 50 families who were located on 60 acres within the flood plain and were relocated intact to an adjacent site overlooking the greenbelt floodway.

The arduous task of aquiring the necessary rights-of-ways has been an ongoing City chore. The City has used condemations, easements, dedications and outright purchases in rights-of-way negotiations. The most satisfactory and successful means has been the negotiations between the City and large property owners where the City acquires a dedication while the owners are given an open space-high density zone. This trade-off has both benefited the City and the property owner.

Problems Encountered

A significant problem that confronts the City today involves the requirements of the Uniform Relocation Assistance and Real Property Aquisition Policy Act of 1970. Under this Act, the owner of real property, before initiation of negotiations, will be provided with a statement of, and summary of, the basis on the amount the Federal agency has established as just compensation. This provision seriously constrains the City's ability to negotiate with owners of large parcels because the just compensation amount would be more costly to the City than the "horse trading" method of negotiation.

Minor problems involve misunderstandings by different groups in implementing the plan. For instance, the recreation staff is pursuing good recreation practices but not necessarily considering hydraulic functional impacts. Also, the legal interpretation of the flood plain ordinance is not understood by hydraulic engineers as to its adequacy or permanence.

Summary of Key Factors

Scottsdale's experience has indicated that the following key factors have contributed to the greenbelt floodway program's success:

1. Strong community support.
2. Adopting of a strict flood plain ordinance.
3. Ability to negotiate directly with owners of large parcels.
4. Use of funds from various sources, i.e., HUD, BOR, etc.
5. Awareness of interdisciplinary misunderstandings.

The author wishes to thank Mr. Len Erie, Capital Improvement Engineer, City of Scottsdale, for his frankness in discussing the City experiences.

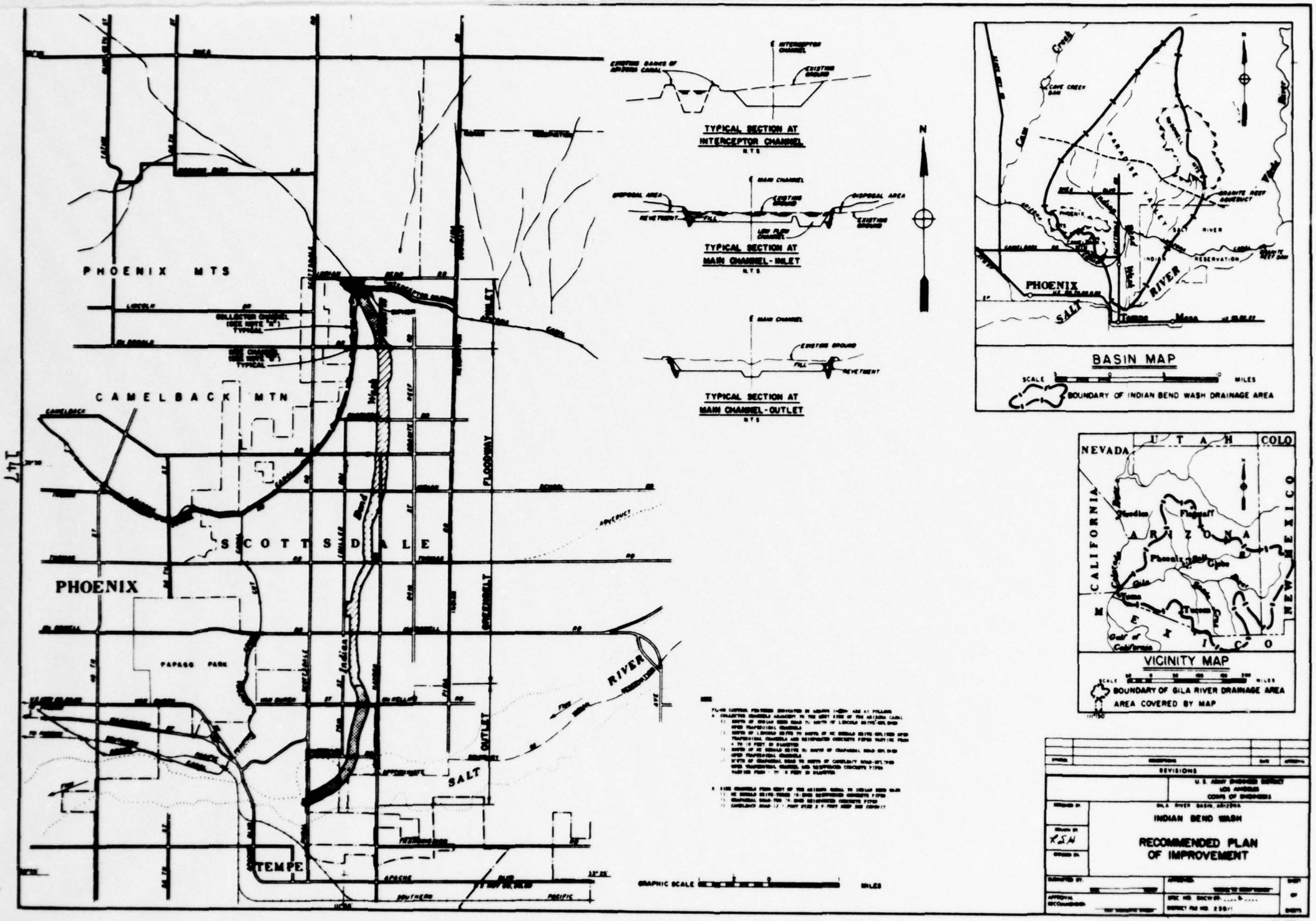
PHOENIX MTS
CAMELBACK MTN
SCOTTSDALE
PHOENIX
PAPAGO PARK
TEMPE
SALT
RIVER
FLOODWAY
GREENBELT
OUTLET
TYPICAL SECTION AT
INTERCEPTOR CHANNEL
TYPICAL SECTION AT
MAIN CHANNEL - INLET
TYPICAL SECTION AT
MAIN CHANNEL - OUTLET
EXISTING GROUND
FILL
REVETMENT
DISPOSAL AREA
N
GRAPHIC SCALE
MILES
BASIN MAP
BOUNDARY OF INDIAN BEND WASH DRAINAGE AREA
VICINITY MAP
BOUNDARY OF GILA RIVER DRAINAGE AREA
AREA COVERED BY MAP
NEVADA
UTAH
COLO
CALIFORNIA
ARIZONA
NEW MEXICO
MEXICO
Gulf of California
REVISIONS
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
GILA RIVER BASIN, ARIZONA
INDIAN BEND WASH
RECOMMENDED PLAN
OF IMPROVEMENT

PLATE 1

ANALYTICAL TOOLS IN PLANNING NONSTRUCTURAL FLOOD CONTROL MEASURES

By

Darryl W. Davis [1]

Introduction

The recent focus upon planning nonstructural flood control measures by federal, state, and local agencies has been brought about both by a greater awareness of the broader opportunities available for managing flood losses and an increasing reluctance to always resort to large scale physical construction to solve flood problems. Thus far there has been little large scale implementation of nonstructural measures and only a few nonstructural adjustments by individual property owners.

The planning task is to formulate measures that can be implemented both for existing development and also that can manage future development so that it will be compatible with the flood hazard. The implementation of nonstructural measures will generally be at the community level and in a setting where the solutions will require tailoring a mix of measures to individual site characteristics. This is so because nonstructural measures are somewhat unique in that their means for reducing flood losses are quite site and structure specific. It is quite likely that there will be situations in which only a part of a set of adjacent structures will be amenable to protection by a particular measure or group of measures. In a different setting, planning for future development in the flood plain would comprise identifying bonafide uses of the flood plain land and formulation of perhaps more generally applicable classes of measures that would provide development control and protection.

Planning nonstructural measures will therefore involve land use analysis and detailed scale analysis of structures in a site specific community setting in which many, and in some instances all, aspects of plans must be implemented at the local, community level. In such a setting the relationship between the nature of the individual measures, their implementability and equity among property owners as viewed at the community level will be quite important. The somewhat unique planning needs and implementation setting has implications related to the appropriate analytical tools needed to perform the formulation and analysis.

Chief, Planning Analysis Branch
The Hydrologic Engineering Center, May 1976

This paper will overview the general planning setting and planning tasks related to nonstructural flood control measures with the specific objective of identifying needed analytical tools. The presently available tools that were designed specifically to facilitate planning nonstructural measures or that are serving other needs but could be useful will be described. The gap between the available technology and what appears to be needed to perform systematic formulation of nonstructural measures will then be described.

Nonstructural Measures

The types of measures that are of interest are loosely categorized by James (1) * as 1) measures that can be undertaken for a specific flood event (emergency measures), 2) measures that modify the susceptibility of existing flood plain structures to damage and 3) measures that manage future development in terms of location and damage susceptibility to minimize flood damage.

Emergency Measures (during a flood event): These measures include emergency evacuation, flood fighting such as by sand bagging, and emergency relief services and facility repair. These measures at times have been grouped and referred to as comprising elements of preparedness plans. The measures are compatible with other measures and are, in effect, a last resort serving primarily to save lives and prevent flooding from occurring when facilities are near their design limits of performance. The effectiveness of these measures relies heavily upon flood forecasting, upon prior organization and training at the community level, and upon property owner initiative. The information needs for formulation and evaluation of these measures include 1) the flood hazard and stream response characteristics (to assess forecasting possibilities), 2) infrastructure data on public utilities, services, transportation, etc., 3) institutional structures and capabilities for managing information dissemination and organizing and supervising work crews, 4) social information related to property owner perceptions of flood hazard and propensity to undertake individual action and 5) the effectiveness of each of the individual measures in terms of their performance during specific flood situations.

Modify Existing Structure Susceptibility to Damage: This category includes the nonstructural measures of flood proofing and permanent flood plain evacuation/relocation. Flood proofing refers to both the protection of the structure by excluding water, such as could be accomplished by barriers and ring levees or by raising the structures, and also accommodation of flood waters by adjustments of use within a structure, such as using lower floors for less damage susceptible activities. The measures in this general category are considered to

* References are contained in the Appendix References

be permanent solutions to a flood problem in that their implementation would modify for an extended period into the future the damage susceptibility of the property.

The information needs for formulation and evaluation of these measures include 1) quantitative definition of the flood hazard (current and potential future) in a site specific sense, 2) cost and performance (damage prevention characteristics) of individual measures, 3) the spatial location of the individual measures and 4) community institutional and social data necessary to design an implementation strategy. The particularly difficult aspect of planning for these measures is that a site-specific design for virtually all existing structures in each particular flood hazard condition is needed.

Management of Future Development: Management of future development mitigates flood losses by causing activities to locate in concert with the flood hazard, and for those activities that do locate in the flood plain, to require adjustments in their location, facility arrangements, and materials such that flood damages will be minimized. The measures within this group include the spectrum of administrative and legal actions that would encourage locational decisions to be made based on due cognizance of flood risks, and the development and enforcement of building standards.

The specific mechanisms available for managing future development include such means as technical flood hazard information dissemination programs, incentive measures such as tax structures penalizing flood plain occupancy, disaster and financial relief sanctions (such as with the National Flood Insurance Program), and exercise of police power for the public good such as by restrictive zoning.

The information needs for formulation of measures in this category include 1) flood hazard under existing conditions and any condition that may affect flood hazard within the flood plain in the future, 2) cost and performance of management measures in terms of the potential effectiveness in causing desired locational decisions and facility adjustments, 3) the degree to which alternative incentives and sanctions may be accepted locally and 4) the institutional data needed to design an implementation strategy to accomplish the program objectives.

Planning and Analytical Tools

The planning tasks associated with nonstructural measures for a flood plain or a specific portion of a flood plain are to:

1. Identify the candidate nonstructural flood control measures. This will be dependent upon the characteristics of the

flood hazard at each specific flood plain location and the performance characteristics of the individual measures, both for existing (developed) conditions and future (undeveloped) conditions.

2. Formulate solutions for the specific site and flood hazard. This may include design of the appropriate type of flood proofing measure (such as opening closures, sealing of basements, elevating of structures, facility removal, etc.).

3. Determine the size and mix of individual measures necessary to assemble candidate measures into alternative flood management solutions for the flood plain. This requires adapting the individual measures to those particular flood plain locations and characteristics that emphasize their strengths.

4. Assess the value and impacts of the alternative solutions by traditional economic and environmental impact analysis and flood control benefit studies.

5. Design an appropriate implementation strategy. 1/

The appropriate role of analytical tools in formulation of nonstructural flood plain management plans is to first develop information that would not otherwise be available to permit assessment of the characteristics and performance of individual measures and then to manage all information that may be available, or may be developed, in such a way that it can provide timely input to the planning process. Based on the discussion in the general overview of the nonstructural measures and associated information needs and the requirements of the planning tasks that were outlined, the following categories have been identified so that the analytical tools needs could be systematically discussed.

1. Flood Hazard Assessment - the usual hydrologic/hydraulic technical analysis required to describe the elevation and spatial delineation of flood hazard.

1/ In early phases of planning studies, it may be satisfactory to merely suggest or identify the responsibility for implementation once a set of measures are found feasible and attractive, but at more definitive stages when sanctions and approvals are required, it will be undoubtedly necessary to more precisely define the feasibility in terms of designing specific mechanisms that must be undertaken to cause the measures to come into being. The design of implementation strategies is strongly linked to institutional and social analyses.

2. Economic Assessment - includes the damage potential characteristics of structures, costs and benefit performance of individual measures and locational analyses as required for development of information related to future development.

3. Environmental Assessment - impacts in the traditional fashion.

4. Plan Formulation - selecting from among individual measures those to be mixed into a system.

5. Data Management - to integrate information development and decision criteria.

6. Social/Institutional Analyses.

In order to restrict the subject matter, the following discussion will focus on the analytic tool needs unique to planning nonstructural measures and generally will not elaborate on those needed for planning other flood control measures when common to the needs of nonstructural measure planning.

Flood Hazard Assessment

Flood hazard can be characterized by the elevation and spatial area delineation of specific exceedance interval flood events. The traditional analytical tools that are used to develop this information are available within The Hydrologic Engineering Center's (2) family of generalized computer programs. Although the general hydrologic analysis capability required for planning nonstructural measures exists, there continues to be a significant struggle by hydrologists in the development of flood hazard information in the smaller watersheds for site-specific physical characteristics for which observed runoff data needed for model calibration is unavailable.

There are two aspects related to future flood hazard that are of interest in nonstructural measure planning.

- Modifications in the runoff characteristics of off flood plain areas, such as may be caused by increased urban development or modification of surface water management systems either onsite or within the watershed area.
- Modification of the flood plain response and conveyance characteristics as affected by development and management works within the flood plain itself, such as large scale placement of fill.

Determining the increased runoff due to urban development of the watershed is a difficult problem and is not particularly unique to nonstructural measure planning. The literature, particularly that prepared by persons outside the hydrologic analysis field, contains such diverse opinions as--there is no significant hydrologic effect of future urban development to the belief that small changes in development will cause a ten to twenty fold increase in flood flows.

- Expanded data management techniques for interfacing data banks with analysis tools and for interpreting and displaying output.

Economic Assessment

The information needs and analytical tools for economic assessments will be divided into analysis of damage potential (existing and future) and location analysis for future developments.

Damage Analysis: Information is needed to determine the potential flood damages for existing development for the with and without nonstructural measures conditions. This is within the scope of traditional flood damage frequency analysis and in a general sense, is exactly the same type information as is normally developed in flood control studies. However, it is required at a quite different scale and for a different context of analysis conditions. In traditional analysis, one could collect field data, aggregate the information to particular index locations, and process the information a few times (relatively speaking) to determine the performance characteristics of structural measures that generally modified the flood hydrology extensively over a very large regional area. In contrast, nonstructural measures that are seeking to reduce structure damage are site specific on virtually a structure by structure basis. Even though it is unlikely that a nonstructural flood control measure program would select from among specific houses in a community only those that would be economically and otherwise attractive for management, it is necessary to analyze each structure so that a reasonably accurate assessment of overall performance is possible.

The damage analysis requirements for nonstructural flood control measure planning for existing conditions, (in the context of ER 1105-2-351 "Evaluation of Beneficial Contributions to National Economic Development for Flood Plain Management Plans") can be summarized as: a) catalog all existing development within the flood plain on a structure and site-specific basis, b) compute expected annual damages and c) compute residual annual damages with nonstructural measures on a structure by structure site-specific basis.

The damage analysis for development that may locate within the flood plain under future conditions would be similar to that required under existing conditions with some important differences. The specific location and character of future structures will be unknown thus requiring a more general analysis, such as conversion of "types" of development, e.g., commercial, residential,etc.,to damage potential. Also, the policy associated with development controls (such as a policy requiring flood proofing to the 100-year flood level plus one foot) will be an unknown and thus must be flexibly accommodated within the analysis.

The economic damage analysis that seems appropriate for nonstructural flood control measure planning is therefore that required to manage data computations on a detailed individual structure and location basis so that information could be provided that is needed to design and assess the performance of specific measures. In effect, traditional analysis technology with strong data management characteristics and flexible computational capabilities is needed.

Available analytical tools include those that have been traditionally used for flood damage frequency analysis. They could be applied in normal fashion except on an individual structure by structure level of analysis. An analysis that would traditionally aggregate a particular reach that may include 500 structures to one index location for computations might have to include every individual structure as an index location for individualized computations. Tools of this nature that are presently available include the Los Angeles Econ program (4) that permits computations of damages for present and future conditions and planning period equivalent by use of the "zone" representation of the flood plain , and the HEC Average Annual Damage program (5) that performs traditional index location flood damage integration for a specific condition . A number of Corps Districts have similar such flood damage analysis computational tools.

Although it is feasible to apply existing tools on this basis, there are certainly more efficient ways of processing large amounts of structure by structure data in a systematic analysis framework. There is presently under development at The Hydrologic Engineering Center, in cooperation with the Institute for Water Resources, a conceptually traditional flood damage frequency analysis tool that will have a strong data management link. The program will allow computation of all aspects of the inundation reduction requirements of ER 1105-2-351 and serve as a data manager for other damage calculation programs and other analysis needs.

The important issue of management of land use data for damage assessments was addressed in the Oconee Pilot study (2). The Oconee technique makes use of a gridded land use and topography data file to compute the damage susceptibility of individual parcels of the flood plain at a scale that may be as small as an acre. The damage susceptibility is aggregated to index locations by computer manipulation. Expected annual damage calculations are then performed. This technique seems to have great potential for rapid damage analysis of future land use patterns and alternative development control policies.

In summary, the damage information requirements for nonstructural measure planning can be developed using traditional analysis tools. There is a need to adapt and refine those analysis methodologies to improve their data management aspects and their capacity for systematically processing large amounts of data, including analysis of future land use and development control policy. The comprehensive inundation reduction computer program under development at HEC, and expansion of the damage assessment technique developed for the Oconee Pilot study can contribute substantially to alleviating the deficiency in damage computation analytical capability.

Location Analysis for Future Development: There is a need to understand and assess the economic forces driving location decisions within the flood plain so that specific measures to accomplish an objective, such as control of future damage potential, can be formulated and the performance evaluated. Specifically, there is a need to a) generally assess the economic aspects of locational decisions, b) quantify the magnitude of the economic forces driving location decisions within the flood plain, c) identify the components of the economic system that can be manipulated to encourage the desired location decisions to be made, and d) provide information to quantify costs and benefits.

There are presently a few comprehensive analytic tools designed to perform some type of locational analysis. Probably the best known to the Corps is the INTASA Flood Plain Simulator (6). The function of the Simulator is to allocate future land use by time periods to flood plain locations, given that the ultimate distribution of land use within the flood plain is known, and perform detailed benefit analysis of a flood control plan, such as the evaluation of a flood control reservoir. The allocation of land use and subsequent benefit computations are based on economic rent concepts computed as site development and transportation costs less damages. The program is large, complex, controversial and, as would be expected for a complex economic model, requires significant amounts of data. Other more recently developed analysis tool that seek to solve the larger problem of performing the location analysis and selecting appropriate measures are represented by the Flood Management Simulator (7) and research as reported in "Prescriptive Economic Models for Nonstructural Flood Control" by Cornell University (8). These latter tools are research tools that were carefully tailored to a specific problem. They, too, are based conceptually on economic rent for decision criteria, but are somewhat cruder in analysis detail. They view the task completely as an economic allocation problem whereas the simulator views the task as an economic allocation problem within the context of an externally determined ultimate land use pattern.

There appears to be a need for a simpler scoped, more practical locational analysis tool that would permit more general locational assessments than is needed for detailed benefit analysis. The tool would operate with available data and would facilitate plan formulation throughout the early to mid-ranges of the planning process, the critical phase for plan formulation purposes. The tool does not yet exist and to the writer's knowledge, is not currently under development.

Environmental Assessment

Environmental objectives have provided a strong impetus to the current focus on nonstructural measure planning. The preservation of riverine open spaces and the control of future development so that massive structural solutions are not required is the focus of environmental planning. Nonstructural measures are not particularly unique in terms of environmental information needs for formulation and environmental impact analysis of proposed solutions. There does exist a need to manage environmental data and perform general environmental analysis of flood plain areas to facilitate flood control planning in general and planning of nonstructural measures in particular.

Analytical tools for detailed simulation of physical, biological and chemical processes of importance in environmental analysis continue to receive a high degree of research attention.

More general analysis such as is possible using the spatial analysis environmental program, Resource Information and Analysis (RIA) (9) under development at HEC has received less attention. The RIA program is in a conceptual sense, the analytical form of Ian McHarg's procedures for environmental design. The capability to perform attractiveness, vulnerability and first order impact analysis exists in this program and was applied to the Trail Creek Test (3) of the Phase I Oconee Basin Pilot study. The technology takes advantage of computerized data files (similar to the spatial damage analysis previously discussed) and comprises a significant, underutilized general environmental assessment capability that might be especially well suited for the environmental issues involved in nonstructural flood control measure planning.

Plan Formulation

The task of formulating viable nonstructural measures, either alone or as components of broader flood plain management schemes, exists at a number of alternative levels of detail that correspond to various phases of the overall planning process. At an initial level, the desired determinations are to answer such questions as: Are there any measures that are attractive? and given an affirmative answer; from among those that are potential candidates, which are the ones that could be of substantial value in managing flood losses? At this stage the flood hazard information may be of fair quality but information related to the individual structures and site-specific designs of the nonstructural measures would not likely be available. It is obvious that this is the appropriate and most attractive planning phase for integrating nonstructural measures with structural solutions that may also be under consideration. This initial phase of the formulation task has been referred to by many as "screening", in that one is sifting from among many, a smaller set of feasible attractive measures that would be studied in more detail. During subsequent planning stages further refinement in analysis is in order to design specific measures, determine economic costs, performance, and overall impacts related to other planning concerns. During these latter stages, the more traditional project evaluation analysis would be performed.

For existing development, the damage potential of existing structures and performance characteristics of candidate measures would be determined so as to identify where management might be feasible and identify measures that could accomplish the damage reduction. For future activities that may be expected to locate in the floodplain, and for which the sites have been identified, information needed is that for formulation of administrative measures that would manage the damage susceptibility of the structures. For future development for which the sites and activities are to be determined (a land use planning task), the information needed is that related to location decisions and also that needed to permit design of the administrative measures. The damage analysis tools previously discussed can provide the requisite information for existing conditions so that screening by application of simple criteria by external (to the analytical tool) analysis is a feasible means of approaching the task. The only limitation of such an approach is the relative difficulty in considering a broad range of measures for many site specific conditions that thus causes this approach to result in a simplified analysis.

The flood control measure optimization capability developed by HEC (10) for the St. Louis District has the capability of including for integrated formulation in a general way (by index locations and not individual structures) nonstructural measures along with the usual structural measures of storage, levees, channels, pumping ect. The methodology is comprised of an analytically controlled, optimum seeking detailed hydrologic simulation and flood damage analysis. The nonstructural capability of the tool is such that initial integration of structural and nonstructural measures into viable alternative solutions within a relatively compact urban system could be performed. The capability exists and has been applied for formulation of interior drainage plans by the St. Louis District. The capability to include nonstructural measures was not used, however, so that the utility of the tool used for nonstructural measure formulation has not been tested in a specific planning setting.

Nonstructural measures may be similarly considered (as an aggregate at an index location) in the system simulation program HEC-5C (11). The strength of this tool is in permitting the consideration of a very general representation of a nonstructural measure for a location (say a city) within a comprehensive system flood control study, such as might be needed in a comprehensive analysis of say the Susquehanna River Basin.

Another technology that is emerging that has potential for nonstructural measure formulation permits comprehensive consideration of the activity location, ground elevation, and land use in an overall systematic process of developing and analyzing damage potential. The capacity provided by the spatial analysis methods developed for the Oconee Pilot study to process large amounts of fixed land use data within the context of an analysis of a proposed development pattern is an example. The types of information shown in the below Table V-3 taken from the Trail Creek report (3) illustrate the potential of the technology for assessing alternative development control policies.

TABLE V-3

TRAIL CREEK TEST
DAMAGE EVALUATIONS
(1000's of Dollars)

Evaluation Condition	Reach 1 Ex. Ann.	Reach 1 100 yr.	Reach 2 Ex. Ann.	Reach 2 100 yr.	Reach 3 Ex. Ann.	Reach 3 100 yr.	Reach 4 Ex. Ann.	Reach 4 100 yr.	Reach 5 Ex. Ann	Reach 5 100 yr.
I Existing Land Use w/o SCS	1.5	2.8	2.5	4.7	12.0	14.2	.6	1.4	0	0
II Existing Land Use w/SCS	1.2	2.4	1.5	2.5	11.0	11.2	.4	.9	0	0
III 1990 Land Use w/o SCS & w/100 yr. policy	19.3	524.3	63.8	569.3	23.8	63.4	.4	.9	0	0
IV 1990 Land Use w/SCS & w/100 yr. policy	4.4	6.1	21.8	143.7	17.8	18.5	.3	.6	0	0
V 1990 Land Use w/o SCS & w/o 100 yr. policy	1033.3	1727.5	350.0	1300.0	32.7	152.0	.4	.9	0	0

The information presented in this table was developed by successive processing (for each policy) with the spatial analysis program to yield elevation damage relations at the index locations, and subsequent damage-frequency integration using traditional analysis methods. The following paragraphs taken from the report provides an indication of the assessments that are possible with the technology.

> "The results displayed in the Table are somewhat suprising and at first glance may be difficult to understand. An initial reaction might be that evaluation condition III should be similar to I since the policy of no new development occurring at elevations below the 100-year event is in effect. The Table shows a large increase in both expected annual damages and the damage due to the 100-year event. This increase is because (1) damage does occur below the zero depth elevation (See Table V-1 land use category (3), (2) the 100-year flood for 1990 land use conditions is higher than the 100-year flood for existing land use conditions, and (3) damages are sustained by new development from events that exceed the 100-year event.
>
> The results are somewhat sensitive to assumptions and current policy is sufficiently ambiguous that the correct assumption to make is not obvious. It was assumed herein that the 100-year level that applies under the flood insurance program is that defined by existing land use conditions and that development is placed such that the finished ground floor (first floor) is placed at this 100-year elevation. The techniques can accept alternate assumptions such as use of a future 100-year flood elevation and placement of basements, etc., above the designated flood. The consequences of the assumption regarding future damages seems sufficiently important that consistent policy should be established for use in future studies."

Other conceptually comprehensive general formulation tools are emerging from the research community. Examples are the Flood Management Simulator and the Cornell research, previously discussed, in which location decisions (for future development) are analytically integrated with planning for nonstructural measures. The role of both of these analysis tools would be to provide very general land use planning data that would assist in identifying alternative future development patterns. Conceptually the tools are appealing but the practicality of such general analysis in a specific planning setting is yet to be tested.

The technology gaps that exist of 1) screening technology for existing flood plain development, 2) screening for known future development and policies and 3) integration of location analysis and selection of policies and measures, are addressed by tools that have been discussed. The comprehensive inundation reduction analysis tool under development by HEC and an expanded Oconee spatial analysis technology could likely provide much of the technology for 1) and 2). Technology for 3) may be impossible to implement at a practical operational level--further study of available research tools is warranted.

Social/Institutional Analysis

It is clear that most of the potentially viable nonstructural measures that may be considered in nonstructural measure planning will require a complex implementation strategy adapted to a multitude of social and institutional settings. At the present time, there are no proven analytical methodologies that would assist in developing information to support development of such a complex implementation strategy. However, IWR is in the final stages of preparing a report which deals with both the conceptual and the analytical requirements of formulating implementation strategies. (12)

This report characterizes the local community as a functioning utility that must raise revenue, purchase goods and manage activities for the purpose of providing public services, one of which might be raising funds and causing the implementation of nonstructural flood control measures. In this context, one of the more significant tasks of any nonstructural measure formulation is identifying the responsible local agencies and institutions and defining their revenue raising powers and management authorities that would be needed to undertake program implementation. Substantial progress has been made in defining concepts and important aspects of institutional analysis, particularly in the context of urban studies where solutions are at times outside the sphere of traditional federal implementation, as is true for many nonstructural measures. One finding is that a key fact of institutional analysis is that of definition of the revenue raising and financial capabilities. It appears, at first glance, that the analysis of the overall financial structure is performed by local communities and institutions on a continuing basis by local government officials and institution managers. Thus the basic information (tax structure, property values, legal authorities, etc.) should be readily available and in many instances, in a form amenable to analytical analysis by use of computer modeling. Analytical investigations in this area would seem to have high pay-off potential and be worthy of attention by researchers. The capability thus created could be especially useful in formulating measures that would be responsive to the local setting and assessing the local impact of alternative solutions.

There are a number of the measures, especially those related to emergency activities, that rely upon individual initiative and continued vigilance by the individual property owners. James (1) describes the factors determining the success of means of inducing nonstructural measures at the community level. It is clear that the attitudes, perceptions and overall practices within a specific community will need to be understood if proposals requiring individual initiative, or even community consensus, are to be viable alternatives. The tool of questionnaires and subsequent analysis ranking has proved to be a useful information development device. Whether further analytical development in terms of processing such information would provide further useful data is not known. General modeling of social attitudes, etc., seems at present to be an unrealistic expectation.

Data Management

Data management refers to the systematic acquisition, storage, retrieval and data interface manipulations between data storage location and analysis tools. A common need that is currently lacking in existing available tools, such as traditional damage analysis, and could be the key component of new technologies, such as the locational analysis and community and institutional financial structure modeling, is comprehensive data management.

The comprehensive inundation reduction computer program under development by HEC has focused in part upon management of field collected damage data. The spatial analysis methodology developed for the Oconee Pilot study is primarily a data management technique that has significant potential for processing of geographic and other resource data unique to nonstructural measure planning. An apparent pressing need is a more general data management structure that would encourage systematic collection of the needed data and then provide the capacity for information storage, retrieval, and processing that could facilitate a number of analytical methodologies ranging from financial analysis of institutions through detailed assessment of existing structure damage potential and analysis of alternative land use patterns. System of Information Retrieval and Analysis for Planners (SIRAP) (13) is a presently functioning system concieved with similar objectives in mind. The tasks remaining in data management are those relating to the development of systematic means for placing new and updated data into management systems, and linking the data management systems to analysis and display tools.

Summary and Observations

The planning of nonstructural flood control measures, as viewed from the context of analytical tools to facilitate this process, has indicated that there is a need to focus analysis on the individual site-specific structure in its setting and that this analysis needs to be performed systematically on a comprehensive flood-plain wide scale. It appears that analytical techniques will contribute primarily in the context of more efficient development and processing of the detailed site specific information rather than any grand contribution to planning methodologies. The planning task associated with nonstructural measures is sufficiently complex so as to not be amenable to a comprehensive analytical solution. Analytical tools to service nonstructural measure planning should be viewed as providing a means for information development and information management.

The specific items that have been identified as potentially fruitful areas for research and development of analytical techniques to facilitate nonstructural measure planning are:

1. Systematic, efficient, data management and damage analysis of individual existing structure and future land use information.

2. Practical capacity for performing locational and land use analysis of potential future development.

3. Social/institutional analysis--in particular that part of institutional analysis which is amenable to analytical methods relating to the financial structure of existing institutions and communities.

4. Data management to service both a variety of analytical methods and overall study management. This appears to be the major and significant opportunity to substantially improve information development and use in planning.

The discussions and observations within this paper suggest that analytic tools can substantially improve the information flow and thus the planning of nonstructural measures. This view needs to be placed in perspective. The analytic needs for planning are probably not the critical needs related to planning nonstructural measures. The policy issues related to cost sharing, the federal planning role, and federal implementation role are the significant issues. The adopted position on these issues will also have substantial bearing on the needed character of analytical tools. A planning role perceiving as an end product the design of specific implementable, site-tailored measures would require an order of magnitude increase in types of analysis and the level of detail necessary as compared to a planning role perceiving as an end product the identification of feasible solutions to be recommended to local institutions for detailed planning and implementation.

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Flood Proofing at Logan, Ohio
and the Flood Hazard Factor

By

Richard E. McCoy, Jr., Civil Engineer, Flood Plain Management Services, Planning Branch, U.S. Army Engineer District Huntington, W. Va.

INTRODUCTION

Initial investigations for providing flood protection for two small communities resulted in expanding the study to include numerous alternatives. The final results were a composite of the most productive of the alternatives which were assembled into the "best" plan. The consideration of "flood proofing" as an alternative although not incorporated into the "best" plan provided an interesting view of a long heralded alternative.

Purpose

The purpose of this paper is to provide a perspective of the generalized techniques used to evaluate residential flood proofing on a community wide basis and how the stage-frequency relationship or interest rate might be used to decide where such a technique might be a viable inclusion in the "best" plan.

Definitions

Throughout this paper the following definitions apply:

Flood Proofing: Permanently elevating a residential structure in place to lower susceptability to flood waters.

Flood Hazard Factor: The difference in elevations between the 100-year recurrence interval flood and the 10-year recurrence interval flood in tenths of a foot. The alphabetic suffix is a predetermined code indicative of the skew of the stage-frequency relationship. Example FHF 050A.

Setting

At Logan, Ohio, one of two small communties, for which an investigation to provide flood protection was being considered, a total of twelve alternatives for providing protection were analyzed. One of these alternatives was to evaluate, flood proofing of all residential structures located below the 100-year flood level.

Method of Analysis

The application of flood proofing to single family residences in Logan, Ohio, was selected for this study because of the availability of certain data that would provide a representative view of the costs and benefits of flood proofing.

The available data from previous surveys for Logan made it possible to generalize many factors about single family residences and somewhat simplify what could have been a complex set of alternatives. An outline of the analysis is as follows:

(1) Cost to flood proof an individual structure
(2) Nature of Structure to be flood proofed and degree of protection required
(3) First cost to flood proof structures in the community
(4) Average annual cost of flood proofing
(5) Damages prevented by flood proofing (average annual)
(6) Average annual benefits
(7) Benefit/Cost of Flood Proofing

The cost to flood proof individual structures had been investigated in some detail in 1970 in the preparation of "Report on Tug Fork..." in which datailed costs analyses were carried out for flood proofing fifteen (15) residential structures to various levels of protection. These residential structures were located in Matewan, West Virginia, and represented a cross-section of types and conditions to be found in that community.

Although a variety of flood proofing techniques have been suggested in the past, it was determined in the investigation for "Report on Tug Fork..." that for extreme depths of flooding and light residential wall construction raising in place is the only practical means of flood proofing. Stability analysis for raising in place indicates an upper limit of six feet for this method.

The fifteen residences in Matewan were selected to develop the design and costs of flood proofing by raising in place. The residences were selected from three groups with respect to their physical condition (sound, deteriorated and dilapidated) and costs were developed for raising each type in place.

The values and conditions were determined for the residences and the ratios of costs of flood proofing to various levels were estimated. These ratios formed the basis for determining the cost of flood proofing in Logan, Ohio

The ratios developed for "Report on Tug Fork..." for sound structures are tabulated below:

Condition of House-Sound

$$\frac{\text{Cost Raise-2 feet}}{\text{Value of House}} = 0.17$$

$$\frac{\text{Cost to Raise-4 feet}}{\text{Value of House}} = 0.23$$

$$\frac{\text{Cost to Raise -6 Feet}}{\text{Value of House}} = 0.31$$

Other values were developed for deteriorated and dilapidated structures but were not applicable for Logan, Ohio. It was determined that the structures in Logan, Ohio, for which flood proofing was being considered were in sound condition. These values were interpolated for each 0.5 foot increment and a factor of 20% for engineering and design and supervision and administration of construction was applied to the estimated cost of flood proofing.

A damage survey performed in 1965 gave insight to the number, first floor elevations, condition , values and types of residential structures in the flood plain at Logan, Ohio. A design was assumed which incorporated raising all single family residential structures with first floor levels below the elevation of the 100-year recurrence interval flood to that elevation. This involves raising 337 such structues. Further analysis of the survey data revealed that the structures had an average value of $10,200 and would have to be raised anywhere from one-half to six feet.

Using the survey data it was possible to proportion the number of structures needing flood proofing at each one-half foot increment of protection required. The distribution of the various first floor elevations are represented by the values in the second column (#Structures) in the following computation.

Below is the computation of total first cost of flood proofing the 337 structures in Logan, Ohio:

First Cost of Flood Proofing - Logan, O

Flood Proofing Required	#Structures Average Value$10,200	Value of Structures Dollars	Cost Flood Proofing
0.5	40	408,000	57,120
1.0	61	622,200	93,300
1.5	27	275,400	44,064
2.0	51	520,200	88,434
2.5	36	367,200	67,932
3.0	47	479,400	95,880
3.5	33	336,600	72,369
4.0	20	204,000	46,920
4.5	13	132,600	33,150
5.0	6	61,200	16,524
5.5	1	10,200	2,952
6.0	2	20,400	6,324
	337 Structures	Total Cost	$625,005
		E&D, S&A (20%)	125,001
		Total Cost Incl E&D, S&A	$750,006

At an interest rate of 5-7/8% and a 50 year project life, the average annual costs for flood proofing would be $46,755.

The damages prevented by flood proofing a residential structure by raising in place are the differences in average annual damages that are to be expected before and after raising.

In order to determine damages prevented at Logan, Ohio, by the proposed flood proofing scheme it was necessary to develop a representative stage damage relationship. Using the 1965 Survey data it was possible to determine the mix of the four types of one-family residential structures, one and two story with and without basements. Using the generalized stage-damage information developed by the Federal Insurance Administration in its publication "Flood Hazard Factors, Depth Damage Curves, Elevation-Frequency Curves, Standard Rate Tables", a representative stage-damage curve for such a mix was developed. This stage-damage information incorporated a content value equal to 30% of the structural value. Knowing the stage-damage relationship and stage-frequency relationship and degree of flood proofing required for the 337 structures, it was possible to determine the average damages prevented should the plan be carried out to provide such protection.

Below is the computation of average annual damages prevented:

Average Annual Damages Prevented
by Flood Proofing - Logan, O.

# of Structures	40	61	27	51	36	47	33	20	13	6	1	2
Flood Proofing (ft)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
Avg. Ann. Damages Prevented/ Structure	8	11	19	26	37	47	62	76	98	119	147	174
Total Damages Prevented	$320	$671	$513	$1326	$1332	$2209	$2046	$1520	$1274	$714	$147	$384

Total Average Annual Damages Prevented $12,420

This value would be an appropriate estimate of average annual damages if the structures had an infinite life. However, the damage survey revealed a distribution for the useful lives of residential structures in Logan and it is not anticipated that the structures would be replaced due to existing flood plain regulations.

Average annual damages prevented were reduced in a manner appropriate to the expected lives and resulted in a value of average annual benefits of $10,015 for a 50 year project life and at an interest rate of 5-7/8%.

The benefit-cost ratio for flood proofing the 337 structures in Logan is 0.2. A summary of this analysis follows:

	Interest Rate 5 7/8%
	50 Yr. life
First Cost of Flood Proofing at Logan (337 structures) includes 20% E&D, S&A	$750,006
Avg. Annual Cost of Flood Proofing	$ 46,755
Avg. Ann. Benefits of Flood Proofing	$ 10,015
B/C Ratio	0.2

The unfavorable benefit-cost ratio for flood proofing residential structures was felt to be indicative of what could be expected of such an analysis at the second community where a similar situation exists. Detailed costs and benefits of flood proofing for the second community were not carried out.

Variations in Analysis

The results of the Benefit/Cost determination certainly indicated that there are situations where it is a waste of time to go through the exercise of evaluating flood proofing. The question before a planner is when to go through the exercise and when to discount this alternative.

From an initial examination of all the input in the analysis it appeared that two factors might have a significant effect on the Benefit/Cost ratio. The two variables are the stage-frequency relationship and the interest rate at which the ratio is determined

To test this hypothesis a reanalysis will be made with various stage-frequency relationships.

A generalized factor associated with stage-frequency information has been coined by the Federal Insurance Administration and is called the Flood Hazard Factor (FHF). This term is an indication of the relationship between the difference in the expected levels of the 100-year flood and the 10-year flood and is expressed in tenths of a foot. An alphabetic suffix is generally an indication of the skew of the stage-frequency relationship.

The analysis of flood proofing at Logan was originally made for what would be a FHF075A. Without changing any of the other variables in the original analysis the B/C was recalculated for several stage-frequency relationships. The B/C ratio and appropriate Flood Hazard Factor are tabulated below:

Reanalysis of Logan, O., at various FHF

FHF	B/C
200A	0.10
160A	0.12
120A	0.15
080A	0.23
040A	0.62
030A	1.19
020A	3.04
010A	7.75

From the table it can be seen that the B/C ratio becomes greater than unity when the FHF becomes less than 040.

This gives a valuable indication to the planner that flood proofing should only be considered as an alternative when the FHF is low, in this case 040.

Another factor that might cause a significant change in the B/C ratio is a substantial change in the interest rate at which the analysis was made. To test this hypothesis the analysis was redone at several different interest rates for the various FHF. The results are displayed on the following graph:

An examination of the graph reveals that a lowering of the interest rate does enhance the B/C ratio to a small degree but not in such a pronounced way as changing the stage-frequency relationship (FHF).

Conclusion

The result of this analysis does show it is possible to develop generalized techniques to evaluate the potential of flood proofing as an economically feasible non-structural alternative.

Also, the analysis reveals that the stage-frequency relationship (FHF) has profound effect on whether flood proofing is economically feasible. The FHF should be low before any detailed consideration should be given to flood proofing as a non-structural alternative.

The interest rate although it does effect economic feasibility is not as pronounced in its effects and may be given secondary consideration in determining whether a detailed analysis of flood proofing should be undertaken.

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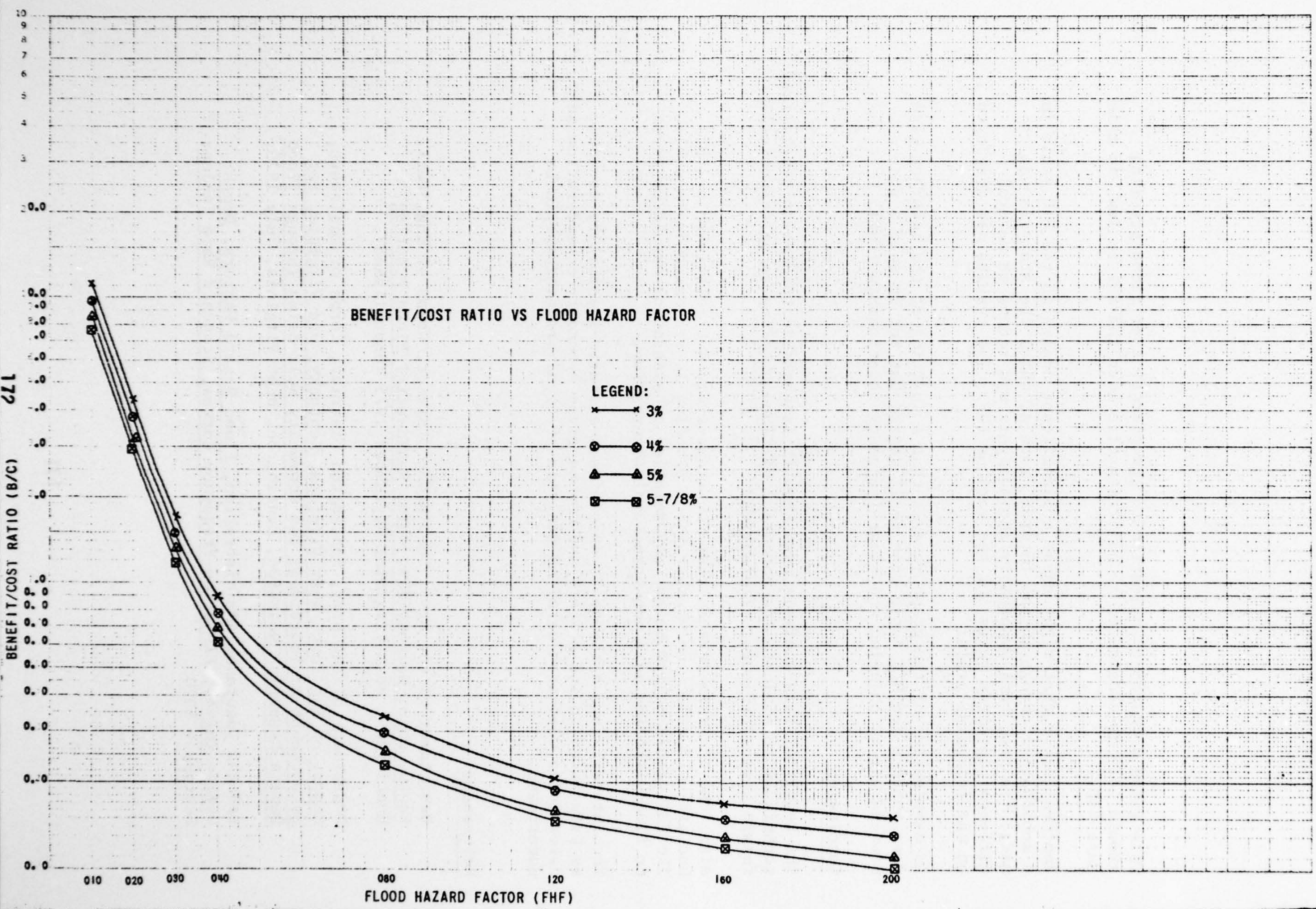
BENEFIT/COST RATIO VS FLOOD HAZARD FACTOR
LEGEND:
3%
4%
5%
5-7/8%
BENEFIT/COST RATIO (B/C)
FLOOD HAZARD FACTOR (FHF)
010
020
030
040
080
120
160
200

GREAT LAKES OPEN-COAST
FLOOD LEVELS

By
L. T. SCHUTZE

U. S. ARMY CORPS OF ENGINEERS
Detroit, Michigan
May 1976

PREFACE

The secret of any nonstructural flood damage reduction is to provide the endangered landuser information so he can reduce or minimize his risk. The classic example in our business is the peaceful brook that becomes a raging torrent. The Great Lakes with 11,000 miles of beautiful shoreline is probably the least understood flood producing waterway.

The Great Lakes with their unique physical makeup change levels slowly. Even during the recent record high levels period the lakes were very calm most of the time. But when energized by the appropriate wind conditions, they become a menacing force.

In the period from December 1972 to April 1974 the Corps of Engineers spent $20,000,000 to construct, or aid in the construction of emergency dikes for the lakes under Operation Foresight. The benefits resulting from Foresight are a $64,400,000 *reduction in the flood damages.* The problem of Great Lakes flooding is complicated by its magnitude, the great geographic extent of its area of impact, and the many agencies involved in its solution.

In accordance with agreements reached at the 17 July 1974 meeting of the Joint FRC-GLBC Task Force, the Corps developed 100-year open-coast flood levels for all reaches of the United States shoreline of the Great Lakes. This paper describes the water level data available and the techniques used in developing a uniform procedure to determine the 100-year flood level for all the Great Lakes.

GREAT LAKES OPEN-COAST FLOOD LEVELS

By
L. T. Schutze[1]

INTRODUCTION

1. Nearly one-third of the 4,000-mile boundary between Canada and the United States is covered by the waters of the Great Lakes. The nearly 95,000 square miles of water surface of the lakes contain about 5,000 cubic miles of fresh water - enough water to cover the continental United States to a depth of nearly 10 feet. The water levels are continually changing as the amount of water entering and leaving each lake varies with the hydrological conditions. The extreme variation in monthly mean lake levels recorded since 1900 has ranged from 3.8 feet on Lake Superior to 5.7 feet on Lake Michigan-Huron, 6.0 feet on Lake Erie and 6.6 feet on Lake Ontario. The average rise from winter low to summer high level ranges from one foot on Lake Superior to 1.6 feet on Lake Ontario.

2. Short-Period Level Fluctuations. - The Great Lakes are considered to be essentially non-tidal because of the small fluctuations of levels due to the gravitational pull of the moon and sun, and these less than 2-inch tides are masked by the greater fluctuations of levels produced by wind and barometric pressure conditions. Depending upon the depth of the lake and the shape of the shoreline, the water level along the shore is subject to significant fluctuations due to strong winds acting for several hours on the water surface. Southwesterly winds during a Lake Erie storm on 10 November 1975 caused the water level to rise about 7 feet at Buffalo, New York, and to fall 6 feet at Toledo, Ohio. Although wind setups of this magnitude are very rare except at the east and west ends of Lake Erie, significant wind setup is experienced at many sites along the Great Lakes shoreline. Typical examples of wind setup on Lake Erie are shown on Lake Survey Center summaries of storm water levels in Figures 1-3.

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[1]Hydraulic Engineer, Great Lakes Hydraulics & Hydrology Branch, Engineering Division, Detroit District, Corps of Engineers

3. <u>100-Year Flood</u>. - High water levels create flooding problems along many reaches of the Great Lakes whether these levels are caused by an unusually large volume of water, or by a combination of wind setup and water level due to a lesser volume. In conjunction with the National Flood Insurance Program, the Federal Insurance Administration (FIA) has adopted the 100-year flood as the standard for identification of flood hazard areas. This paper is concerned with the 100-year flood levels for the more than 3600 miles of Great Lakes mainland shoreline within the United States.

4. <u>Water Level Data</u>. - Great Lakes water levels have been observed by water level recording gages since 1900 when the Corps of Engineers installed gages in stilling wells at Mackinaw City, Michigan, and Buffalo, New York. Since that time additional gages have been placed in operation by government agencies of Canada and the United States. At present there are 44 gages with 10 or more years of record maintained along the shoreline of the lakes. The records of these gages include hourly readings, daily and monthly mean levels, and maximum and minimum instantaneous levels for each month. These instantaneous levels reflect the general lake level plus any wind setup existing at the time. The fluctuation of levels resulting from waves is removed by action of the stilling wells and is not recorded.

5. <u>Annual Flood Levels</u>. - Since the 100-year flood represents the flood level that on the average will have a one-percent chance of being equalled or exceeded in any given year, a frequency curve analysis of flood levels at each gaging station was made. The basic frequency curve used in hydrologic engineering is the frequency curve of annual maximum or minimum events. The annual maximum flood level at each station was taken as the maximum instantaneous level recorded each year. Over the period of record, changes in the amount of water diverted into and out of the lake basins and changes in outlet conditions have significantly affected the levels of the Great Lakes. To account for the effect of these changes on historical levels, the annual maximum flood levels were adjusted to present diversion and outlet conditions.[2]

6. <u>Exceedence Frequency Curve</u>. - The 49 sets of adjusted annual maximum flood levels covered varying lengths of record from 75 years at Mackinaw City and Buffalo to as few as 11 years at Harrisville, Michigan. The flood levels at Buffalo were ranked in

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[2]Regulation of Great Lakes Water Levels Report, International Great Lakes Levels Board, 7 December 1973.

decreasing order and plotted on probability graph paper, Figure 4, with plotting positions determined by linear interpolation between positions of largest and smallest levels:

$$P_1 = 1 - (0.5)\ 1/_N$$

$$P_N = 1 - P_1$$

Where P_1 = plotting position of largest event

P_N = plotting position of smallest event.

7. Station Frequency Curves. - The one percent exceedence frequency at each water level gaging station was computed by the analytical method of computing a frequency curve as described in Statistical Methods in Hydrology by Leo R. Beard, published by the Corps of Engineers at Sacramento, California, January 1962. The frequency curve for Buffalo derived by this method is shown on Figure 4. The derived frequency for each station was obtained by the following equation:

$$1\%\ \text{exceedence level} = M + 2.33\ s$$

Where, M is the mean of the annual flood levels in the set
s is the standard deviation
2.33 is the Pearson Type III coordinate from Beard's Exhibit 39 for zero skew coefficient and 1% frequency.

8. Open-Coast Flood Levels. - The 100-year open-coast flood level in the vicinity of each of the 49 stations was derived from the calculated one percent exceedence level at the station taking into consideration such factors as the number of years of record, physical environment of the gage, levels at other gages on the lake and the configuration of the adjoining shoreline. The average distance between gaging stations on the U.S. shoreline of the Great Lakes is about 125 miles with some as far apart as 200 miles. The open-coast levels between gaging stations were interpolated for a smooth transition to avoid irrational rises and falls in the levels shown. The derivation of open-coast levels at and between stations is a judgmental rather than a mathematical process. The 100-year open-coast flood levels for the five Great Lakes are shown as Plates 1 thru 5. Also shown are tables giving the 1% and 50% frequencies of flood levels at each station. The inclosed plates are greatly reduced, but the 100-year open-coast flood levels reach by reach along the U.S. shoreline of the Great Lakes have been compiled on navigation charts and copies are available from the District Engineer, U.S. Army Corps of Engineers, P. O. Box 1027, Detroit, Michigan 48231.

9. Flood Levels in Connecting Channels. - One problem which arises in determining 100-year open-coast levels is the short period of record available at some gage sites. Of the 49 gages used to determine the 100-year levels on the 5 Great Lakes, 22 had fewer than 25 years of record and 16 had less than 20 years. The techniques used to transfer one percent exceedence levels at the gages to the 100-year level on the adjacent open-coast, compensate to some extent for errors in levels based on short periods of record. Along the 117 miles of U.S. shoreline on the connecting channel between Lakes Huron and Erie, there are no sites along the nearly 60 miles of Lake St. Clair shoreline where recording gages have operated more than 23 years. Therefore, the one percent exceedence levels could not be modified by comparison with levels from other sites with longer periods of record. As time goes on, the 100-year level on Lake St. Clair should be reviewed and revised if necessary. In the 1953-1974 period of 22 years, the annual flood levels on Lake St. Clair have varied over a range of 4.2 feet. In the same period the flood levels at Mackinaw City have varied 4.9 feet. Using the 75 years of Mackinaw City data, the one percent exceedence level during the last 22 years is 0.37 foot higher than for the entire 75 years of record. From this comparison, the 100-year level from 22 years of record on Lake St. Clair is probably between 0.3 and 0.4 foot higher than a value based on a 75-year period.

10. Selection of Hydrologic Events. - Several methods have been proposed to utilize published monthly mean lake levels available for long periods of record to augment the maximum annual flood level data available for limited periods of time at some sites on the lake. The proposed methods in general, use the published levels as undisturbed levels at the site with a short record. One method applies an average setup to these undisturbed levels to obtain annual flood levels to use with the recorded flood levels. The setup used is based on the setups recorded at the station. Other methods disregard the recorded flood levels and derive a frequency curve by combining frequency curves of the undisturbed levels and wind setups based on the recorded setups. These methods assume that the monthly mean level is the same at all places on a lake, a condition which rarely occurs. They also assume that wind setup observed over a short period of record is typical of conditions over an extended period of record. No record demonstrating the validity of this assumption on the Great Lakes has been found. Further, the maximum annual flood levels at a site along most of the connecting channels and occasionally on the lakes are not the result of wind setup.

11. Recommendation. - The techniques described above for deriving the 100-year open-coast flood levels on the Great Lakes from recorded maximum annual flood levels are recommended for insurance purposes because they are based on observed lake levels. If desired these techniques may be used to derive open-coast flood levels for other exceedence intervals.

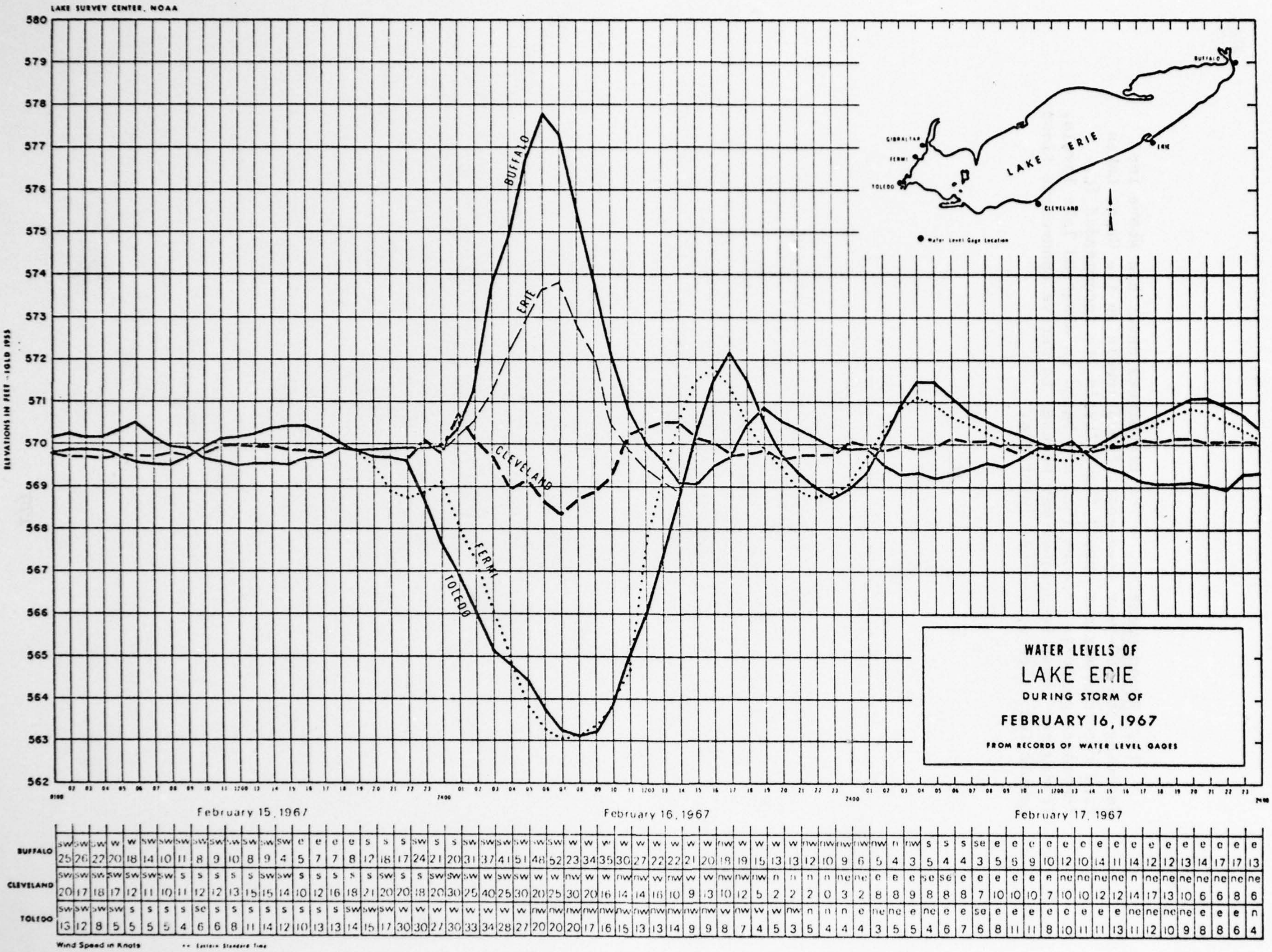
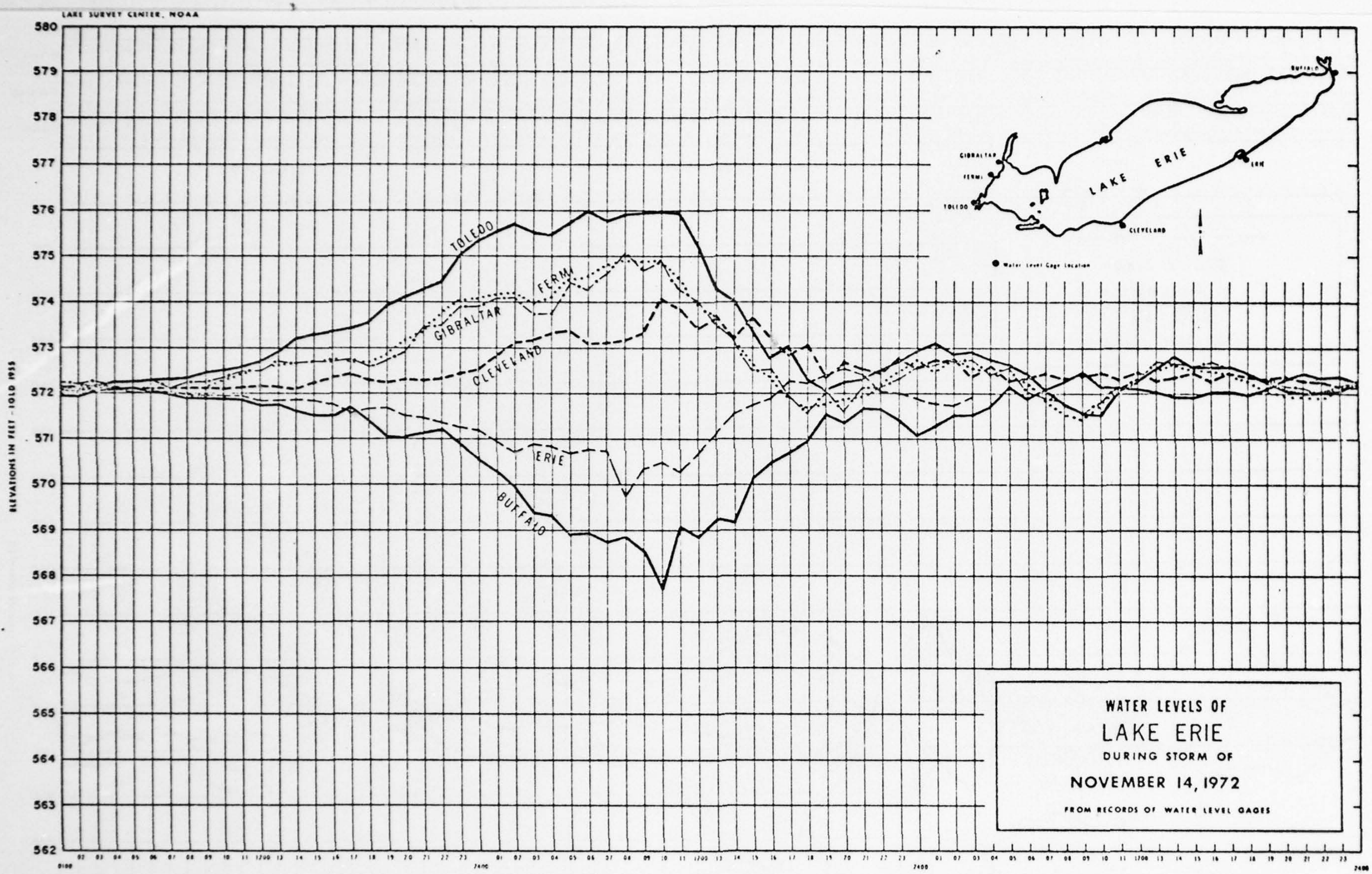


FIGURE I. 1967 STORM



November 13, 1972

BUFFALO	s 4	s 4	s 5	s 4	se 5	s 5	s 5	s 7	se 3	s 3	ne 3	ne 9	ne 10	ne 11	ne 9	ne 6	ne 7	ne 8	e 10	e 12	ne 7	ne 12	e 13	e 11
CLEVELAND	s 3	n 0	se 3	n 0	s 3	n 0	n 0	n 0	n 0	s 4	e 8	e 7	e 9	ne 10	ne 6	ne 9	ne 10	ne 11	e 13	e 12	ne 13	ne 13	ne 16	ne 13
TOLEDO	ne 3	n 3	n 4	ne 3	n 3	ne 7	ne 7	ne 8	ne 9	ne 10	ne 12	ne 10	ne 10	ne 15	ne 13	ne 16	ne 16	ne 17	ne 17	ne 19	ne 19	ne 20	ne 20	ne 21

November 14, 1972

BUFFALO	e 18	e 16	e 15	ne 18	ne 25	e 21	e 24	e 22	e 24	e 23	e 28	ne 21	ne 25	ne 22	ne 16	ne 16	ne 15	ne 16	ne 22	ne 18	ne 17	ne 23	ne 21	ne 14
CLEVELAND	ne 11	ne 19	ne 13	ne 16	ne 12	ne 15	ne 15	ne 16	ne 13	ne 12	ne 14	ne 17	ne 19	n 20	n 15	n 20	n 17	n 13	n 15	n 15	n 13	ne 13	n 12	n 13
TOLEDO	ne 18	ne 16	ne 20	ne 25	ne 20	ne 20	ne 16	n 15	n 17	n 13	n 15	n 13	n 16	n 14	n 15	n 15	n 15	n 14	n 12	nw 13	n 12	n 12	n 11	nw 10

November 15, 1972

BUFFALO	ne 11	n 9	ne 8	n 7	n 6	n 7	n 9	n 6	n 6	n 10	nw 7	n 8	n 9	nw 6	nw 8	nw 8	nw 5	sw 5	w 7	w 6	nw 6	nw 6	nw 6
CLEVELAND	n 12	n 13	n 13	n 11	n 13	n 13	n 11	n 15	n 14	n 11	n 12	n 13	n 8	n 10	nw 6	ne 10	n 7	n 4	n 7	n 9	n 5	nw 4	n 4
TOLEDO	n 13	nw 12	nw 12	nw 11	nw 10	nw 12	nw 14	nw 10	n 8	nw 9	n 8	nw 10	n 10	n 4	n 4	n 6	n 8	n 5	n 5	nw 5	n 3	n 5	n 5

NOTE: Wind speed in knots   ** Eastern Standard Time

FIGURE 2. 1972 STORM

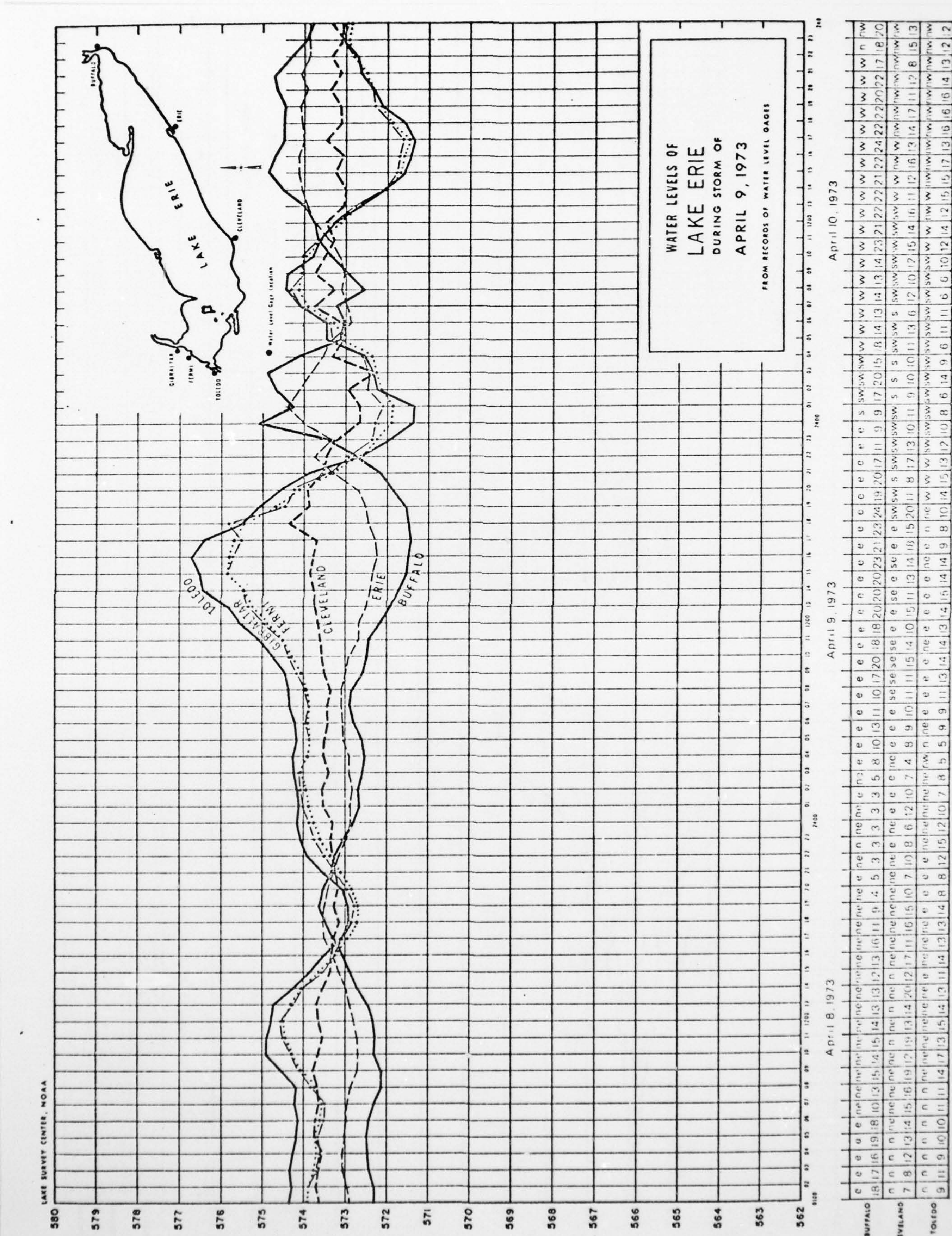


FIGURE 3. 1973 STORM

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PROCEEDINGS OF A SEMINAR ON NONSTRUCTURAL FLOOD PLAIN MANAGEMEN--ETC(U)
MAY 76 K E MCINTYRE, G D COBB, F H THOMAS

UNCLASSIFIED HEC-SP-08 NL

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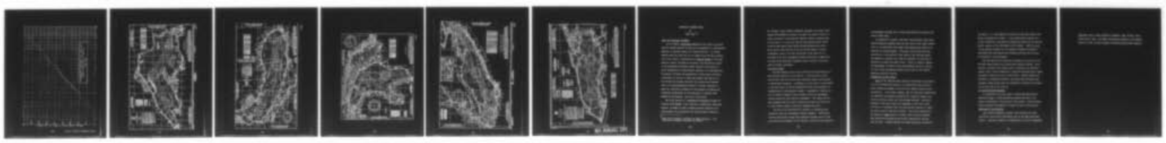

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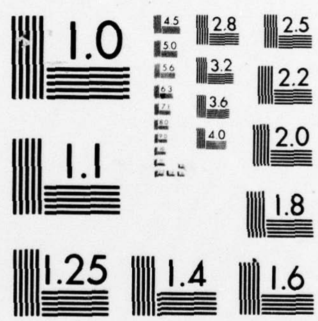
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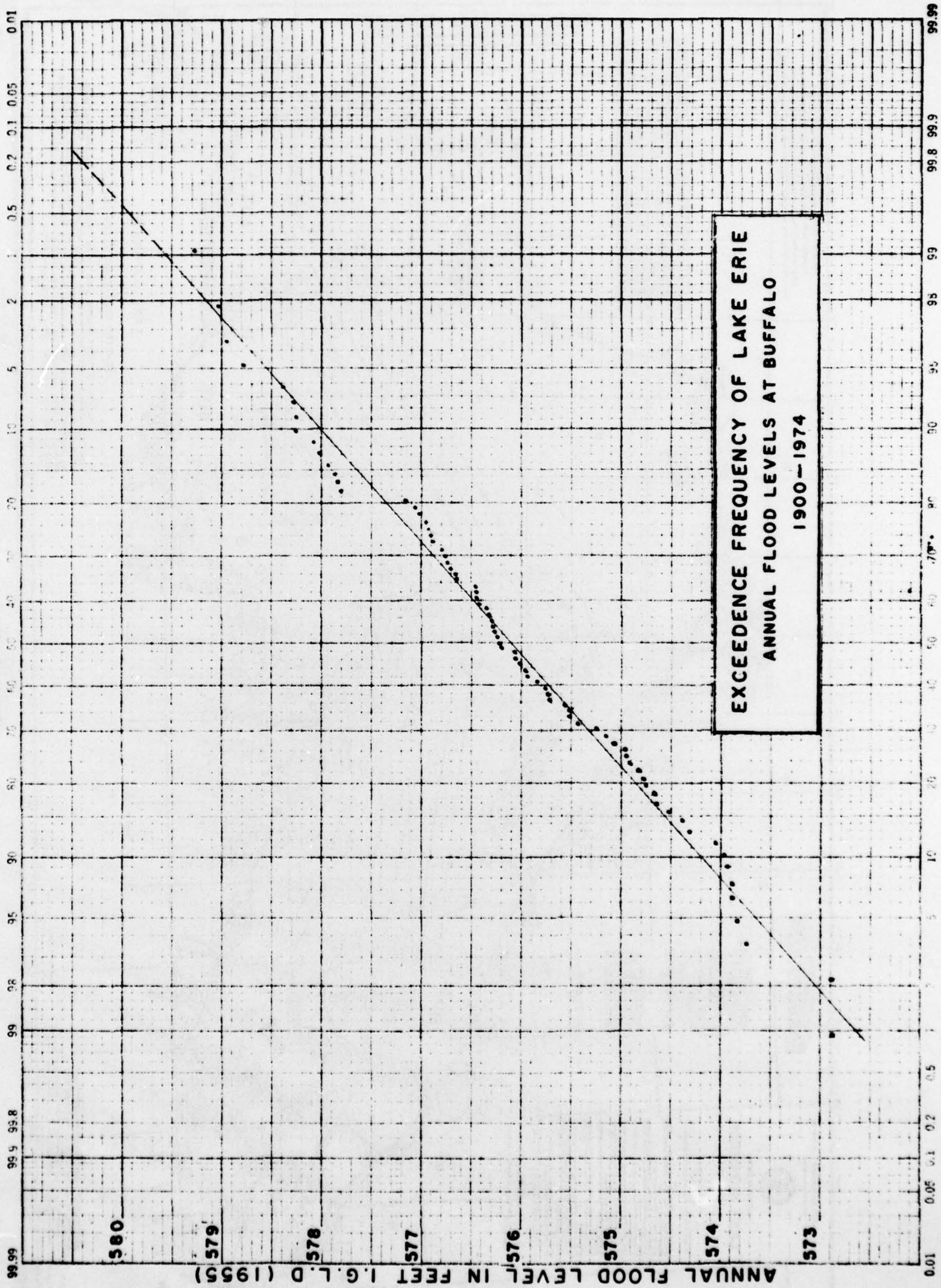
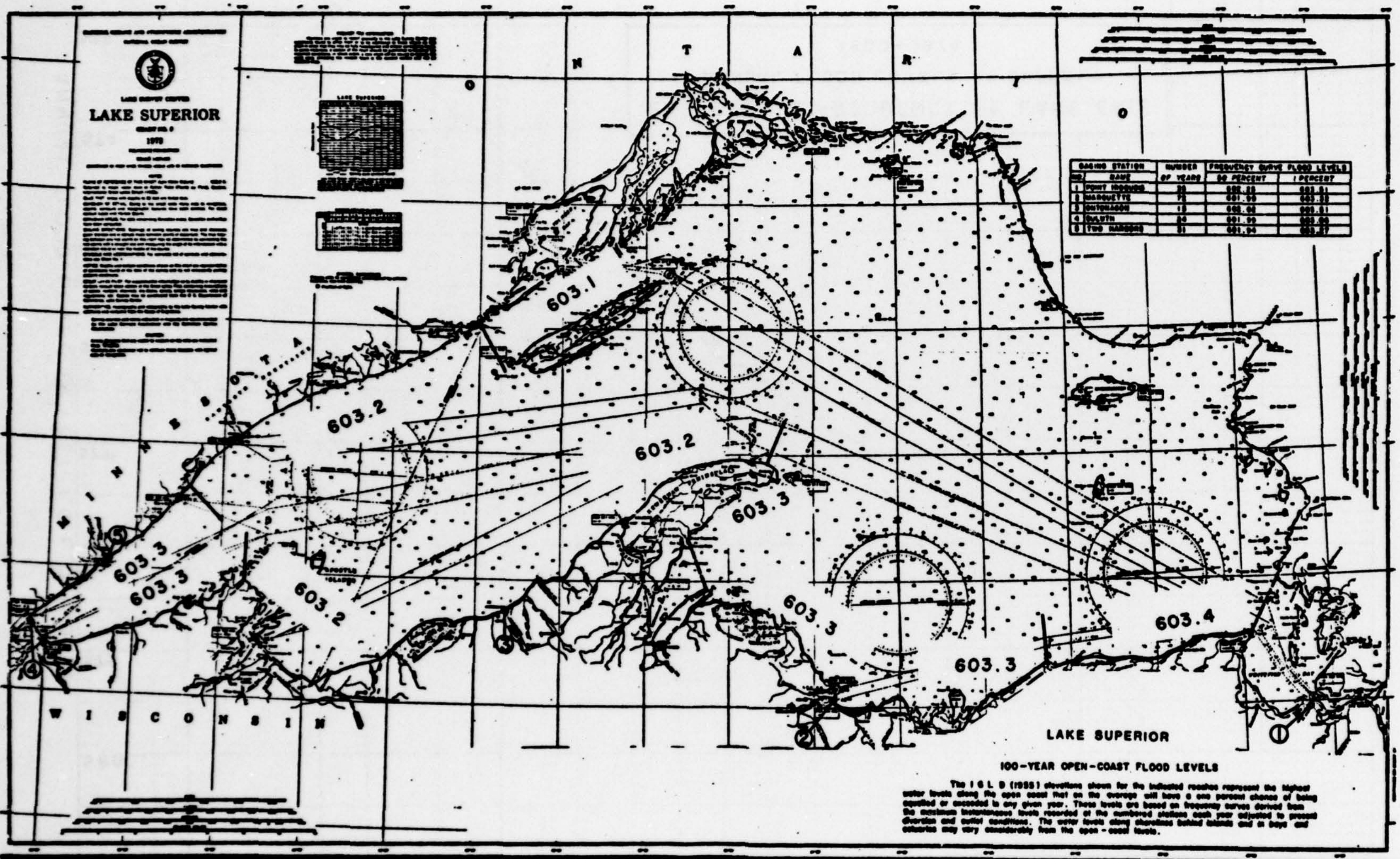


FIGURE 4. BUFFALO FREQUENCY CURVE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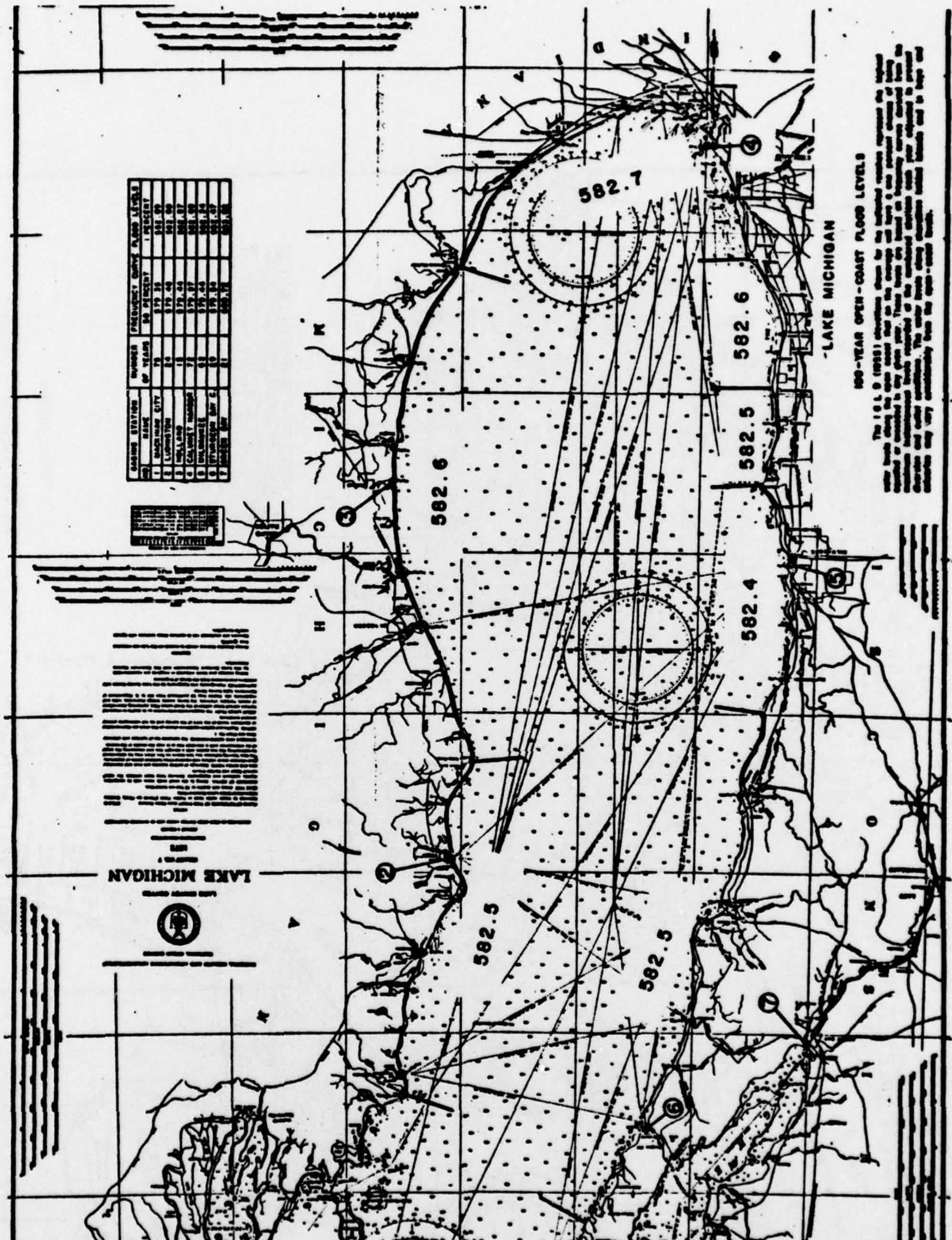
LAKE SUPERIOR
100-YEAR OPEN-COAST FLOOD LEVELS

PLATE I


LAKE MICHIGAN
100-YEAR OPEN-COAST FLOOD LEVELS
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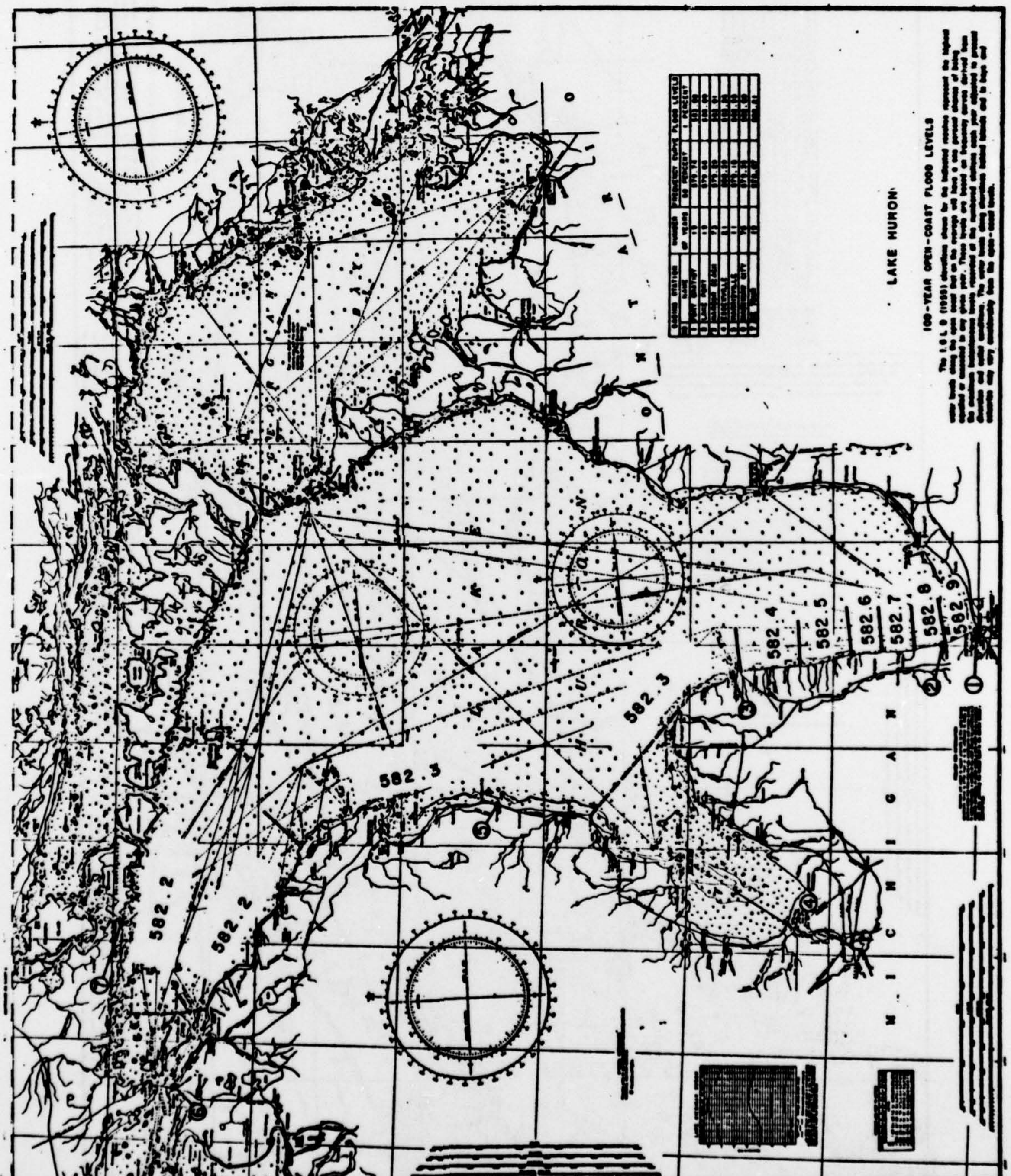
LAKE MICHIGAN

PLATE 2


LAKE HURON
100-YEAR OPEN-COAST FLOOD LEVELS
PLATE 3
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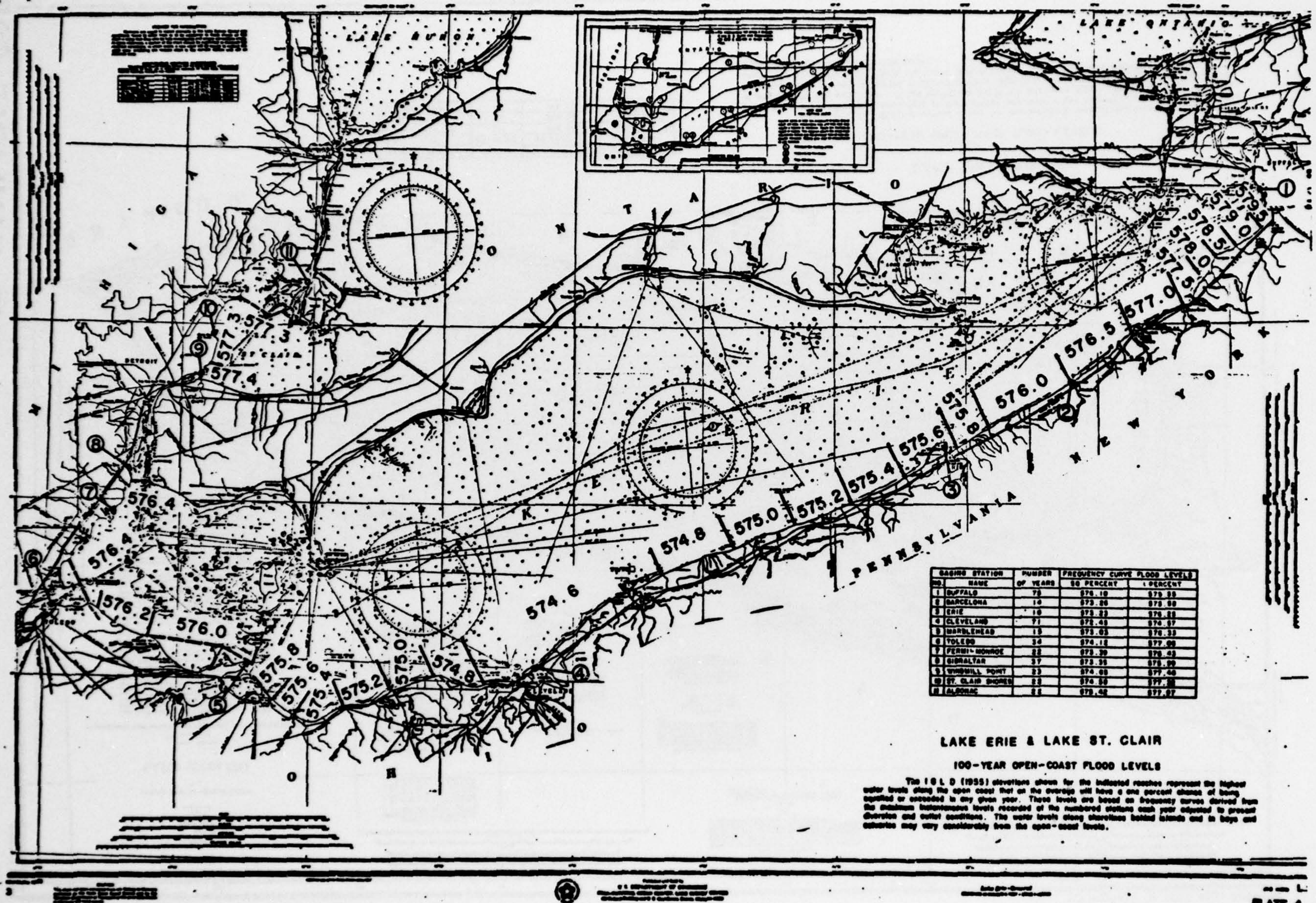
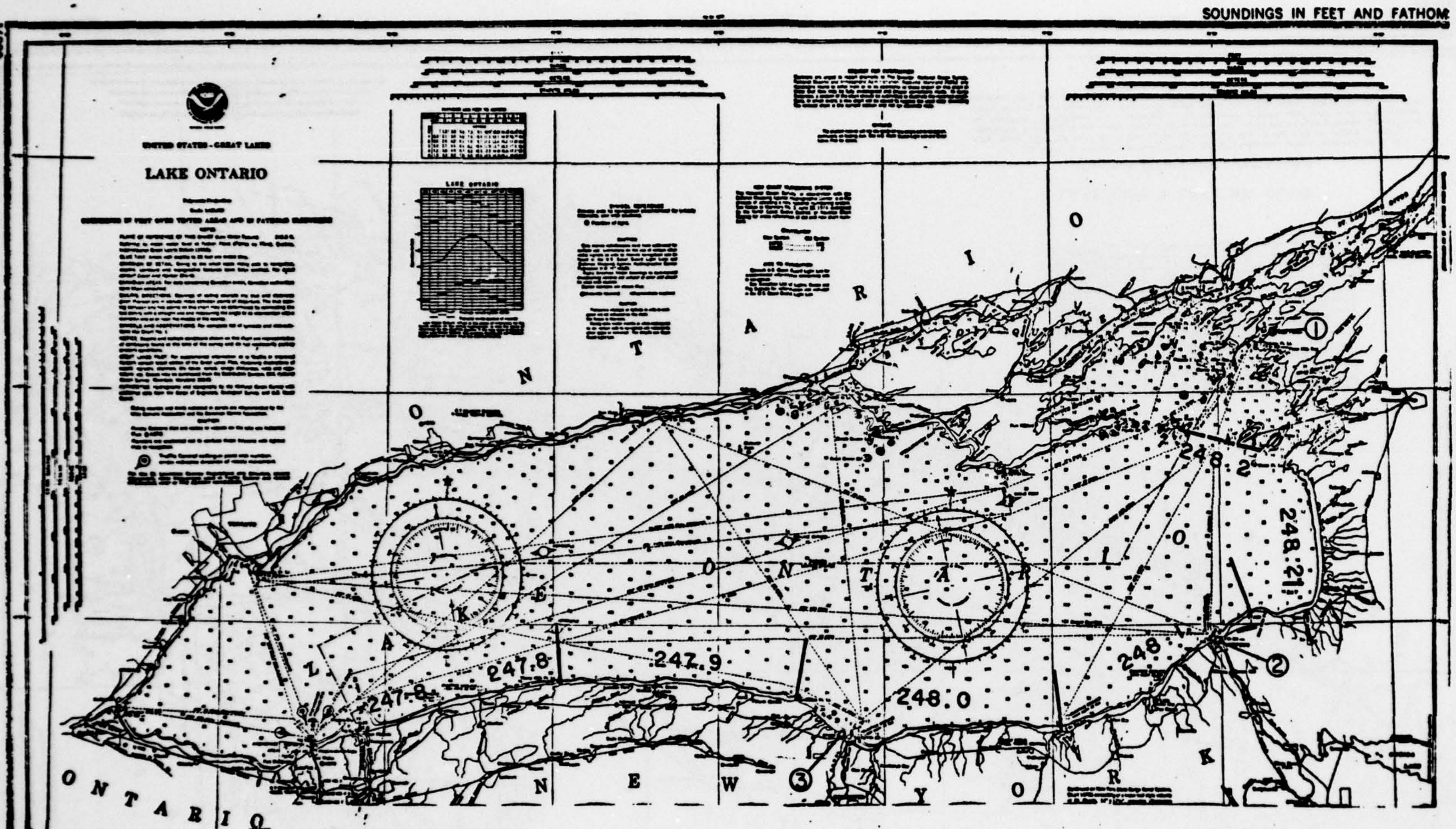


GAGING STATION		NUMBER	FREQUENCY CURVE FLOOD LEVELS	
NO.	NAME	OF YEARS	50 PERCENT	1 PERCENT
1	BUFFALO	79	576.10	579.35
2	BARCELONA	14	573.26	575.98
3	ERIE	10	573.23	576.23
4	CLEVELAND	71	572.43	574.97
5	MARBLEHEAD	13	573.03	576.33
6	TOLEDO	34	574.12	577.96
7	FERMI-MONROE	22	573.30	576.43
8	GIBRALTAR	37	573.35	575.99
9	WINDMILL POINT	23	574.05	577.46
10	ST. CLAIR SHORES	22	574.50	577.[illegible]
11	ALGONAC	22	573.42	577.97

LAKE ERIE & LAKE ST. CLAIR

100-YEAR OPEN-COAST FLOOD LEVELS

The I G L D (1955) elevations shown for the indicated reaches represent the highest water levels along the open coast that on the average will have a one percent chance of being equalled or exceeded in any given year. These levels are based on frequency curves derived from the maximum instantaneous levels recorded at the numbered stations each year adjusted to present diversion and outlet conditions. The water levels along shorelines behind islands and in bays and estuaries may vary considerably from the open-coast levels.



LAKE ONTARIO

100-YEAR OPEN-COAST FLOOD LEVELS

GAGING STATION		NUMBER	FREQUENCY CURVE FLOOD LEVELS	
NO.	NAME	OF YEARS	50 PERCENT	1 PERCENT
1	CAPE VINCENT	30	246.24	247.51
2	OSWEGO	38	246.28	248.06
3	ROCHESTER	16	246.29	248.42

The I.G.L.D (1955) elevations shown for the indicated reaches represent the highest water levels along the open coast that on the average will have a one percent chance of being equalled or exceeded in any given year. These levels are based on frequency curves derived from the maximum instantaneous levels recorded at the numbered stations each year adjusted to present diversion and outlet conditions. The water levels along shorelines behind islands and in bays and estuaries may vary considerably from the open-coast levels.

PLATE 8

OVERVIEW OF SEMINAR ISSUES

By

James Tang [1/]

Legal and Conceptual Framework

In his remarks, BG McIntyre emphasized that Public Law 93-251 requires Federal agencies to give full consideration to nonstructural measures in planning projects for flood protection. He further remarked that the Corps will do its utmost to do the best planning job in this regard. Presentations by Cobb and Thomas of the Water Resources Council provided an overview of the legislative history of the comprehensive approach toward reducing flood hazards of which consideration of nonstructural measures is an important part. Discussions following the presentation of these papers reflected a perception on the part of many participants that dwelling on the distinctions between structural and nonstructural measures tends to be counterproductive because it focuses attention on means for achieving an objective at the expense of balanced and integrated concentration on the objectives of reducing flood damages and encouraging wise use of flood plains.

While the concept of a comprehensive management program for reducing flood damages is not difficult to understand, additional guidance is needed in order to define planning objectives and institutional roles consistent with these national objectives.

1/ James Tang, Economist, Institute for Water Resources. This overview was prepared following the Seminar.

For instance, Corps planners frequently encounter cases where flood hazards and problems are obvious, but where the Federal interest in either structural or nonstructural measures cannot be demonstrated. In such cases, it is not clear how far the planning effort should go and to what extent plans should include measures and actions which satisfy local desires but do not satisfy Federal criteria. Furthermore, there is no clear definition of the Corps role in providing flood plain management planning assistance to communities for plans which they would implement without financial assistance from the Federal government.

The Policy Issues

The most important policy issue inhibiting the consideration of nonstructural measures is cost sharing. There has been no clear policy other than on an ad-hoc basis regarding Federal participation in nonstructural measures. Furthermore, no such policy is anticipated in the near future in view of exceptionally high cost estimates for implementation of nonstructural schemes. Consequently, planners are left to judge by themselves which measures should be recommended without knowing the cost sharing arrangements. One seminar participant suggested that the logical planning task should be carried out as usual without regard to who would implement the plans.

The role of the traditional B/C analysis in formulating nonstructural plans was challenged by several speakers. Difficulties cited by participants ranged from conceptual problems such as those associated with assessment of the "benefits" resulting from evacuation to measurement problems such as those associated with assessing the value of open space.

As reported by Incaprera and other field planners, most flood proofing measures proposed could not pass the B/C test taken individually or in combination even though these measures may prove to be effective to varying degrees. Since many flood plains have been settled over a long period of time often by less affluent people, the emphasis on benefits will tend to discourage the provision of protection to people who need it most. There is a need to improve the measurement of benefits under environmental quality or quality of life so that appropriate weights may be given to this equally important planning criterion.

Methodology and Data System

Davis of HEC indicated that analytical techniques are available for use in performing an analysis of nonstructural and structural plans although the degree of precision will depend largely on data availability. It was noted, however, that our analytical capabilities for hydrologic and economic evaluation far exceed our present capability to analyze social and institutional problems. Analytical problems in the latter areas are compounded by both lack of data and lack of a conceptual basis for dealing with questions of equity and other socially significant factors. This may be explained by the remarks of James saying, in effect, that structural measures deal mainly with engineering works while nonstructural measures deal with men. Problems dealing with human perception, motivation, and behavior in a free democratic society are much more complex than those of engineering in nature. If any nonstructural measures are to work effectively, they must be accepted and enter into the decision making process of the individuals to be affected. There is a need to give greater attention to the changing attitudes and behavior associated with flood hazards and proposed solutions and this must be reflected in future guidance.

What has been said of analytical techniques also holds true for the data system required for nonstructural measure planning. Unfortunately, available data relates mostly to physical and hydrologic aspects, while little information is available regarding social impact assessment involving the use of flood plains. Another dimension of the data or information problem is the urgent need to develop some guidance to make certain that the information collected and published by the Corps may be put into use.

An Interdisciplinary Approach

As recognized in the case study of Indian Bend Wash Project, reported by Ruiz, an interdisciplinary approach was one of the factors contributing to the success of the project. Future guidance needs to address this approach in detail and put it into practice.

Importance of Case Examples

Case studies presented by several field planners are quite instructive, particularly experiences such as the Indian Bend Wash Project. Successful examples in comprehensive flood plain management approaches such as those planned for Waterloo, Iowa; Briston, Tenn.; Charles River, Mass.; and others discussed by speakers at the seminar should be cited in future guidance on planning nonstructural measures.