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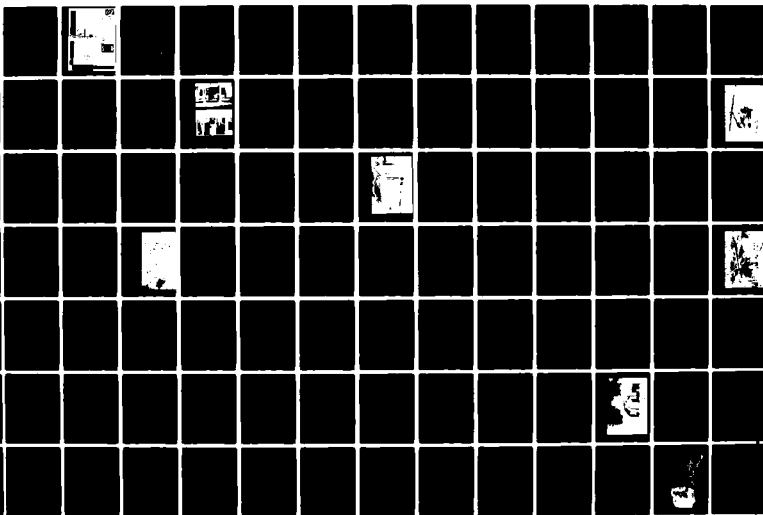
THE DEVELOPMENT OF NONSTRUCTURAL ALTERNATIVES(U) CORPS
OF ENGINEERS ST PAUL MN ST PAUL DISTRICT MAY 79

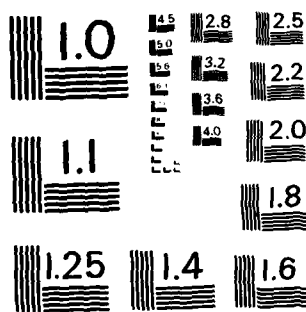
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SUMMARY OF FINDINGS

This report presents the results of a study of Corps of Engineers involvement in nonstructural flood control alternatives. The study was conducted during 1978 by the St. Paul District. It concentrates on flood proofing and floodplain evacuation, the two alternatives implementable by the Corps that are capable of reducing existing flood damages. It notes that the Corps has recommended and undertaken very few nonstructural projects to date. Prospects for future involvement are poor without changes in policy and procedures. Five major conclusions are drawn and recommendations made to effect such changes.

CONCLUSION 1: Many benefits of flood damage reduction projects are not included in benefit-cost ratios.

RECOMMENDATION 1: *Broaden the principle of excluding certain financial costs associated with unquantifiable benefits from the benefit-cost ratio.*

CONCLUSION 2: The optimum time to acquire property in flood prone areas is immediately after a damaging flood.

RECOMMENDATION 2: *Seek continuing legislative authority for employing nonstructural measures immediately after flood emergencies.*

CONCLUSION 3: It is nearly impossible to consider and determine the fate of individual structures in the planning stage of a nonstructural project which combines evacuation and flood proofing.

RECOMMENDATION 3: *Simplify plan formulation criteria by planning for total acquisition of the design floodplain followed by individual disposition of each acquired property on the basis of technical and economic considerations.*

CONCLUSION 4: Most planning for nonstructural projects assumes abandonment of floodplains as major economic resources.

RECOMMENDATION 4: *Seek legislative authority to plan for, encourage, or bring about the optimum compatible use of project floodplains.*

CONCLUSION 5: A significant lack of knowledge exists among water resource planners and the general public regarding the characteristics of nonstructural alternatives, especially flood proofing and floodplain evacuation.

RECOMMENDATION 5: *Educate those within and outside the Corps as to the characteristics of nonstructural alternatives and their limitations compared to structural alternatives.*

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PREFACE

"Nonstructural alternatives (to reduce flood damage) are often more cost effective and less environmentally damaging than structural measures. Therefore, there is a need to emphasize nonstructural measures, including land acquisition, within existing Federal programs, where consistent with primary program purposes. To accomplish this objective . . . Army is to use the general water resources authorities of the Corps of Engineers."

President Jimmy Carter, 12 July 1978, memorandum to the Secretaries of the Army, Commerce, Housing and Urban Development, and the Interior.

"Alternatives, especially nonstructural or small-scale solutions to specific problems such as floods, should always be investigated as substitutes for expensive and damaging projects which often do not provide effective solutions anyway."

President Jimmy Carter, 18 April 1977, statement announcing his decisions on 32 Federal water resource development projects.

"We now look at nonstructural options as the most desirable solution to flood problems since they are usually least disruptive to the natural environment."

Lt. General John W. Morris, budgetary testimony before the House and Senate Subcommittees on Public Works of the Committees on Appropriations, 9 February and 8 March 1977, respectively.

These statements notwithstanding, as of January 1979, no projects using primarily nonstructural measures to reduce current levels of flood damages have been implemented by the Corps of Engineers. It is possible that one project will begin implementation this year in Wisconsin with a second possible in Texas beginning in 1980. Three others, two in Michigan and one in Georgia, have more remote chances for eventual implementation. No other such projects are on the horizon, nor do they seem likely.

INTRODUCTION

For decades, the Corps of Engineers has been involved in structural measures (dams, levees, and channel modifications) to control flooding. It has spent billions of dollars to construct large and small flood control projects in all areas of the Nation. The projects built have prevented flood damages many times greater than their costs.

At the same time, the total dollar value of flood damages suffered annually has been rising. This rise has resulted in part from the inflationary changes in dollar values and the gross increase in capital improvements over the years as the population and economy have grown.

Many believe the increase in damages is also caused by increased investment in flood prone areas by developers and investors who believe that such areas have been made safe by existing projects or would be made safe by future Federal flood control projects. Regardless of the merits of this reasoning, flood damages are greater than they would have been if people had not developed areas which could have been shown by engineering studies to be flood prone.

Recognition of this fact has stimulated suggestions that alternatives to flood control measures for reducing flood damages exist. These alternatives would guide human behavior into desired paths to reduce damages, unlike flood control measures which direct floodwaters into desired paths. The Corps has termed these alternatives "nonstructural." They include floodplain evacuation (temporary or permanent), flood proofing, floodplain zoning, and flood warning systems.

Nonstructural alternatives have been available to Federal agencies since 1938. The Flood Control Act of that year authorized Federal purchase of flood prone properties and the permanent removal of developments

from the floodplain if purchase and removal would be less expensive than a flood control project and both options were economically feasible. In the years since, discussion and attention have focused increasingly on nonstructural alternatives; however, greater emphasis has continued to be placed on structural measures.

The 1960's and early 1970's brought a period of increased environmental awareness and recognition of the environmental problems which could be caused by the construction of major engineering flood control works. This awareness and recognition added perceived environmental benefits to the attractiveness of nonstructural alternatives. During this period, several Corps projects which incorporated significant nonstructural concepts were planned; some were implemented.⁽¹⁾ In 1969 at Prairie du Chien, Wisconsin, the Corps proposed to acquire floodplain properties and permanently remove the developments from the floodplain. A similar project was later planned for Baytown, Texas. Along the upper Charles River in Massachusetts, wetland acquisition is planned to preserve natural flood storage areas from future development which would worsen flood conditions. In Littleton, Colorado, an authorized structural project was modified to allow floodplain land acquisition and the creation of a greenbelt to reduce the amount of structural flood control work needed.

In 1972, a climactic event occurred with the potential to shape flood damage reduction policies for future decades, just as the Mississippi River flood of 1927 had done. Hurricane Agnes devastated large areas in the eastern part of the country, causing major floods and flood damages in areas, some of which had previously experienced repeated floods. Many of these areas were protected by structural works which were overtopped or otherwise proved inadequate.

(1) After a devastating flood in 1964, the Corps participated in a floodplain evacuation project in Klamath, California. Under accelerated planning and design, a flood-free site was constructed for this small community after the flood had essentially destroyed the existing settlement. The new site and the project were technically a success, but, during the time required for building a new site, many of the original inhabitants were forced to move elsewhere for want of a place to live in the interim.

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Partly in response to the damages caused by Hurricane Agnes and the great Federal expense incurred in disaster cleanup and assistance, Congress strengthened the flood insurance program. It introduced provisions which made it essentially mandatory for the Nation's flood prone communities to zone their floodplains according to standards and policies established at the Federal level.

For the Corps of Engineers, this policy was followed by the Water Resources Development Act of 1974 which authorized several of the above-mentioned projects for construction and specifically noted that Federal agencies had the authority to acquire floodplain lands for flood damage reduction and other purposes. Later presidential orders and policy statements have been followed by or have stimulated the writing of Corps regulations which have increased the emphasis placed on nonstructural alternatives. Thus, for many, nonstructural alternatives appeared to be the wave of the future. Particularly to those strongly motivated by concern for the potential environmental damage caused by structural flood control works, substituting nonstructural alternatives for structural measures appears to be an environmental panacea in the area of flood damage reduction. However, as with most ideas that are seized as the one solution to a problem, it has become apparent that nonstructural, as well as structural, alternatives have many drawbacks.

The greatest inherent difficulty with nonstructural alternatives is that they involve altering human behavior, which is more complex and more difficult to predict and control than the behavior of the natural world. Further, in a nation generally founded on the principle of minimal government interference with individual behavior, resistance to attempts at controlling private actions within floodplains has predictably been encountered. The widespread delaying tactics against introducing floodplain zoning laws, the evasion of ordinances where they have been introduced, and the weakening of the mandatory provisions

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of the flood insurance program indicate the strength of the opposition. In contrast to structural measures, which may be opposed by organized interests often not located in or near the benefited area, nonstructural measures are often opposed by the residents of floodplains who would benefit most from such programs.

Apart from this larger problem, a critical problem for the Corps of Engineers is the need to demonstrate economic feasibility for all projects through the benefit-cost ratio. Despite analyses of many projects around the Nation, only very few nonstructural alternatives have benefit-cost ratios greater than unity. Current project evaluation criteria insure that the small number of economically feasible nonstructural projects is not likely to increase significantly.

These and other problems associated with the planning and implementation of nonstructural alternatives are discussed in later sections of this report. Most of the problems became important to the St. Paul District in its effort to develop and implement the authorized floodplain evacuation project at Prairie du Chien. This project, so far the only one of its kind to follow more or less conventional Corps project planning, authorization, and implementation routes, has been noted as a model of Corps involvement and commitment to nonstructural alternatives almost since it was proposed in 1969. The flooding problems of this community cause sufficiently high damages to give the project marginal economic feasibility. The nature and physical location of Prairie du Chien make the evacuation project particularly advantageous and acceptable to the city. North Central Division and various Washington level offices of the Corps substantially assisted in the development of this project. Despite these factors in its favor, it was against strong odds that St. Paul District was able to bring this project to the implementation stage in 1978.

During preconstruction planning for the Prairie du Chien project, St. Paul District received telephone calls from other District and Division offices asking for our experience with nonstructural alternatives

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and the problems we encountered in implementing them. These calls provided evidence that such problems are major concerns of Corps planners nationwide in their efforts to produce implementable projects with major nonstructural features. The intent of Congress, the President, and policy makers in the water resources field to increase the Federal emphasis on nonstructural alternatives appears to have created a dilemma. This dilemma has developed because existing procedures and regulations inhibit our implementation of meaningful nonstructural projects (projects which reduce existing flood damages significantly and genuinely satisfy local desires).

Procedures that require decades to move from project planning to authorization and construction are possible to apply effectively only when nature, with its slow rate of change, rather than society, is the major element with which to deal. The methods and regulations designed to measure the economic benefits of major engineering works do not count many of the benefits society now apparently ascribes to nonstructural measures. However, national environmental groups and State and regional organizations pressure Corps offices to develop such solutions, encouraged by the apparent Washington support for such measures. Meanwhile, few nonstructural project plans have survived the Corps initial screening process or have been recommended even at the feasibility report stage.

In early 1978, St. Paul District proposed this study to identify and recommend actions that would bring Corps capabilities of implementing nonstructural alternatives into better balance with public statements and perceptions concerning those capabilities. The study is based on the experiences of St. Paul and other Districts and is designed to inform higher authorities, within and outside the Corps, of field level problems and to suggest policy changes to permit implementation of nonstructural measures. North Central Division approved the study and has provided substantial assistance. The Office, Chief of Engineers (OCE) and Division and District offices nationwide have provided additional support. This report contains the results of the study and recommendations for efficiently planning and implementing desirable nonstructural projects.

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GENERIC CHARACTERISTICS AND PROBLEMS OF NONSTRUCTURAL ALTERNATIVES

Five alternatives for flood damage reduction are commonly considered nonstructural:

1. (Improved) flood warning.
2. Floodplain zoning.
3. Flood insurance.
4. Flood proofing.
5. Floodplain evacuation.

Each of these alternatives has specific problems relating to its effectiveness and implementability. The first three share the characteristic of being unable to present a near-term solution to flood damage problems.

FLOOD WARNING

Flood warnings provided over the years by the National Weather Service have proved invaluable in saving lives and giving people in danger areas an opportunity to remove or protect some of their possessions. Improvements to the warning system to increase warning times or accuracy will likely be beneficial and cost effective. In areas where warning times are brief, such efforts can achieve little in the way of reducing damages to permanent improvements or hard to move possessions. Thus, in flash flood areas, loss of life can be minimized but the dollar value of damages can be reduced only fractionally with improved flood warning.⁽¹⁾

(1) Flood warning systems can be separated into predicting floods and communicating the predictions. Communication has not received the same attention that prediction has, with reliance placed generally on the mass media and/or sirens. Recently, weather radios have been introduced. These radios automatically sound an alarm when a warning signal is transmitted. The radio is then turned on to listen to the official forecast from the National Weather Service. Currently, these radios are geared to warn about tornadoes and severe thunderstorms. Purchase is optional with each person. In a hazardous floodplain, such radios could be supplied, by various means, to all dwellings and/or business establishments and keyed to respond to flash flood warnings as well.

FLOODPLAIN ZONING

Floodplain zoning may be regarded as a response to long-range flood warning. The regulatory floodplain is usually an area that is expected to be flooded on the average of once in 100 years. On the basis of this expectation, zoning regulations discourage construction within the regulated area. In this manner, zoning reduces the growth of future damages where it is effectively enforced, but does not affect existing floodplain development. Because it works against the perceived and, perhaps, real economic interests of floodplain property owners, zoning is often strongly opposed by the owners and evaded where possible. Floodplain property owners build without getting permits, influence local administrators to approve variances, or delay the introduction of zoning ordinances. This effort by private citizens to thwart the intent of floodplain zoning will no doubt continue as long as these citizens perceive the zoning laws as injuring their economic well-being. These attitudes and actions hinder the effectiveness of zoning nationwide.

FLOOD INSURANCE

Flood insurance, by itself, does not reduce flood damages. In fact, when subsidized as it is now by the Federal Government, it may encourage greater flood damages by spreading the financial burden over a larger segment of the population, just as disaster relief does. The national flood insurance program, however, has been coupled with a (virtually) mandatory program directed at achieving nationwide local floodplain zoning according to national standards. The program thus has two goals: (1) to compensate flood victims for their monetary losses in the short term and (2) to encourage floodplain zoning for the longer-term reduction in flood damages. Most floodplain residents are, at most, unappreciative of the benefits supposedly accruing to them from the insurance portion of the program. They believe that even the subsidized premiums are too high. Many also do not believe that their claims are paid fairly.

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Except for the flood forecasts of the National Weather Service, the national flood insurance program is the primary Federal program in the area of nonstructural alternatives to flood control. As such, it bears certain similarities to the wastewater treatment program which, in terms of financial outlay, has recently been the largest Federal program in water resources management. Like the wastewater treatment program, the flood insurance program was established by Congress to achieve specific national goals, and its implementation has generally not been subject to benefit-cost ratio criteria for economic feasibility. Also, like the wastewater treatment program, the primary implementation of the flood insurance program (that is, floodplain zoning) is done at the local level although the primary funding is Federal.

Although the flood insurance program is a result of a specific congressional directive and may promote various environmental goals, it is questionable whether the program, accompanied by zoning, produces net economic benefits for the Nation. Analyses performed by several District offices have shown that the two nonstructural alternatives which act directly and rapidly on floodplain land use to reduce flood damages (evacuation and flood proofing) have dramatically low benefit-cost ratios. Even when allowing for overhead expenses and premature loss of existing capital investments, these economic analyses suggest that there often is a net economic return derived from placing improvements within the 100-year floodplain,⁽¹⁾ even when relatively high flood damages occur.

FLOOD PROOFING

Flood proofing (raising buildings above flood levels, elevating utilities, raising access roads, etc.), like floodplain evacuation, can reduce existing flood damages. In economic terms, however, it is

(1) The 100-year floodplain is also known as the 1-percent chance floodplain, the 10-year floodplain as the 10-percent chance floodplain, etc.

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much more practical when applied to new construction as opposed to existing floodplain developments. Significant institutional problems are involved in spending public funds for the improvement of private property. When implemented, flood proofing permits and encourages continued economic use of the floodplain.



These photographs (courtesy of South Atlantic Division) are from a collection documenting an example of residential flood proofing by a private homeowner living along Peachtree Creek. The top photograph shows the house before it was flood proofed. Through appropriate design, this house remains an attractive dwelling, despite being raised several feet above grade (see bottom photograph).

FLOODPLAIN EVACUATION

Floodplain evacuation reduces flood damages by removing improvements from the floodplain. Its effectiveness for this single purpose seems beyond question. However, as currently implemented, it severely limits future use of the evacuated floodplain land for economically productive activities.

Most project plans evaluated for floodplain evacuation have envisaged future uses of the land for open space, greenbelts, interruptible recreational purposes, and wildlife. These plans have particular appeal and benefits for those concerned with environmental issues. However, on reflection it is clear that, almost by definition, easily interruptible uses of any area provide little economic return. As such, net economic efficiency of the future use of the Nation's floodplains seems clearly negative under current programs.

Flood proofing and floodplain evacuation are essentially the only nonstructural alternatives potentially implementable by the Corps and capable of relieving or reducing current flooding problems. Therefore, they are the focus of this study. Both have major problems regarding economic feasibility, plan formulation, and local acceptance. These problems have greatly restricted the implementation of these two alternatives throughout the Nation.

STATUS OF NONSTRUCTURAL ALTERNATIVES IN CORPS PROJECTS

PLANNING GUIDANCE

At least since the passage of the Water Resources Development Act of 1974, the nonstructural alternatives of floodplain evacuation and flood proofing have been actively considered by all Corps Districts. In many cases, these alternatives were seriously considered in earlier years as well. To date, however, very few of these alternatives have been recommended or implemented.

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Entering such an essentially new program area, the Corps does not yet have fully standardized procedures and regulations specifically applicable to nonstructural alternatives, although the situation has improved. During the early 1970's, regulations specifically formulated for nonstructural alternatives were practically nonexistent. ER 1105-2-351, "Evaluation of Beneficial Contributions to National Economic Development for Flood Plain Management Plans," was clearly oriented toward structural measures. In recent years, several new applicable regulations have been developed. Some have stirred considerable controversy at the District and Division levels.

Policy guidance on nonstructural alternatives has improved with two new engineering regulations distributed in 1978. ER 1165-2-122, "Use of Nonstructural Measures in Planning for Flood Damage Reduction," deals with plan formulation for nonstructural alternatives. It represents a significant advance in policy guidance based on some of the lessons of the past few years. Among other notable elements, it:

1. Specifies the 80-percent Federal - 20-percent non-Federal cost-sharing formula indicated in the 1974 Water Resources Development Act and announced as policy by the President in June 1978.
2. Recognizes that a lower design level of protection than is normal for urban areas may be acceptable for nonstructural alternatives.
3. Stresses the desirability of planning for groups of structures rather than for individual buildings, where such grouping is possible.

The other regulation, ER 1105-2-353, "Evaluation of NED Benefits and Costs for Evacuation and Relocation as Non-Structural Measures for Flood Plain Management," covering benefit evaluation for floodplain evacuation measures, became effective on 10 July 1978. As noted elsewhere, difficulty in developing economically feasible plans for

evacuation and relocation predates this regulation. However, project benefit-cost ratios evaluated with this regulation will be slightly less than if project benefits were evaluated under the general guidance of ER 1105-2-351. Thus, the new regulation further decreases the potential for finding nonstructural alternatives with benefit-cost ratios greater than unity.

ER 1105-2-353 limits the flood damage reduction benefits to that portion of flood damages externalized through the Federal Insurance Administration program or other public damages. Damages borne by the floodplain owner/occupant (that is, the deductibles and uninsurable damages) cannot be claimed. Therefore, nonstructural plans have a slightly less favorable method of benefit measurement than a structural plan because a structural alternative for the same damageable units will include the deductibles and uninsurable damages prevented as benefits. All other benefit categories, including flood insurance administrative cost savings, were previously creditable under ER 1105-2-351.

Support for the benefit measurement method advocated in ER 1105-2-353 appears entirely based on an assumptive economic principle;⁽¹⁾ namely, that the market value of floodplain properties will accurately reflect the degree of flood risk and the availability of flood insurance. Thus, floodplain property market values are expected to vary directly with the availability of flood insurance and inversely with the degree of flood risk. The empirical studies to support the assumption were not furnished with the regulation and could not be found during a search of subject literature for the general or most specific cases. By contrast, documentation of this nature was considered critical to support use of projected growth as presented in ER 1105-2-351.

Without exploring further technical considerations, evacuation alternatives are only slightly less favored as a result of the new regulation. However, the trend of policy changes implemented by ER 1105-2-353 seems to be toward criteria which are less and less favorable to such alternatives.

(1) Pages 3-4, Paragraph 7(d), ER 1105-2-353, dated 10 July 1978.

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The consideration by the Office of Management and Budget of endorsing a new Federal program with potential for large future expenditures has naturally slowed the development of firm policies encouraging the planning and implementation of nonstructural alternatives. Similarly, very real questions as to the best methods for designing nonstructural projects have delayed the issuance of general guidelines. Until very recently, each field office has been forced to develop its own guidelines and policies on a preliminary basis for submission to higher authority and often for after-the-fact modification.

IMPLEMENTATION

Almost all Corps flood damage reduction projects in planning or implementation stages include some nonstructural elements which will reduce the future growth of flood damages. Usually, this means that recommendations are made for the introduction or continuance of floodplain zoning regulations and participation in the national flood insurance program. The Corps does not implement or even significantly influence these alternatives. Of course, the assumption of floodplain regulation as a part of the base condition influences plan formulation for recommended structural alternatives.

More significantly, about two dozen projects contain provisions for acquiring undeveloped or sparsely developed floodplain lands in fee or by easement. Acquiring these lands for overbank storage can reduce the magnitude of accompanying structural improvements needed to achieve the design level of protection.

Two of the best known flood damage reduction projects of this nature are those at Indian Bend Wash, in and around Phoenix, Arizona, and in Littleton, Colorado, below the Chatfield Lake and Dam on the South Platte River near Denver, Colorado. At Indian Bend Wash, the structural features consist mainly of inlet, outlet, and interceptor

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structures built by the Corps. The floodway along which the flood flows will travel is under the control of the local sponsor and is to be managed as a greenbelt park with comparatively little vulnerability to flood damages. At Littleton, the authorized project called for channel works in conjunction with the upstream reservoir of Chatfield Lake. This plan has been modified to include floodway greenbelt acquisition to preserve the natural character of the river through Littleton while reducing flood damages

Although these and similar proposed floodway acquisition features in projects around the country are considered nonstructural in that they do not alter flood flows by themselves, they may be regarded as further refinements of a traditional structural measure; that is, reservoirs. Like small ponding areas behind levees or major reservoirs behind large dams, greenbelt floodways temporarily store and route floodwaters in areas where the resulting damages will be minimal. Greenbelt floodways may require no modification of flood flows and obviously result in very short-term and limited storage of flood flows, but the concept is not fundamentally different than that of other reservoirs. Greenbelt floodways are generally proposed for areas with little or no development, just as upstream reservoirs tend to be placed in areas of sparse development.

The Charles River Natural Valley Storage Project may be viewed in the same light. No construction is planned for this project; the project consists of acquiring wetlands and other areas adjacent to the upper Charles River. These areas function essentially as flood control reservoirs by storing floodwaters for days or weeks and gradually releasing them downstream. By acquiring these lands in fee or easement and preserving their flood storage potential, the project aims to eliminate the need for future construction of an artificial reservoir to provide the flood storage now available naturally. Thus, it attempts to create or preserve flood storage areas under Corps authority without construction activity.

The three projects described above which incorporate nonstructural features into their plans all deal with essentially undeveloped floodplain lands. This characteristic is typical for nonstructural projects. The economic, political, and social impacts of evacuation and flood proofing

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alternatives for developed floodplains have rarely been investigated in depth, essentially only at the four sites discussed below.

PRAIRIE DU CHIEN, WISCONSIN

This project was developed in 1969 after it was discovered that no traditional structural alternative was economically feasible. A levee, the conventional solution for communities along rivers such as the Mississippi River, was the most nearly feasible structural alternative at Prairie du Chien. However, it was not economically justified primarily because permeable soils in the area would have required major pumping facilities and associated high costs. Further, the proposed levees would have been 14 feet high; this was socially unacceptable to this city long used to intimate contact with the river.

The feasibility report proposing evacuation and flood proofing was completed in 1970 and approved by the Board of Engineers for Rivers and Harbors and the Chief of Engineers. Significant policy questions associated with Federal funding participation in such an enterprise precluded the Office of Management and Budget from taking timely action on this project in its review process. At the request of Congress, the report was submitted without comment from the Office of Management and Budget. Congress authorized the project in 1974 with cost-sharing set at 80 percent Federal and 20 percent non-Federal.

The current plan, after minor reformulation during postauthorization studies, calls for 130 residential and 2 business properties to be acquired. The buildings would be removed from the floodplain through demolition or relocation. Displaced residents would be resettled outside the floodplain. Technical assistance with flood proofing would be provided to remaining floodplain property owners. All residential properties on St. Feriote Island, which is separated from the mainland by a shallow channel, and all residential properties on the city's mainland at elevations below that of the 10-year flood would be acquired. The two businesses are on the island. As the local sponsor, the city of Prairie du Chien will be the acquiring agency and will hold title to the project lands.

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Significantly, for reasons of economic feasibility, many undeveloped parcels and several businesses in the area of severe flooding will not be acquired. Similarly, all properties on the mainland above the 10-year flood level were excluded; they will be left vulnerable to flood depths as high as 5.5 feet above grade at the 100-year flood level.

The project first cost for reducing flood damages in this 10-year floodplain subject to severe spring flooding is \$4.2 million. The project has a benefit-cost ratio of 1.2. A substantial portion of the project's economic benefits is derived from area redevelopment benefits.

BAYTOWN, TEXAS

This project was authorized in 1976, is in the late stages of postauthorization planning, and is included in the President's budget for construction funding in fiscal year 1980. The plan is to acquire and remove all (about 450) dwellings in the community's 50-year coastal floodplain - a floodplain apparently created by human action. Ground-water withdrawals over the past decades to satisfy the demands of oil refining and other needs have caused subsidence of the ground at Baytown as well as at a number of other areas along the Texas coastal plain. Although all of Baytown appears to be vulnerable to the problem of subsidence, the project area is the lowest and most vulnerable developed area subject to damage from tidal and storm surges.

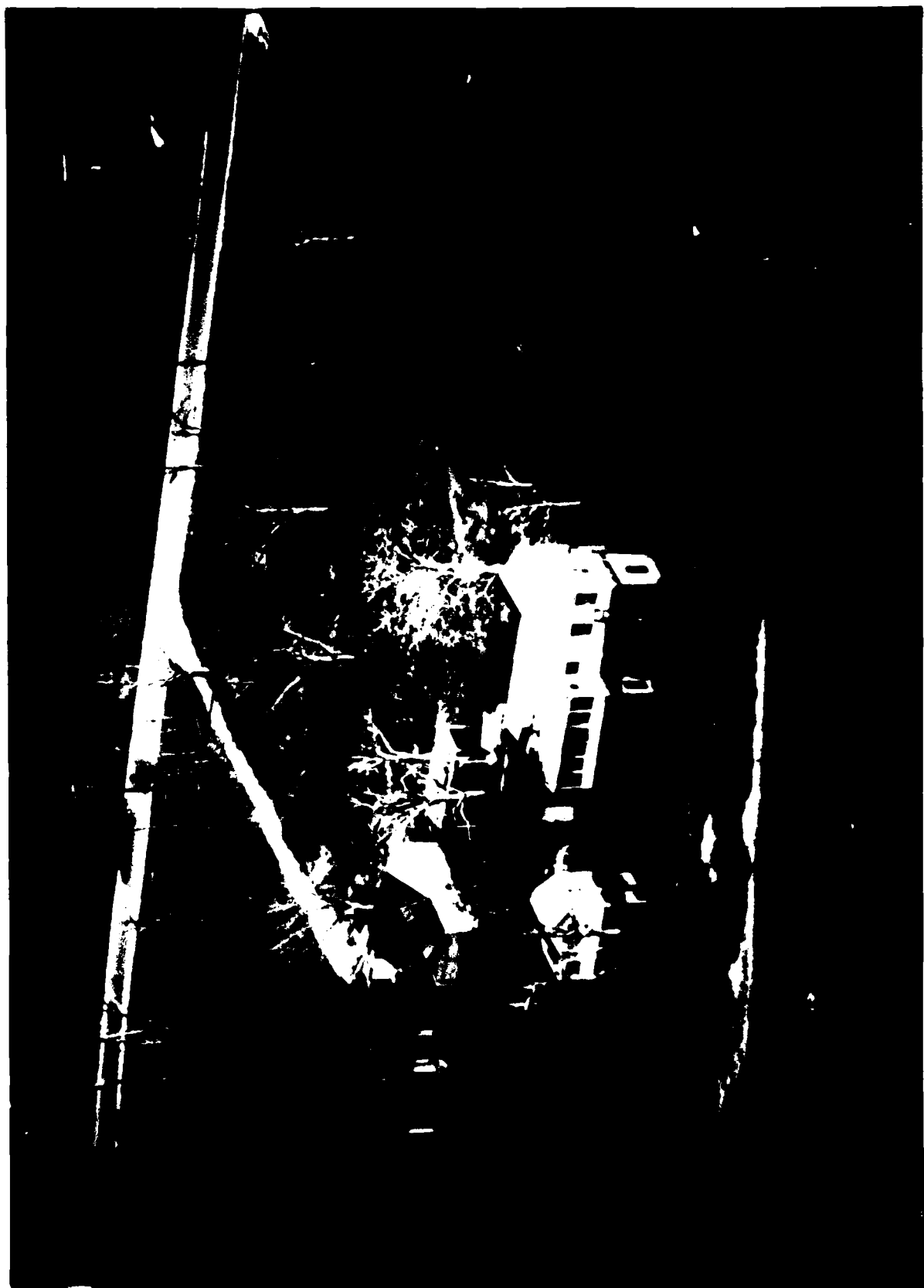
The project area is a residential suburban subdivision built and occupied since the mid-1950's. When the area was first developed, it was not notably vulnerable to frequent, severe flooding nor was the ground subsidence problem expected to assume the magnitude which occurred. The unusual combination of fairly sudden changes in ground levels shortly after the kind of rapid suburban growth possible only in recent decades produced a noteworthy misallocation of economic resources. This misallocation has allowed Baytown to become the only project site to date in which the flood damage reduction benefits to be gained from floodplain evacuation exceed the costs. While there may be similar communities, none has become evident to date. The current first cost and benefit-cost ratio estimates for Baytown are about \$35 million and 1.4, respectively.

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This scene from the proposed evacuation zone in Baytown, Texas reveals the plight of local residents, some of whose homes now occupy a virtual salt marsh. Note the dead trees, standing water, and marsh vegetation throughout the area seaward of the road. During storm surges, the depth of water increases significantly.

When this middle class suburban community was developed in the late 1950's and 1960's, the area was several feet higher and, to all appearances, an attractive place to build and live. Clearly, with or without government regulation, no one would build houses at this site today. Only ignorance of the severity of the ground subsidence problem allowed development of such a nature that the proposed Baytown floodplain evacuation project almost uniquely possesses strong economic feasibility on the basis of flood damage reduction benefits alone. Sudden changes in natural conditions, such as the still sinking ground level here in Baytown or other unusual circumstances, appear necessary for potential floodplain evacuation alternatives to possess a benefit-cost ratio greater than unity under current evaluation procedures.

(Photograph courtesy of Galveston District)



MIDLAND, MICHIGAN

In the early 1950's, a structural project was authorized for this community as part of a basin-wide plan. Much of the justification for the structural plan was lost when Dow Chemical proceeded on its own to construct levees to protect its property. However, the levees did not protect vulnerable residential areas with several hundred inhabitants. Recent severe floods helped stimulate a reformulation of the authorized plan. This reformulated plan proposed the acquisition and removal of about 100 residential properties from the floodplain.

As in Prairie du Chien, this residential floodplain in Midland is older and has been passed by as other sections of the city grew and prospered. Again, as in Prairie du Chien, at current interest rates the proposed evacuation project does not have a benefit-cost ratio greater than unity on the basis of flood damage reduction benefits alone. However, unlike Prairie du Chien, Baytown, or Atlanta (see the following section), the city of Midland has a definite recreation plan for the floodplain land to be evacuated. This recreation plan would produce more benefits than those which would derive from reduced flood damages.

This project, as a result of the reformulation to a nonstructural alternative, requires congressional reauthorization. Its estimated first cost and benefit-cost ratio in 1976 figures were \$4 million and 1.16, respectively.

PEACHTREE AND NANCY CREEKS, ATLANTA, GEORGIA

This project site is along two urban creeks which are subject to flash flooding. The creeks are surrounded primarily by residential developments in one of metropolitan Atlanta's most attractive neighborhoods. Although the flood problem has long been recognized and structural solutions exhaustively investigated in earlier decades, no major flood has occurred in the memory of current residents. This factor complicates local acceptance of a plan with significant local costs.

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This study is in the late stages of a feasibility investigation. Consequently, the present nonstructural plan may still be changed significantly. The current plan involves all of the approximately 700 residential properties in the 100-year floodplain. It provides for flood proofing most of the residences by raising them; others would be acquired and demolished.

The present first cost estimate of \$45 million makes this the most expensive nonstructural alternative to reach a stage near recommendation. Its estimated benefit-cost ratio of 1.00, however, is similar to those of other recommended nonstructural projects. In addition, many area residents doubt that the flood threat is as critical as the Corps determination indicates. They object to the local share of the cost which, under the 80-percent Federal - 20-percent non-Federal cost-sharing formula, would be about \$9 million. Others believe that the aesthetic values of the wooded area outweigh the flood risk. Further, some community officials fear the loss of tax base if the proposed project is implemented.

SUMMARY

Of all the project sites which have been investigated by the Corps for flood damage reduction over the last decade, only these four have reached the stage of offering meaningful nonstructural options to deal with existing flood damages. So far, only Prairie du Chien has received construction funding from Congress and only Baytown demonstrates more than a marginal benefit-cost ratio on the basis of flood damage reduction. Table 1 summarizes Corps investigations of nonstructural measures.

Table 1 - Summary of Corps investigations of nonstructural alternatives to flood control (1)(2)

District	Project location	Nonstructural measures considered	Benefit-cost ratio	Discussion
Albuquerque	Presidio, Texas	Floodplain management Flood warning and evacuation Flood insurance Flood proofing Relocation	Less than 0.7 - - 0.51 0.14	Cost of flood insurance is prohibitive because of the characteristics of the income region. Also, flood insurance does not protect, but offers incentive for further action. In this area, facilities for implementation are limited.
Buffalo	Buffalo, New York	Flood warning and emergency action, flood proofing, flood insurance; floodplain management, permanent evacuation	0.67	Benefit-cost ratio for combined nonstructural plan.
Detroit	Midland, Michigan	Permanent evacuation, subsequent recreation	2.63 ⁽³⁾	Selected plan.
	Monroe County, Michigan	Relocation of 291 structures	1.31	No local sponsor could be found.
Galveston	Baytown, Texas	Flood proofing	-	Because of nature of flooding (long duration, subsidence of land surface), this measure is undesirable, costly, and ineffective. Offers no relief to existing development. Does not provide long-term solution.
		Zoning regulations	-	
		Improved flood forecasting and temporary evacuation	-	
		Rent-back option	-	
		Permanent evacuation and relocation	1.4	Would nullify basic objectives of flood control. Selected plan.
	Cypress Creek, Texas	Floodplain acquisition, land use controls, developmental locational criteria, building design practices, subdivision platting practices, tax incentives, infrastructure placement	-	Preliminary discussion, no in-depth evaluation.
Huntington	West Columbus, Ohio	Residential flood proofing Raising residential structures Permanent relocation of residences	-	
Kansas City	Beatrice, Nebraska	Flood insurance, floodplain zoning Evacuation of 0- to 10-year floodplain Flood proofing	- 1.04 -	Already in effect. Selected plan. Recommended on a selected basis.
Los Angeles	Indian Bend Wash, Maricopa County, Arizona Gala River basin, New River and Phoenix City Streadus, Arizona Milford, Ohio	4.5-mile urban greenbelt floodway with open space development (parks, golf courses, lakes) Floodplain regulations Flood proofing Evacuation	1.9 -	Benefit-cost ratio does not include area redevelopment benefits. Not feasible because of the high density development in the area.
Louisville		Permanent evacuation, flood warning, and temporary evacuation, flood proofing, flood insurance, and floodplain regulation, warning signs, intentional flooding, tax adjustments, relocation of damageable property in structure	-	The flooding problems are relatively minor. No economically feasible plan was found.

Table 1 - Summary of Corps investigations of nonstructural alternatives to flood control (1)(2) (cont)

District	Project location	Nonstructural measures considered	Benefit-cost ratio	Discussion
Memphis	Nonconah Creek, Tennessee and Mississippi	Emergency evacuation Zoning Flood proofing, land treatment, flood insurance, floodway preservation	-	Property is not readily movable; warning time is short. Does not protect existing development.
New England (Division)	Charles River watershed	Preservation of natural storage areas	2.0	Selected plan. Natural storage areas would be pre-served to preclude need for future structural project.
Norfolk	Richmond, Virginia	Evacuation Flood proofing Flood proofing and evacuation (100-year level of protection) Voluntary property sales plus warning	0.5 0.3 0.7 0.5	
Omaha	South Platte River, Colorado, Chatfield Dam and Lake	Floodplain regulation and acquisition	-	Not economically feasible.
Philadelphia	Temple, Pennsylvania	Permanent evacuation Flood proofing	- 0.26 0.03	Commercial and Industrial. Residential.
	Christina River basin	Improved flood warning, preparedness planning Evacuation Flood proofing Flood warning and preparedness planning	5.3 - 7.8 0.56 - 0.71 Marginal 4.2	Economically and socially justified in the long term. Measures should be examined in more detail.
	Chester Creek basin	Regulation of land use in upland areas Permanent, semipermanent, and contingency flood proofing Acquisition of development rights Policy adjustments Floodplain management Permanent evacuation Temporary evacuation Flood proofing Temporary flood proofing	- - 0.25 - - 0.57 Less than 0.30 0.67 0.59	Shows promise; should be examined in more detail. Shows promise; should be examined in more detail. Does not solve existing flood problems. No feasible plan could be found.
Sacramento	Cache Creek basin, California	Flood proofing existing development and regulating future growth Evacuation of the floodplain Flood proofing future facilities	0.8 Less than 0.4 -	Economically feasible but not responsive to the need for reducing existing flood damages.
	Lower Jordan River, Utah	Zoning and building regulations Flood proofing Permanent evacuation	- 0.6	Unreasonably high costs.
San Francisco	Klamath, California	Relocation	3.4	Project was implemented.

Table 1 - Summary of Corps investigations of nonstructural alternatives to flood control (1) (2) (cont)

District	Project location	Nonstructural measures considered	Benefit-cost ratio	Discussion
Savannah	Peachtree-Nancy Creeks, Atlanta, Georgia	Flood warning Flood proofing Floodplain evacuation	- 2.42 (4) 2.24	Does not decrease flood damages. Selected plan is combination of evacuation and flood proofing with a benefit-cost ratio of 1.00
Seattle	Chehalis River, South Aberdeen and Cosmopolis, Washington	Floodplain management	0.87	Would only partially meet the needs for flood protection; still permit disruption of public facilities and services during floods; continues to be a threat to life, health, and safety.
	Flathead and Clark Fork River basins, Montana	Relocation Floodplain management	0.29 -	Adverse social impacts Included in recommended plan. Floodplain management is the only justifiable means to alleviate flood problems in some parts of the study area. Selected plan benefit-cost ratio is 2.6
St. Paul	Crow River, Rockford, Minnesota	Flood proofing Floodplain evacuation	0.6 0.5	No economically feasible plan was found.
	Rochester, Minnesota	Flood proofing Relocation		Included in authorized plan, but not in plan selected during Phase I. Relocations would be done only to accommodate channel alignment.
	Prairie du Chien, Wisconsin	Permanent floodplain evacuation, technical assistance for flood proofing	1.2	Selected plan. No structural projects were economically feasible.
	St. Peter-East St. Peter, Minnesota	Flood proofing Floodplain evacuation	0.1 0.01	The only economically feasible plan is the evacuation of East St. Peter with floodplain regulation, flood warning, and flood insurance for St. Peter. Benefit-cost ratio would be 1.1-1.2. Local interests do not support evacuation plan.
	Kickapoo River valley, Wisconsin	Evacuation/relocation Flood proofing	0.66	Few existing residential or business buildings are suitable for flood proofing. Would not reduce flood damages. Would adversely affect regional economy.
Walla Walla	Big Wood River and Tributaries, Idaho	Fee purchase and easement acquisition of rural lands Flood proofing Permanent evacuation	- - -	Flood insurance would be less expensive. Costs greatly exceed those of structural measures.

(1) The projects in the table were selected by the Districts as being significant for their consideration of nonstructural alternatives to flood control.

(2) Generally, the nonstructural measures of flood insurance and floodplain management are considered as part of existing conditions. For communities to participate in the National Flood Insurance Program, they must adopt appropriate floodplain regulations.

(3) Based on a 2 5/8-percent interest rate.

(4) Early plan formulation.

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STATUS OF OTHER AGENCIES' PROGRAMS
AND RELATIONSHIPS TO THAT OF THE CORPS

Several other agencies are involved in reducing flood damages using nonstructural alternatives. Basically, the status of their nonstructural programs appears no more advanced than that of the Corps. This situation is particularly true of the Soil Conservation Service whose responsibilities and authorities, like those of the Corps in civil works, involve flood damage reduction. In contrast, the Tennessee Valley Authority, which has broader responsibilities within its limited geographic region, has had more experience with flood proofing and floodplain evacuation.

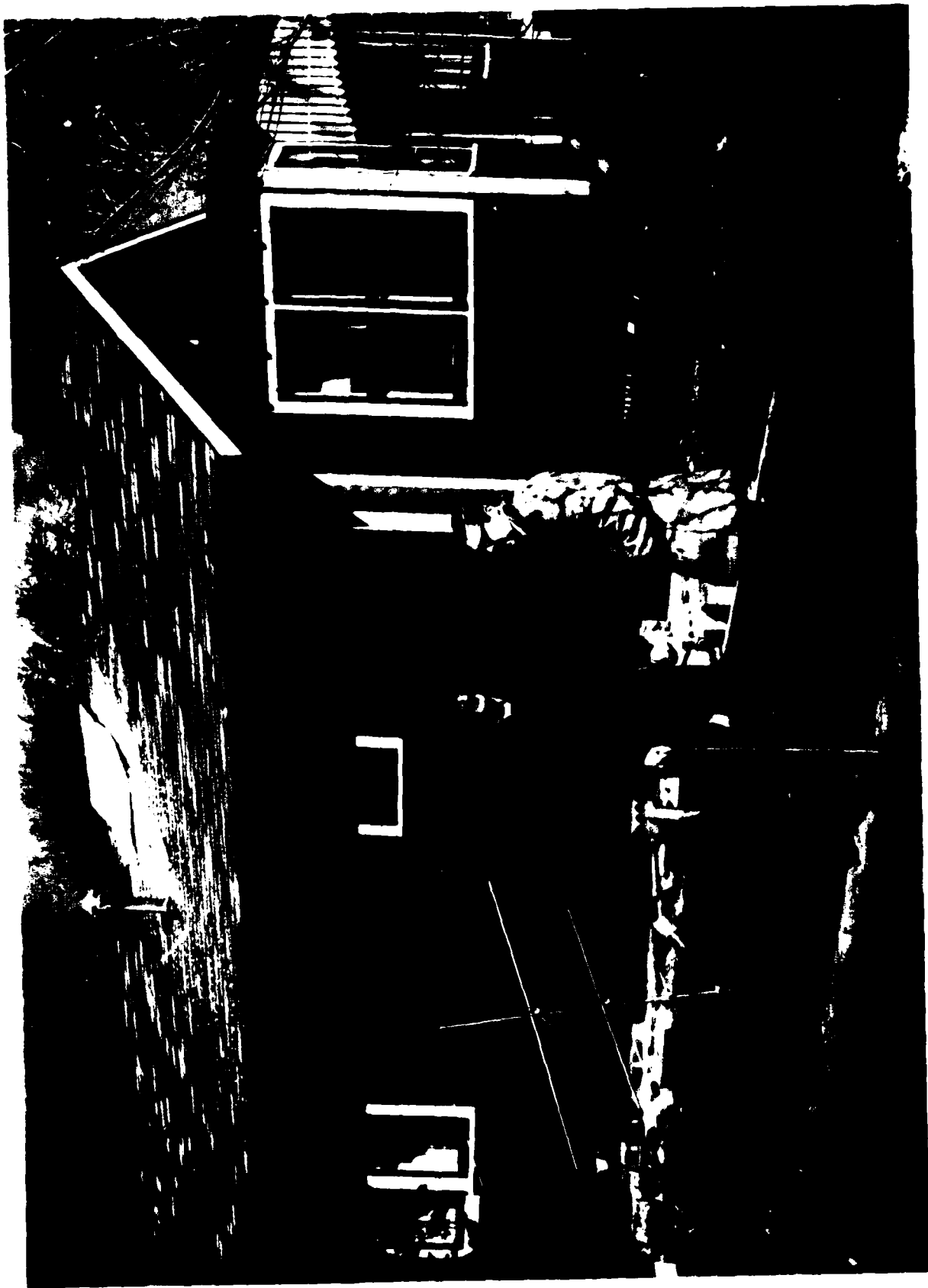
As noted earlier, the Federal Insurance Administration's program is directed at reducing the future growth of flood damages by regulating new development and does not solve existing flood problems. The Federal Insurance Administration does have authority under section 1362 of the Flood Insurance Act of 1968 to acquire and remove damaged floodplain properties under certain specific and limited circumstances. The administration has not used this authority to acquire any properties; however, it is investigating programs to implement the authority. In its present form, this authority does not appear to offer a meaningful solution to serious community flood problems. Restrictions limit its application to areas with extremely severe flooding (for example, three major floods in 5 years) and its application would probably result in limited property acquisitions.

An interesting phenomenon has occurred regarding the implementation of some nonstructural projects which have been studied by the Corps. Sources other than the sponsor or the Corps have provided funding for these projects. This funding serves to speed implementation or to replace Corps implementation. In a number of cases, funding has been provided by other Federal agencies that have only a minor interest in reducing flood damages. For example, in Midland, the Dow Foundation has indicated that it would provide the city with several hundred thousand dollars to implement the planned project with or without Federal participation.

Another example can be seen in Prairie du Chien where the first \$500,000 in implementation funds was provided by a Community Development Block Grant from the U.S. Department of Housing and Urban Development. This funding was available more than a year before Corps funds were ready for expenditure. The department will likely provide additional funds to the city to help implement the project.

In 1974, using Community Development Block Grant funds provided by the U. S. Department of Housing and Urban Development, Prairie du Chien, Wisconsin, began the floodplain evacuation project on its own initiative while the Corps was still engaged in preconstruction planning. The city voluntarily followed the guidelines jointly developed for this project over the years by the Corps and the community. Because funds were limited, a priority list was made of those applying for evacuation, giving preference to families with dependent children or those who were elderly or in poor health.

This house was the first to be moved out of the floodplain as part of the project. Shown here on the eve of the move are the homeowner, a man in his 80's who built the house himself more than 50 years ago, and the Corps project manager. Throughout this project, it has been critically important to maintain a one-to-one relationship with the many elderly and low income residents faced with the choice of suffering continued flood threats or moving from their long-time homes.



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In Beatrice, Nebraska, the Kansas City District developed a feasible evacuation project. The city appears to have accepted the general plan but has declined further Corps involvement. The city intends to implement floodplain evacuation with the help of a Community Development Block Grant from the Department of Housing and Urban Development.

In the Kickapoo Valley of southwestern Wisconsin, in the same county is Prairie du Chien, a more extreme example can be seen. The valley was the site of an authorized and partially constructed project, the La Farge Lake and Dam. Construction was halted when environmental and conservation organizations with the support of some State and Federal representatives opposed its completion. When construction of the dam became uncertain, the village of Soldiers Grove, downstream from La Farge, commissioned a small study outlining the benefits of a floodplain evacuation plan. The village attempted to get the Corps to participate in implementing such a plan. Studies have shown that the plan lacks economic feasibility; therefore, the Corps has not been able to participate, despite the expenditure of considerable time and money in study efforts.

In July 1978, a major flood occurred in the Kickapoo Valley flooding a substantial portion of Soldiers Grove. On the basis of requests for assistance to implement its relocation plan and in view of the recent disaster, Soldiers Grove has obtained more than \$1 million in grants from various Federal agencies. Although the Federal funds will benefit the village, it is questionable whether this uncoordinated method of funding is an efficient way for the Federal Government to participate in floodplain evacuation projects. This procedure repeats, on a smaller scale, the allocation of large amounts of Federal money to Rapid City, South Dakota, soon after its 1972 flood disaster.

In summary, it is clear that neither the Federal Government in general nor the Corps of Engineers in particular has a program to implement nonstructural alternatives for flood damage reduction that is comparable to the program to implement structural alternatives for

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this purpose. The Corps has only a few isolated nonstructural projects or proposals nationwide. Other agencies participate in a comparable number of such projects.

COMMON PROBLEMS IN DEVELOPING NONSTRUCTURAL PROJECTS

PLAN FORMULATION

Approached from the larger context of Corps civil works activities over the decades, real consideration of nonstructural measures as major project elements is a relatively new phenomenon for the Corps. This relative lack of familiarity has adverse impacts on the quality of plan formulation and design, especially when compared to that for structural alternatives. Usually, neither the project planners at the District level nor the reviewers at the Division and Washington levels have had significant experience with even one primarily nonstructural project. The experience of other agencies and private consultants is similarly limited. This inexperience is in marked contrast to the structural expertise the Corps possesses after planning and constructing hundreds of large and small reservoirs and thousands of miles of levees and channel modifications.

At the District level, this lack of experienced guidance results in mistaken assumptions, false starts, and unduly prolonged consideration of plans that cannot be implemented because of local unacceptability or Corps or administration policies. These problems have become noteworthy only where nonstructural alternatives have been considered seriously. In other cases, nonstructural alternatives have only been given a cursory examination to rule out their further consideration.

Reviewers at Division level are, in a sense, in a more difficult position than District personnel. Having no more experience than District planners with nonstructural alternatives because of their rarity, Division reviewers are required to review District plans to make them compatible

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with perceived policies. In the past, such policies often appeared as the convoluted application of regulations designed for structural alternatives. At other times, decisions were based on unwritten policies expressed to Division personnel verbally and subject to unpredictable future changes.

Those in policy positions at the Office, Chief of Engineers; Board of Engineers for Rivers and Harbors; or the Office of the Secretary of the Army have also faced significant problems in their efforts to adapt to increasing emphasis on nonstructural measures. Pressured from the District offices for decisions that could not be based on precedent, agency policy makers have used their best current judgment or delayed in making decisions where possible until more information was available.

The foregoing problems are a predictable consequence of the introduction of a new program. Because they have occurred with other agencies that are adapting their programs to the increased emphasis on nonstructural alternatives, their existence is in no way an indictment of the personnel involved, either in the Corps or other agencies. Nevertheless, they have hampered the development of implementable nonstructural projects.

Specific problems related to the formulation of nonstructural alternatives as opposed to the formulation of more traditional structural alternatives are:

1. The increased complexity of any approach dealing with human behavior versus the more predictable behavior of the natural world.
2. The increased number of permutations possible for a plan dealing with individual structures as increments.

The natural world itself is not simple to understand. It has taken people thousands of years to discover and comprehend a sufficient number of the laws of nature to develop reliable and quantifiable natural sciences. In the area of water resources engineering, knowledge and techniques are still imperfect in many fields.

In contrast with human behavior, however, natural phenomena often seem simple and straightforward. Although the term "social sciences" exists, few would accord to sociology, psychology, or political science the same impressive accomplishments in their areas of application as have been achieved in physics, chemistry, or civil engineering. Economics is probably the only social science with pretensions at quantifiable laws. Even its reputation for accuracy and forecastability has not been impressive.

Formulating any nonstructural alternative involves judgments and interpretations of human behavior. Predicting the behavior of people warned of an impending flash flood is much more difficult than predicting the reliability and timeliness of the instruments and techniques that provide the warning. The effectiveness of floodplain zoning depends on the behavior of the individuals responsible for enforcement, the attitude of their political superiors, and the ingenuity of the regulated property owner in evading regulations. The efficiency of the flood insurance program relates to the above problems, as well as the coordination between Federal and local officials, and even the honesty and sensitivity of insurance claim adjusters in dealing with flood victims.

No one can accurately predict the results of the foregoing programs, although some may be measurable in subsequent years. For the nonstructural measures that the Corps can implement (flood proofing and floodplain evacuation) similar uncertainty exists as to their effectiveness at different levels of protection and in varying circumstances.

The benefits to be gained from flood proofing are uncertain, partly because of a lack of experience with the proposed measures as applied to single-family homes and other smaller structures. Aside from the doubts about structural integrity and waterproofing qualities, the behavior of property owners is unpredictable. Waterproofing shields for door and window openings may have been mislaid when a 50-year event for which they are necessary actually occurs. Also, an uninformed postproject owner might cut a more convenient walkway through the mini-levee around his house.

The uncertainties regarding the long-range effectiveness of flood proofing are present in a more fundamental way regarding the effectiveness of "permanent" floodplain evacuation. Together with floodplain zoning, evacuation is designed to remove flood vulnerable capital improvements from the floodway and other low portions of the floodplain. Even though it may be limited to developments in the 10-year floodplain, as at Prairie du Chien, it does provide protection from the 100-year flood to those persons and improvements removed from this floodplain. This, of course, is unlike a 10-year levee which provides protection only to the 10-year level and often induces higher flood damages when less frequent, greater floods occur.

While evacuation provides a high level of protection to the persons and improvements involved, a reasonable doubt exists regarding the long-term protection of the acquired land. Acquisition-evacuation and floodplain zoning presume the continued existence and enforcement of national policies; State, Federal, and local laws; and agency regulations which generally have been in existence only since the 1960's. These policies may be continued indefinitely, or they may be altered or reversed much sooner. During the first part of this century, the episode of Prohibition revealed that even a constitutional amendment reversing a previous amendment could be quickly forthcoming when enough people objected to laws restricting what they believed to be their fundamental rights.

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Regardless of the merits of legally restricted floodplain use as perceived by its proponents, many others oppose such restrictions. Policies and rules governing human behavior can be changed by an act of Congress, a new presidential executive order, or a more widespread flouting of still-existing laws and cannot be considered permanent conditions on which to base economic or other calculations and forecasts a century or more into the future. The confidence level of the future behavior of the mass of concrete and steel in a major dam is fundamentally much greater than that concerned with the future behavior of a changing society.

The three major structural alternatives for flood control are: (1) reservoirs, (2) floodwalls-levees, and (3) channel modifications. The application of each of these alternatives is, in theory, infinitely variable at each project location, both as to specific design and magnitude. However, in practice, only a few sites are suitable for dam construction, or few alignments for channel changes or levees make engineering and economic sense. These few reasonable structural possibilities are multiplied by differing levels of protection which can be built into each. Although these levels could be varied by small increments, design guidelines have evolved over the years to standardized levels of protection which are determined by economic analysis, policy, and regulation. Once determined, the level of protection is fixed for the entire feature and often for all project elements. One could not rationally construct a continuous levee with greatly varying heights or a dam with half built for a 20-year event and half built for a 100-year event. The possible variations for a structural project are generally reduced to a manageable number through consideration of the characteristics of a particular location, traditional policies, and the very nature of such work.

This built-in degree of simplification in plan formulation applies very little to nonstructural alternatives. Firm policies have not existed during the past years to help standardize planning.

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Further, when dealing with floodplain evacuation or flood proofing, one can rationally develop a plan that considers and treats each structure (residential, commercial, or industrial) differently. Such a plan, which could acquire and demolish one structure, relocate its neighbor, flood proof another structure, and do nothing for yet another, is not easy to develop or administer. Despite these difficulties, it may make sound economic sense from the standpoint of reducing flood damages and, at the same time, meet with general local acceptance. The essence of the complexity in employing nonstructural alternatives is that each structure can be considered as a separate project increment, each property owner might reasonably wish it to be so considered, and rational reasons exist for so doing. Specific examples of the complexity of plan formulation in nonstructural projects can be found at Prairie du Chien, Midland, and Peachtree and Nancy Creeks.

Prairie du Chien, Wisconsin

At Prairie du Chien, the selection of properties to be acquired was critical. Project economics dictated that the selection be made at a level far lower than the 100-year flood typical for many projects. Economics was not the only factor considered in selecting a lower cutoff point. Generally, very few or no residents in the 50- to 100-year floodplain favored mandatory floodplain evacuation. A majority of all those above the 10-year level opposed evacuation although many were willing to participate.

Much of the city's flood problem involved St. Feriote Island, which made an easily identifiable unit. However, many of the residences on the mainland were subject to worse flooding than some at higher elevations on the island. Some island and mainland residents scheduled for evacuation suffered no first-floor damages until the 100-year flood, but land access to their properties was interrupted at the 15- to 10-year flood. In addition to residences subject to flooding, many businesses were located in the lower parts of the floodplain; only two of them possessed incremental economic justification for inclusion in the evacuation project.

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The ultimate decision was to treat all residences with a given access problem alike. Thus, first-floor and ground elevations were not critical, although obviously related. The result of this decision was that residents with homes at higher elevations who did not feel especially threatened were included in the group to be evacuated, while others at somewhat lower elevations were allowed to remain. In either case, some persons on either side of the dividing line were unhappy. The decision, which treated all residents with a specified degree of vulnerability equally, was made while working under severe economic justification constraints which permitted the inclusion of few, if any, uneconomic remnants.

Businesses, as larger increments and without the same degree of social sympathy, were treated differently. Only two businesses were incrementally justified for evacuation and were included in the evacuation portion of the project. Several other buildings that were equally vulnerable were left in the floodplain. The decision to selectively aid businesses on the basis of individual economic feasibility was not an easy one, but it resulted in the greatest reduction of flood damages permitted by economic justification criteria. The same process excluded all undeveloped floodplain parcels from the acquisition program even though the result in some areas is a checkerboard of public and private land holdings that will inhibit future plans to use the acquired lands as a unit.

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This aerial photograph of the north half of Prairie du Chien, Wisconsin, illustrates the possible checkerboard type of acquisition in floodplain evacuation projects. The structures indicated in yellow, primarily residential, are scheduled for acquisition and removal from the floodplain. The structures indicated in red, which are residential, commercial, industrial, and public buildings, will not be acquired. Many of the structures scheduled for acquisition comprise a large contiguous unit while others are interspersed among structures to be left in place. Even in the central residential area of St. Feriole Island, properties without structures and subject to floodplain zoning restrictions will remain in private ownership.

This project's marginal benefit-cost ratio prohibited adding any uneconomic remnants. Adding these other properties would have resulted in a more inclusive and desirable project for potential future recreational uses. Any evacuation project could face similar pressures for including or excluding various contiguous properties as long as flood damage reduction rather than optimum future floodplain use remains the dominant project purpose.



LEGEND

STRUCTURES TO BE ELEVATED
FLOOD PLAIN ELEVATION AND FLOOD BLEED
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ELEVATION 62

DESIGN MEMORANDUM NO. 1
GENERAL PHASE 1
FLOOD CONTROL

MISSISSIPPI RIVER AT
PRAIRIE DU CHIEN, WISCONSIN

SELECTED PLAN

ST. PAUL, MINN. DISTRICT

PLATE

BELMONT ROAD

MAIN ST

WASHINGTON ST

NORTH CORPORATE LIMIT

ST. PAUL, MINN. DISTRICT

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Flood proofing was also a major element in the authorized plan for Prairie du Chien. However, during postauthorization planning, it was determined that flood proofing, to various degrees, was incrementally justifiable only to individual residences and businesses scattered throughout the floodplain. No single contiguous unit of properties could be economically flood proofed. Because the project was only marginally feasible without flood proofing, only structures with an individual benefit-cost ratio greater than unity could be included in the project if overall feasibility was to be maintained.

Individually justifiable properties could have been selected for flood proofing but the problem of social equity also emerged. In general, it costs approximately the same to flood proof all houses of a given size and vulnerability. However, the benefits gained from raising a high-value house are much greater than those gained from raising a low-value house which suffers less dollar flood damages. Applying these facts on a case-by-case basis resulted in a plan that would have flood proofed 20 high-value residences and done little for 80 low-value residences. This action would have meant government assistance to those wealthy enough to afford more expensive properties and no assistance to the rest. Direct Federal participation in flood proofing residences was ultimately rejected.

Striving to maintain equity while reducing flood damages to the minimum level consistent with economic feasibility, the final plan calls for providing technical flood proofing assistance to all property owners, with the implementation and financing of any flood proofing measures to be at the option and expense of the individual. Limited financial assistance could be made available to the local sponsor.

While federally implemented flood proofing of some grouping of structures on a mandatory basis was still under consideration, it was noted that the Government could not force an owner to allow his house to be flood proofed. Therefore, if total flood proofing of a

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selected group was required by policy or other considerations, the Government would have to provide individual property owners with the choice of being acquired instead, using the power of condemnation to assure compliance with a given plan. However, because acquisition-evacuation is more expensive than flood proofing in virtually all cases, the possible costs of evacuation would have pushed the benefit-cost ratio of this marginally feasible project below unity.

The final element of controversy regarding flood proofing is the degree of protection. If a house is to be raised, should it be raised to provide protection to the 50-year, 100-year, or some other level? Further, should measures other than raising, which promised to be only selectively effective, be employed?⁽¹⁾ This problem was solved in Prairie du Chien when it was decided to provide only technical assistance with the implementation and financing at the option of the individual property owner. Clearly, if every person decided on his own work and paid for it, the Federal Government would have no control over the kind or degree of protection beyond providing advice. The ultimate expectation is that a few property owners will raise their houses to the 100-year flood level, more may relocate their basement utilities above selected flood levels, but most will content themselves with removing their fuse boxes and main electrical lines from the basement and other similarly selective measures. It is likely, for better or worse, that no one will flood proof his house to the extent which would have been likely had the work been done to Corps standards.

Midland, Michigan

At Midland, the benefit-cost ratio considerations constraining plan formulation were both more and less restrictive than at Prairie du Chien. They were more restrictive in the sense that the evacuation project was not even close to economic feasibility at current interest rates using

(1) At Peachtree and Nancy Creeks this was a major question and will be discussed later in regard to that project.

flood damage reduction benefits alone. The primary share of project benefits came from planned future recreation use of the acquired floodplain lands after the structures are removed. With the recreation benefits included, the benefit-cost ratio permitted acquisition and relocation of all improvements and persons within selected large parcels in the 100-year floodplain. On the other hand, the importance of future planned recreation uses affected the planning for flood damage reduction.

All of the floodplain parcels planned for acquisition in Midland are in larger contiguous units and will form parts of the various types of recreation areas planned for the evacuated land. Within these areas, all private parcels in the 100-year floodplain would be acquired. However, other properties within the 100-year floodplain are not contiguous with the planned recreation area and are not planned for project acquisition. To reduce flood damages, these properties could be included in the project to maintain consistency. The city, however, views these isolated parcels, which are surrounded by the holdings of large landholders such as Dow Chemical, as lesser problems to be solved by these other interests.

Because the city has access to non-Federal funds to implement a portion of the project, a new problem has been introduced in plan formulation, not only for the city but also for the Corps. With no Federal project in the implementation stage and no guarantee that there will ever be, the city is concerned with stretching its funds as far as possible. One means it is using is to buy only from persons who volunteer to leave the floodplain. In this way, it may be possible to avoid the costs of potential court condemnation suits, replacement housing payments, and allied moving costs. This approach could conflict with potential later participation in a Federal project which would include such payments. This method of acquisition might also be considered to conflict with Michigan law which requires similar benefits for persons whose residences are acquired by municipalities. Moreover, it introduces an undesired element of inequity

into the process. Persons volunteering to have their lands acquired under this approach would not receive any of the payments normally associated with public acquisition of private residential property, nor would they have significant latitude to negotiate a purchase price. Those interested in moving from the floodplain must face the difficult choice of selling out at current market prices or waiting for an uncertain future project which could give greater benefits.

Peachtree and Nancy Creeks, Georgia

A number of problems have emerged in the plan formulation of this study; several relating to flood proofing are among the most difficult.⁽¹⁾ To begin with, Georgia has legal restrictions against using public (State or local) funds to improve private property. Although not every State has identical laws, this principle is an important problem nationwide. If flood proofing measures reduce a structure's vulnerability to damages, the value of the structure has been enhanced. In such a case, how can a local sponsor in Georgia agree to cost share on flood proofing? Here the answer might be a special State law exempting the project from the general law if the project is implemented.

Assuming the legalities can be resolved, questions arise concerning which structures to flood proof and to what level of protection. As stated by South Atlantic Division in its 3 May 1978 letter: "Should a house subject to frequent flooding be raised to a 25-year, 50-year, or 100-year flood level? To be consistent with the flood insurance program, the 100-year flood level should be the criterion. Then, if you optimize a flood protection project at a 15-year flood level, you would raise (flood proof) the structures to the 100-year not 15-year level."

This position creates further questions for those structures between the 15-year and 100-year flood levels. Consistency dictates that those

(1) The following section paraphrases written comments provided by South Atlantic Division, 3 May 1978.

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structures should also be raised to the 100-year level for equity. However, in following this reasoning, no flexibility is allowed in plan formulation, because the entire 100-year floodplain must be flood proofed if any part of it were to be flood proofed.⁽¹⁾ Further, because flood proofing is usually feasible only at levels approximating the 10- to 15-year flood, if at all, this formulation criterion results in a project without a favorable benefit-cost ratio. The Peachtree-Nancy Creek project, formulated with the current combination of flood proofing and evacuation, has an estimated benefit-cost ratio of 1.00.

LOCAL ACCEPTANCE

General

Just as the impetus for improved water quality and sewage treatment plants stems from regional and national interests which essentially compel reluctant municipalities to upgrade their sewage treatment facilities, the drive for nonstructural flood damage reduction alternatives stems from national and regional rather than local interest. Compared to downstream interests, a municipality benefits relatively little from improving its sewage handling capabilities. Similarly, compared to the anticipated national benefits from most nonstructural alternatives, the individual community usually perceives that it pays most of the costs and receives few of the benefits.

Some community representatives believe that floodplain zoning and the Federal insurance program work to deny a community the right to develop portions of its land with possible lost population, jobs, and business. Local officials and residents may not appreciate the effect these measures have on reducing future flood damages.

Floodplain evacuation works like an accelerated program of floodplain zoning to remove or destroy existing floodplain developments, again essentially denying that land to the types of potential future

(1) The dilemma of forcing flood proofing measures on unwilling property owners is evident here as it was at Prairie du Chien.

development preferred by many local interests. It provides the land for a future park or other recreation area, but also removes the property from the tax rolls. Not all of the displaced residents will relocate in the same community, with the result that the town pays some of its inhabitants to move away.

Flood proofing provides for enhanced or intensified use of floodplain lands, and therefore meets with greater acceptance from the total community for economic reasons. On the other hand, some residents fear the unknown aesthetic effects on their properties and neighborhoods.

In contrast, structural measures may enhance the value of community floodplain property. In the case of a reservoir with widespread benefits, this increase in a community's land values could come with little or no direct financial cost to the community. Similarly, increased floodplain land values may accrue when smaller reservoirs, levees, or channel modifications reduce the degree of flooding in a community. Even in those local protection projects, where the non-Federal sponsor bears significant local costs, the costs are only a part of total costs and are generally less than the local benefits. With the perceived benefits received for relatively minimal local costs, local interests usually prefer structural flood control measures.

Floodplain communities tend to reject nonstructural flood damage reduction alternatives which concentrate on floodplain evacuation or floodplain zoning in favor of structural options because they question the benefits in relation to the costs to the community of denying future intensive use of their floodplains. Those few communities which have embraced projects featuring significant nonstructural measures have done so for reasons other than their economic preferences.

The question of attitudes of floodplain property owners toward nonstructural versus structural solutions is distinct from the attitude of the community. In virtually all cases, immediately affected floodplain

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residents and other property owners reject the prospect of floodplain evacuation, flood proofing, or floodplain zoning. To these people, the choice is clear - a structural project will protect them from floods and allow them to continue living their chosen life style in the location they have selected. The financial costs of a structural project may or may not be greater to them or their communities than a nonstructural alternative, whereas the social costs are generally much less.

In this way, one of the features peculiar to nonstructural alternatives (that is, the social costs are borne primarily by the beneficiaries) makes them appealing from the national and regional standpoint but discourages a strong demand for nonstructural projects. Because the system of project conception and implementation primarily depends on support from local benefited interests, the lack of assistance by affected communities bodes ill for future nonstructural projects. Floodplain residents and businessmen will not press to restrict their control over their properties or have themselves moved from their properties when they can urge such costs to be imposed on others (such as the classic example of upstream farmers displaced for a flood control reservoir to benefit a downstream community).

Prairie du Chien, Wisconsin

In Prairie du Chien, a floodplain evacuation plan was acceptable to the local community only because:

1. No structural alternative was viable.
2. The flood problem at the time of project formulation and in the years just preceding postauthorization planning was especially severe, predisposing affected individuals to accept any reasonable solution.
3. A strong chance of obtaining financial assistance from other Federal sources to pay part of the non-Federal share of project costs existed.

If any of these three conditions had not been present, Prairie du Chien probably would not have accepted the floodplain evacuation plan.

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proofing plan that is now being implemented. Even so, some residents of the evacuation zone are opposed to mandatory evacuation, primarily those few at significantly higher elevations than their neighbors. Similarly, many residents outside the floodplain oppose apparently direct payments to improve only the well-being of floodplain inhabitants. If mandatory evacuation had been pressed at notably higher levels of protection, in accord with levels commonly sought for structural projects, local acceptance would have been outweighed by the resistance of those at higher levels in the floodplain who would be unwilling to be legally removed from their homes for perceptibly less reason than their lower neighbors. Mandatory flood proofing would also have been resisted by a number of higher level floodplain property owners, though probably fewer than would oppose evacuation. In sum, even for a community exceptionally adapted to an evacuation alternative, a fine line separated local acceptance from rejection.

Baytown, Texas

In this coastal region afflicted with deep subsidence, the flood problems are so severe that the flood victims are willing to consider any practical solution. Aware that the subsidence will continue and that structural measures will not provide a solution, floodplain residents are generally willing to accept total evacuation as the best answer to their deteriorating situation. However, the rest of the community must help fund the proposed project and may or may not be willing to undertake the local financial burden, now estimated at about \$7 million. The larger community perceives few benefits to itself from the proposed evacuation project even though it is sympathetic to those unfortunate enough to live in the sinking floodplain.

Peachtree and Nancy Creeks, Georgia

The floodplains along these creeks have not suffered severe flooding in recent history, a factor which complicates acceptance by local residents of any plan calling for removal from their homes or major alterations to their properties. This area is one of the most attractive in the greater Atlanta metropolitan region and possesses some of the nicest homes, which tend to directly border on the creeks. The well-to-do residents of these areas are politically knowledgeable; some have organized to oppose mandatory evacuation or flood proofing of their expensive homes.

This photograph shows flooding along Peachtree Creek in Atlanta, Georgia, in 1976. The houses, extensive tree cover, and general aspects of the neighborhood reveal the high quality of this area despite the flood threat. In recent decades, the Peachtree and Nancy Creeks watershed has not been flooded to a level greater than would a 10-year flood. With this flood history, it is small wonder that the owners of the fine properties in the center of the picture are unwilling to be removed from their homes or have their houses altered by flood proofing. They know that there has been no flood comparable to the 100-year flood in the recorded past and that such a flood may not occur in their lives. Thus, many floodplain property owners resist the relatively drastic changes in their lives called for by the proposed project.

In similar floodplains around the country, where the quality of properties means high flood damages and a possible benefit-cost ratio greater than unity, that same quality of housing will make residents cherish it more and resist widespread evacuation or flood proofing. In these cases, residents will naturally press for structural measures that will not affect their life-styles in preference to nonstructural measures that will.

(Photograph courtesy of South Atlantic Division)



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An early version of the proposed project called for the evacuation of only a few structures and flood proofing of the rest. Reaction at a public meeting to discuss the plan suggested that many residents would oppose flood proofing of some homes because of appearance and other factors. It was suggested at this meeting that 8 feet above grade be used as the criterion for the maximum raise; the project was modified accordingly. As a result, the number of properties planned for evacuation increased to more than 200 (from the area which would require more than 8-foot raises). New opposition was aroused from those now scheduled for mandatory removal. With substantial opposition from organized groups within the project area and a local price tag approximating \$10 million, local acceptance of this project is questionable.

ECONOMIC FEASIBILITY

Numerous analyses performed by Districts around the country have demonstrated that, using traditional economic analyses and current methods for benefit-cost ratio computations, only a limited number of potential project sites will have economic feasibility for flood proofing or evacuation projects at levels of protection normally proposed for urban areas. A somewhat larger, but still small, number of project sites will possess benefit-cost ratios greater than unity at very low levels of protection.

The Hydrologic Engineering Center, in a study of the technical aspects of nonstructural alternatives, concluded that economic feasibility for evacuation or flood proofing alternatives might be demonstrated at the 10- to 15-year level of protection, where detailed analysis is warranted.⁽¹⁾ This study also revealed that detailed backup analytical data explaining why nonstructural measures for most potential projects were rejected are generally not available from published project reports.⁽²⁾

(1) The Hydrologic Engineering Center, "Estimating Costs and Benefits for Nonstructural Flood Control Measures," October 1975.

(2) 17 May 1978 letter from the Hydrologic Engineering Center to St. Paul District.

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Despite the lack of data on the many clearly infeasible nonstructural projects, the 10- to 15-year level of protection corresponds well to the experience of St. Paul District in its nonstructural analyses and information gained from other Districts with similar experience. It is debatable whether projects formulated to the 10- to 15-year level of protection provide a significant solution to the flood problems of most communities.

One reason nonstructural projects seldom show economic feasibility was stated by a participant at a September 1978 meeting in Chicago concerning nonstructural alternatives. In the case of evacuation, the entire property must be acquired to protect only that portion of the property which is subject to flood damages. In essence, existing and relatively intensive (and damage prone) use of a floodplain may not be the highest and best use of the land, but it may produce a net economic income. Evacuation, with conversion of acquired land to open-space parkland, actually creates a lower and less economically efficient use of the floodplain. This excludes certain environmental, social, and aesthetic benefits.

Flood proofing is often economically infeasible primarily because it involves modifying existing structures, a process which is always less efficient than when flood proofing is accomplished as a part of the original construction. Nevertheless, flood proofing is clearly less expensive than permanent evacuation and preserves the existing use of the floodplain with reduced flood damages. Despite the technical uncertainties about the effectiveness of flood proofing, flood proofing has better prospects for economic feasibility than does floodplain evacuation.

Those instances where floodplain evacuation or flood proofing is most economically feasible are in areas having a serious misallocation of resources. These situations occur in flood prone regions mainly under the following conditions:

1. Ignorance of an area's true potential flood threat. This lack of knowledge could arise from lack of available information on flood history or a statistically unusual recent flood record.

2. Unexpected changes in an area's hydrology which can result from such things as upstream urbanization or ground subsidence.

3. A comparative low income level which induces people with little capital resources and shortened time horizons to invest in floodplains because it is cheaper in the short term even though it may be more costly in the longer term.

Of the project sites reviewed for this study, Peachtree and Nancy Creeks seem to fit into category 1; Baytown fits into category 2, and Prairie du Chien and Midland fit into category 3.

The lack of economic feasibility as determined by the benefit-cost ratio applied to water resources projects is the critical factor in preventing Federal participation in the development and implementation of nonstructural projects. Economic feasibility problems stem from high purchase costs which are site specific to the damaged units benefited. When structures are removed from the floodplain, fair market values for land and structures become project costs. These existing floodplain values for land and structures when annualized over the life of a flood damage reduction project will usually be greater than the average annual reduction in flood damages.

The frequency of flooding, location of structures in the floodplain, and values of structures determine how close to feasibility an evacuation alternative may be. Using typical depth-damage relationships data (figure 1),⁽¹⁾ and a generalized elevation-frequency curve (figure 2), a

(1) Similar relationships are used throughout the Corps and by other water resource agencies.

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typical pattern of expected average annual damages follows. These variables acting together are shown graphically on figures 3 and 4, respectively. Two residential structures, one valued at \$15,000 and the other at \$50,000 have been assumed to be located at the 10-, 20-, 50-, and 100-year ground elevations. Table 2 uses this relationship for a 1-acre hypothetical evacuation project. In an actual project area a diversity of structures (location, value, unique design) conceals the surplus or deficit in flood damage reduction benefits which each individual residential unit contributes. In the simplified example, homogeneous units compared with typified costs adequately demonstrate that the economic break-even point will generally occur near the 15-year flood elevation (table 3). More expensive houses are more easily justified, particularly if below the 20-year flood elevation, and if relocated rather than demolished. Relocation retains or restores intrinsic values. If a house is structurally unsound or cannot be physically moved, economic feasibility can be improved by salvaging materials. To a lesser degree, some of the existing value of flood-plain property is thereby retained.

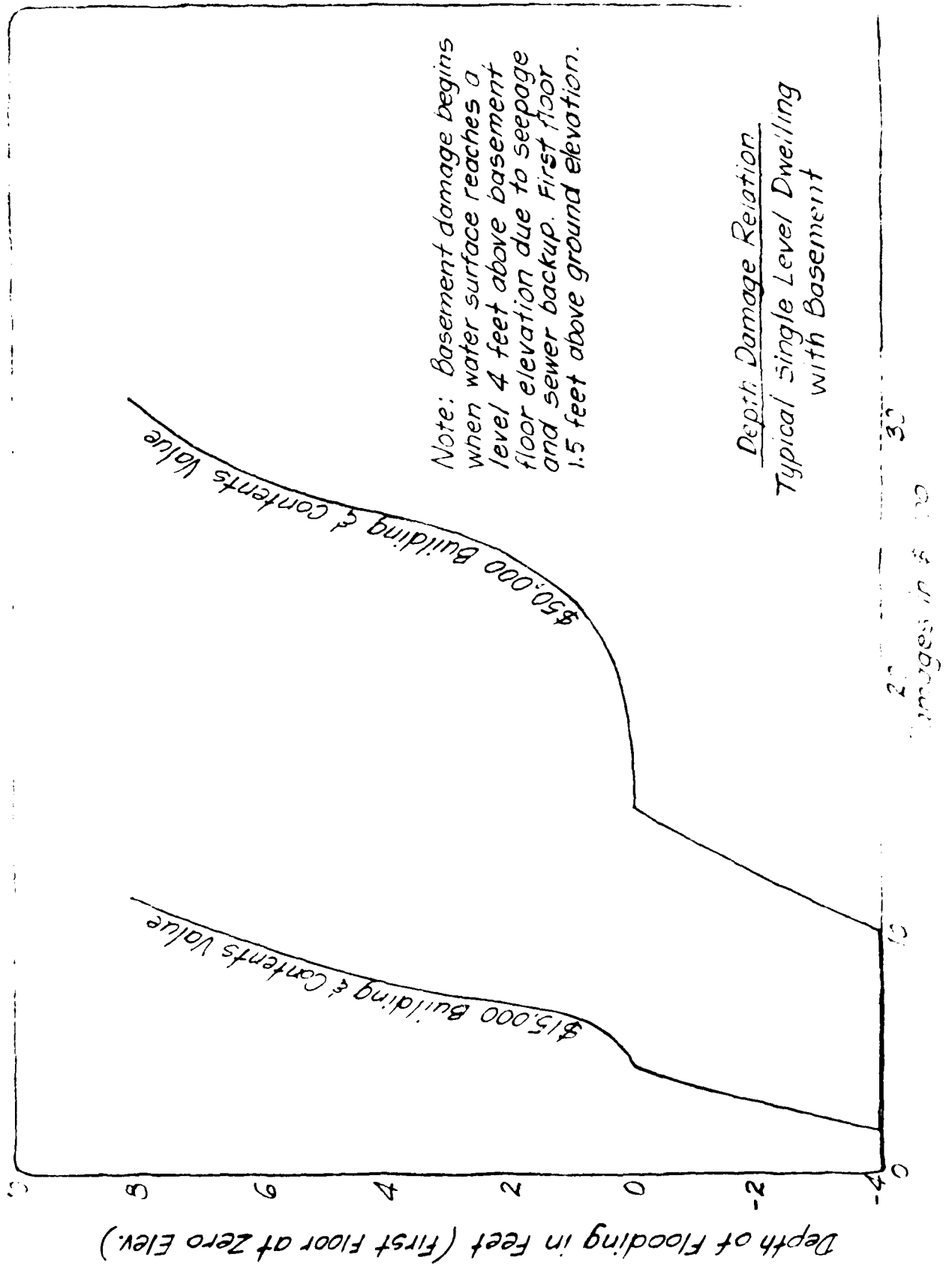
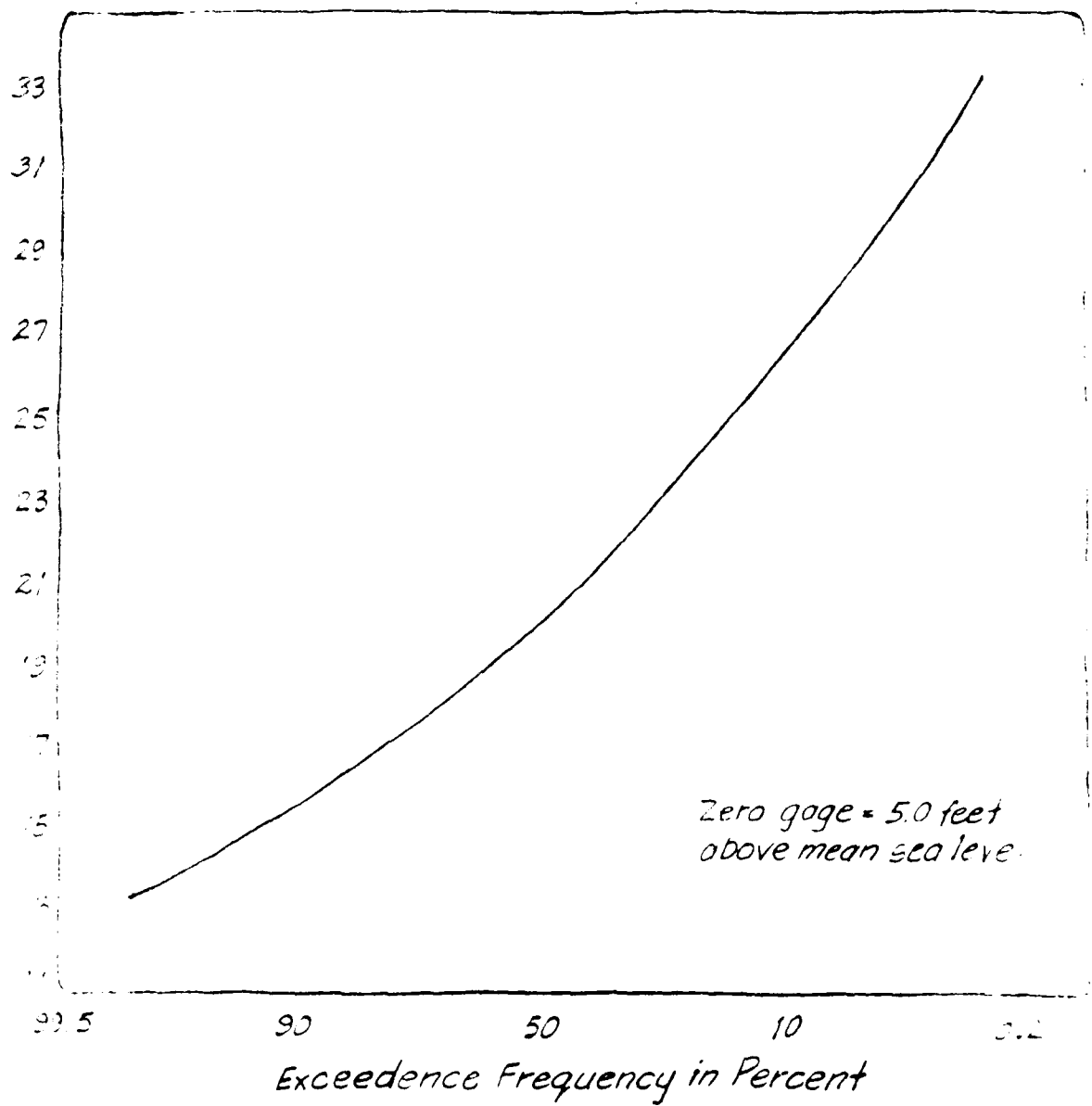


Figure 1



Flood River at
Floodplain, U.S.A.
Elevation-Frequency Curve

Flood River at Floodplain, U.S.A.
 Expected average annual flood damages
 for \$15,000-value house (with basement)
 located with first floor $1\frac{1}{2}$ feet above
 the specified flood level.

<u>Flood level</u>	<u>Average Annual Damages</u>
10-Year	\$620
20-Year	320
50-Year	110
100-Year	30

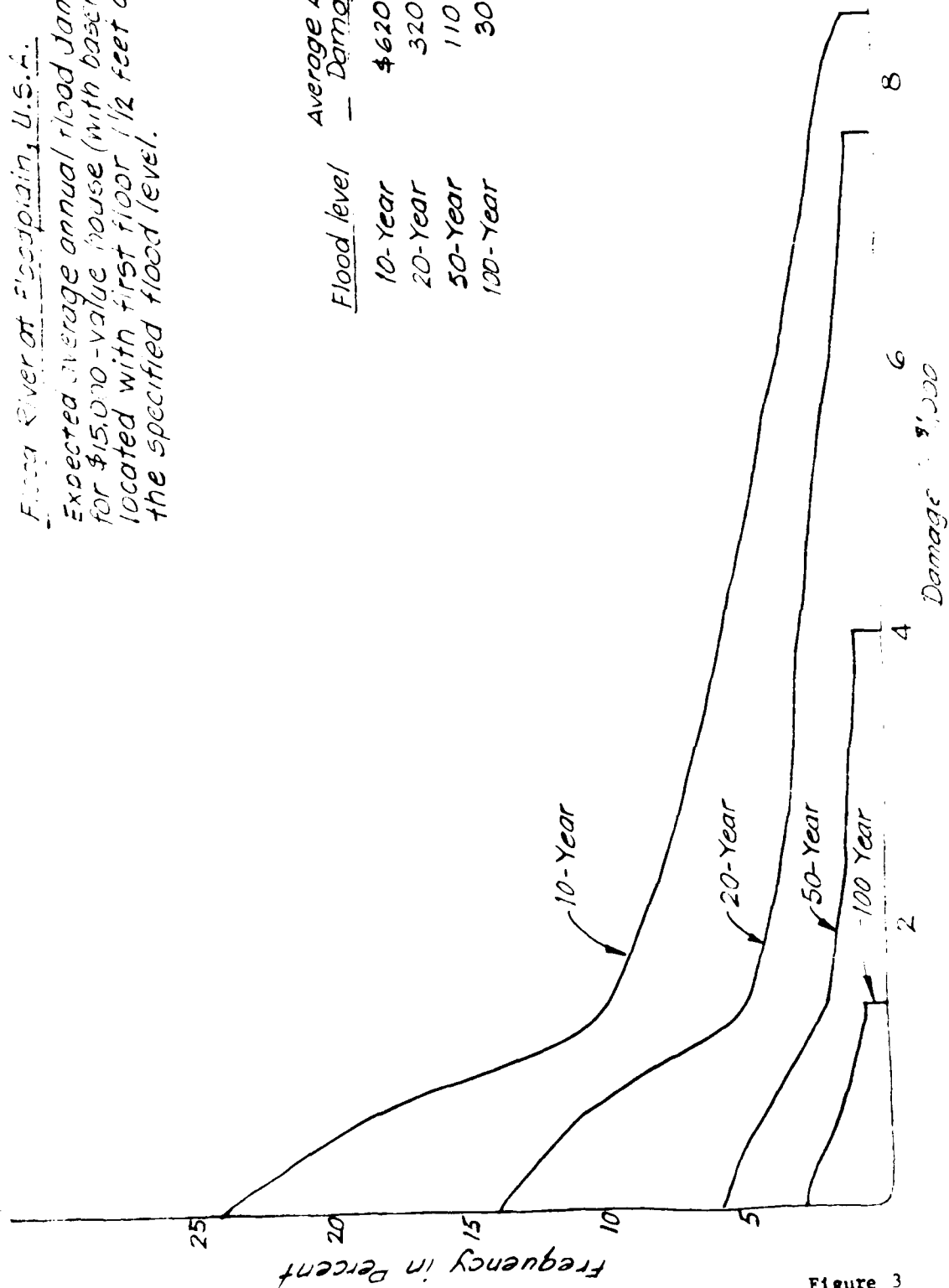


Figure 3

Flood River at Floodplain, U.S.A.
 Expected average annual flood
 damages for \$50,000 value house
 (with basement) located with first
 floor 1½ feet above the specified
 flood level.

<u>Flood level</u>	<u>Average Annual Damages</u>
10-Year	\$2,600
20-Year	1,390
50-Year	540
100-Year	190

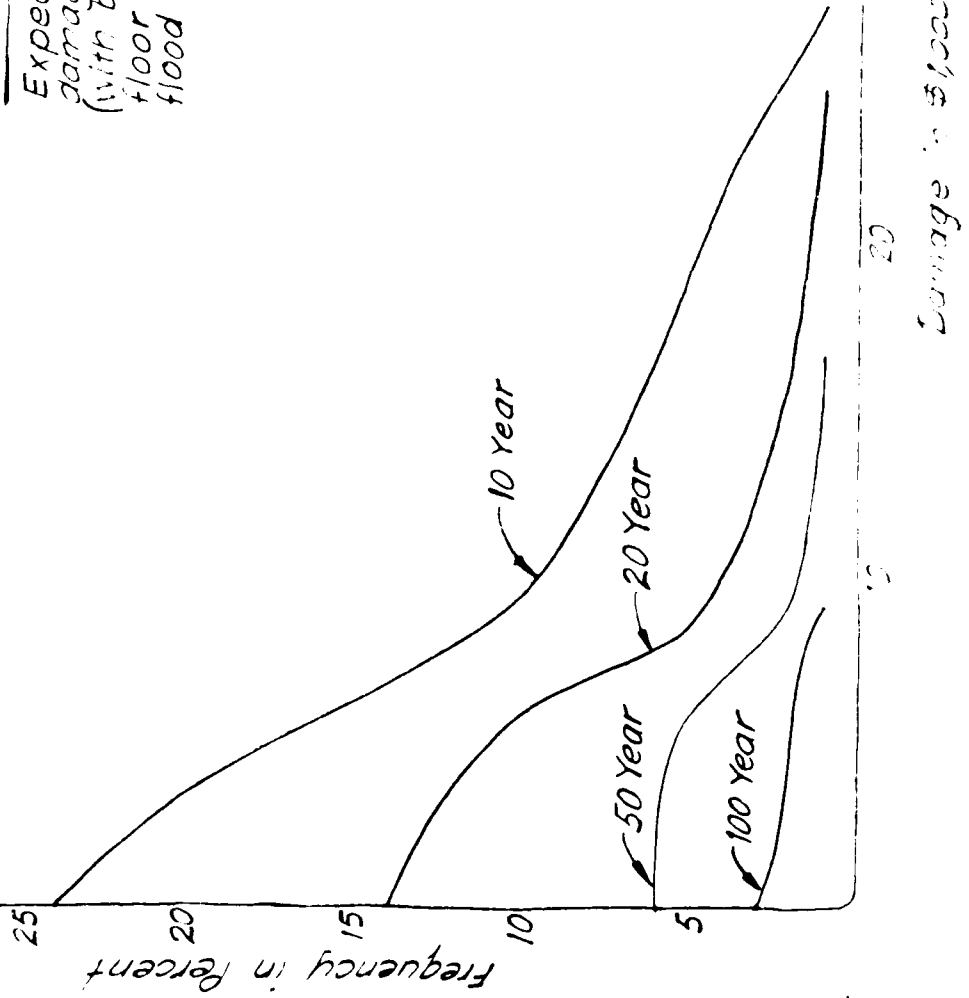


Figure 4

Table 2. χ^2 correlation coefficients for 1994-2003 to residential nonstructural evacuation. 1-acre plot

Item	Permanent evaluation of current uses and structures in the flood-free site			Permanent evaluation of current uses and structures relocated to another site		
	First cost	Average annual benefit	Present worth (1)	First cost	Average annual benefit	Present worth (1)
NED Costs						
Acquisition of lands in the floodplain	\$12,900	-	\$12,900	\$13,000 value structures (6 units on area)	\$30,000 value structures (14 units on area)	\$13,000
Acquisition of structures in the floodplain	90,000	-	90,000	200,000	-	200,000
Removal of structures	40,000	-	40,000	40,000	-	40,000
Net market salvage value	-27,000	-	-27,000	20,000	-	20,000
Conversion of vacated land to new use	2,000	-	2,000	40,000	-	40,000
Total	\$87,900	\$5,000	\$82,900	\$248,000	\$14,000	\$234,000
NED benefits						
Reduction of externalized flood damages (4)	67,000	4,800	62,200	67,000	4,800	62,200
10-year level of protection	34,000	2,500	31,500	34,000	2,500	31,500
20-year level of protection	13,000	900	12,100	13,000	900	12,100
50-year level of protection	4,000	300	3,700	4,000	300	3,700
100-year level of protection	-	-	-	-	-	-
New use of floodplain (5)	-	Ad as applicable	-	130,000	9,300	120,700
All others	-	Ad as applicable	-	-	Ad as applicable	-

- (1) Current price and a 7/8-10-15 interest rate.
- (2) Engineering and operating and time ratios are included.
- (3) Includes average increase for all new, four or six and 50-year projects.
- (4) Includes all of the savings and the average additional ratio in cost, exclusive of all sliding damage, a 10-15-20-25-30-35-40-45-50-55-60-65-70-75-80-85-90-95-100-105-110-115-120-125-130-135-140-145-150-155-160-165-170-175-180-185-190-195-200-205-210-215-220-225-230-235-240-245-250-255-260-265-270-275-280-285-290-295-300-305-310-315-320-325-330-335-340-345-350-355-360-365-370-375-380-385-390-395-400-405-410-415-420-425-430-435-440-445-450-455-460-465-470-475-480-485-490-495-500-505-510-515-520-525-530-535-540-545-550-555-560-565-570-575-580-585-590-595-600-605-610-615-620-625-630-635-640-645-650-655-660-665-670-675-680-685-690-695-700-705-710-715-720-725-730-735-740-745-750-755-760-765-770-775-780-785-790-795-800-805-810-815-820-825-830-835-840-845-850-855-860-865-870-875-880-885-890-895-900-905-910-915-920-925-930-935-940-945-950-955-960-965-970-975-980-985-990-995-1000-1005-1010-1015-1020-1025-1030-1035-1040-1045-1050-1055-1060-1065-1070-1075-1080-1085-1090-1095-1100-1105-1110-1115-1120-1125-1130-1135-1140-1145-1150-1155-1160-1165-1170-1175-1180-1185-1190-1195-1200-1205-1210-1215-1220-1225-1230-1235-1240-1245-1250-1255-1260-1265-1270-1275-1280-1285-1290-1295-1300-1305-1310-1315-1320-1325-1330-1335-1340-1345-1350-1355-1360-1365-1370-1375-1380-1385-1390-1395-1400-1405-1410-1415-1420-1425-1430-1435-1440-1445-1450-1455-1460-1465-1470-1475-1480-1485-1490-1495-1500-1505-1510-1515-1520-1525-1530-1535-1540-1545-1550-1555-1560-1565-1570-1575-1580-1585-1590-1595-1600-1605-1610-1615-1620-1625-1630-1635-1640-1645-1650-1655-1660-1665-1670-1675-1680-1685-1690-1695-1700-1705-1710-1715-1720-1725-1730-1735-1740-1745-1750-1755-1760-1765-1770-1775-1780-1785-1790-1795-1800-1805-1810-1815-1820-1825-1830-1835-1840-1845-1850-1855-1860-1865-1870-1875-1880-1885-1890-1895-1900-1905-1910-1915-1920-1925-1930-1935-1940-1945-1950-1955-1960-1965-1970-1975-1980-1985-1990-1995-2000-2005-2010-2015-2020-2025-2030-2035-2040-2045-2050-2055-2060-2065-2070-2075-2080-2085-2090-2095-2100-2105-2110-2115-2120-2125-2130-2135-2140-2145-2150-2155-2160-2165-2170-2175-2180-2185-2190-2195-2200-2205-2210-2215-2220-2225-2230-2235-2240-2245-2250-2255-2260-2265-2270-2275-2280-2285-2290-2295-2300-2305-2310-2315-2320-2325-2330-2335-2340-2345-2350-2355-2360-2365-2370-2375-2380-2385-2390-2395-2400-2405-2410-2415-2420-2425-2430-2435-2440-2445-2450-2455-2460-2465-2470-2475-2480-2485-2490-2495-2500-2505-2510-2515-2520-2525-2530-2535-2540-2545-2550-2555-2560-2565-2570-2575-2580-2585-2590-2595-2600-2605-2610-2615-2620-2625-2630-2635-2640-2645-2650-2655-2660-2665-2670-2675-2680-2685-2690-2695-2700-2705-2710-2715-2720-2725-2730-2735-2740-2745-2750-2755-2760-2765-2770-2775-2780-2785-2790-2795-2800-2805-2810-2815-2820-2825-2830-2835-2840-2845-2850-2855-2860-2865-2870-2875-2880-2885-2890-2895-2900-2905-2910-2915-2920-2925-2930-2935-2940-2945-2950-2955-2960-2965-2970-2975-2980-2985-2990-2995-3000-3005-3010-3015-3020-3025-3030-3035-3040-3045-3050-3055-3060-3065-3070-3075-3080-3085-3090-3095-3100-3105-3110-3115-3120-3125-3130-3135-3140-3145-3150-3155-3160-3165-3170-3175-3180-3185-3190-3195-3200-3205-3210-3215-3220-3225-3230-3235-3240-3245-3250-3255-3260-3265-3270-3275-3280-3285-3290-3295-3300-3305-3310-3315-3320-3325-3330-3335-3340-3345-3350-3355-3360-3365-3370-3375-3380-3385-3390-3395-3400-3405-3410-3415-3420-3425-3430-3435-3440-3445-3450-3455-3460-3465-3470-3475-3480-3485-3490-3495-3500-3505-3510-3515-3520-3525-3530-3535-3540-3545-3550-3555-3560-3565-3570-3575-3580-3585-3590-3595-3600-3605-3610-3615-3620-3625-3630-3635-3640-3645-3650-3655-3660-3665-3670-3675-3680-3685-3690-3695-3700-3705-3710-3715-3720-3725-3730-3735-3740-3745-3750-3755-3760-3765-3770-3775-3780-3785-3790-3795-3800-3805-3810-3815-3820-3825-3830-3835-3840-3845-3850-3855-3860-3865-3870-3875-3880-3885-3890-3895-3900-3905-3910-3915-3920-3925-3930-3935-3940-3945-3950-3955-3960-3965-3970-3975-3980-3985-3990-3995-4000-4005-4010-4015-4020-4025-4030-4035-4040-4045-4050-4055-4060-4065-4070-4075-4080-4085-4090-4095-4100-4105-4110-4115-4120-4125-4130-4135-4140-4145-4150-4155-4160-4165-4170-4175-4180-4185-4190-4195-4200-4205-4210-4215-4220-4

Table 3. Results of floodplain studies for the 1950-55 period (1)

Level of protection (2)	\$15,000 structures		\$50,000 structures		Relocation with relocation to new site (3)		Average annual net benefits
	Benefit- cost ratio	Benefit- cost ratio	Benefit- cost ratio	Benefit- cost ratio	Benefit- cost ratio	Benefit- cost ratio	
10-year	0.77	-51,400	0.33	-11,400	0.65	-5,200	+7,100
20-year	0.40	-3,700	0.09	-1,000	0.80	-3,000	+900
50-year	0.15	-5,300	0.23	-4,000	0.69	-4,600	-3,500
100-year	0.05	-5,900	0.08	-11,400	0.65	-5,200	-5,400

- (1) Benefits for reuse of the floodplain and the other unique categories are additives for specific projects.
 (2) Structures demolished.
 (3) Structures resold after relocation.
 (4) Ground elevation surrounding structures.

A remaining significant source for major project benefits stems from the useful purpose to which vacated floodplain land may be dedicated. Land used for open space or general recreation will generally provide only limited project benefits. Inasmuch as economic feasibility based on flood damage reduction is usually marginal, significant benefits from the floodplain land in a new use may be critical to a favorable benefit-cost ratio. The principle involved is the maintenance or restoration of economic values while still conforming with good floodplain management practices.

In summary, evacuation and relocation project economics can be improved by:

1. Relocating and restoring structure value at a new flood-free site.
2. Decreasing project costs by salvaging materials from demolished structures.
3. Developing the highest compatible economic use for the floodplain.

DISCUSSION AND CONCLUSIONS

GENERAL

Very few Corps nonstructural flood control projects are in place, under development, or being studied. This lack of nonstructural projects appears to be inconsistent with statements made by the President and the Chief of Engineers to fully consider and emphasize nonstructural solutions to the problems of flood prone communities. Many people infer from this inconsistency that the Corps and other agencies can implement nonstructural projects but are unwilling to do so. This inconsistency results in criticism from many quarters that the Corps is laggard in its implementation of the presidential directive. However, when current policies and procedures are followed in an attempt to comply with that directive, the ultimate result is either large numbers of token analyses of nonstructural alternatives or much wasted effort in producing details of infeasible plans.

In recent years, the Corps has tried to make the consideration of nonstructural alternatives equal to that provided for structural measures. This goal is highly desirable in many ways, but under current procedures, it has resulted in a few Corps implemented nonstructural projects. Current policy obscures key differences between the two approaches: structural alternatives are flood control measures with most costs and benefits measurable in monetary terms; nonstructural measures are flood damage control measures with often distinctly different inputs and outputs.

Over several decades, the consideration of Corps reservoirs as single-purpose flood control structures has evolved into today's multipurpose projects which produce hydropower, water supply, recreation, and irrigation benefits as well as flood control. Nonstructural measures have been formulated almost exclusively for flood damage reduction. Yet, because these nonstructural measures alter land use

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in developed urban areas, they offer the potential of redesigning the floodplain toward an optimum mix of environmental, aesthetic, and economic purposes. Given the opportunity made possible by extensive floodplain acquisition, nonstructural projects need to attain the same maturity shown by multipurpose reservoirs and meet needs beyond those of flood damage reduction.

These considerations, treated in greater detail in the following pages, result in the conclusions outlined below:

CONCLUSION 1 - ECONOMIC ANALYSIS: Many benefits of flood damage reduction projects, especially those which cause people to advocate nonstructural alternatives, are not included in benefit-cost ratios.

CONCLUSION 2 - DISASTER RESPONSE CAPABILITY: The optimum time to acquire property in flood prone areas is immediately after a damaging flood.

CONCLUSION 3 - CHANGE IN PLANNING CRITERIA: Although desirable, it is nearly impossible to consider and determine the fate of individual structures in the planning stage of a major Federal project.

CONCLUSION 4 - OPTIMUM FLOODPLAIN USE: Most nonstructural planning considers abandoning floodplains as major economic resources.

CONCLUSION 5 - AWARENESS OF NONSTRUCTURAL LIMITATIONS: A significant lack of knowledge exists among water resource planners and the general public regarding the characteristics of nonstructural alternatives, especially flood proofing and floodplain evacuation.

ECONOMIC ANALYSIS

Project economic analysis should recognize that many of the benefits of flood proofing and floodplain evacuation are national and regional and do not meet goals intrinsic to the project site or specific project. Precedent exists in current regulations for excluding various project costs from the economic analysis of a given project. The most important exclusion for evacuation projects has been the deletion of replacement housing payments made in accordance with the Uniform Relocation Assistance and Real Properties Acquisition Act of 1970 (Public Law 91-646). Up to \$15,000 in project costs for each displaced resident homeowner is considered a financial cost to be paid, but not an economic cost charged to the project benefit-cost ratio. Although this exclusion of cost from the benefit-cost ratio applies to all projects, it is particularly important for floodplain evacuation projects since real estate costs are such a large part of total project costs.

Exclusion of the above costs from the benefit-cost ratio has been Corps policy for several years and has been restated recently for continued applicability to floodplain evacuation projects in ER 1105-2-353. Other precedent for cost exclusion is found in ER 1105-2-117, "Responsibility for Costs of Improved Standards in Highways and Housing Relocations," which deals with costs associated with highway betterments as well as replacement housing payments. Highway betterments are considered to benefit people outside the project area because they provide safety and other benefits that are difficult to quantify, the benefits are assumed to be at least equal to the costs. Therefore, the costs and benefits are excluded from the benefit-cost ratio.

Many outputs associated with civil works projects have not been and cannot be quantified at this time. Some of these outputs are beneficial; others are detrimental. Only those outputs which can be

quantified and put into monetary terms are included in the benefit-cost analysis. The justification for excluding the specific costs noted above is that the authorization for spending funds for those purposes is in laws not relating to specific projects or, in the case of Public Law 91-646, not relating in any special manner to water resources development. The judgment of the Nation, expressed through Congress, is that these benefits are worth the costs.

Each year, the Federal budget includes large sums spent to achieve a wide variety of goals - money spent without any benefit-cost analysis, but whose benefits are deemed worthy of the costs incurred. Water resource projects, particularly those including nonstructural measures, produce various outputs identical to those sought by other separately funded national programs not constrained by benefit-cost analysis. These projects should have costs allocable to these purposes separately identified and excluded from the benefit-cost ratio. The benefit-cost ratio should measure only monetary inputs in regard to monetary outputs.

If adopted, such a principle should apply to all water resource projects, structural as well as nonstructural. Many features of structural projects are included for reasons of human safety, aesthetics, or other desirable purposes. The costs of these features should not be included in the evaluation of a project that would be economically efficient if it were formulated only for the national economic development objective. The classic example of noneconomic considerations lowering the benefit-cost ratio of structural projects is the policy to increase the level of protection to that of the standard project flood or some other extremely low frequency event. Of course, these increases may be made for very valid policy reasons, such as human safety. Nevertheless, the economic analyses could state that a given project has a benefit-cost ratio optimized by engineering at, say,

1.9 and note that a benefit-cost ratio of 1.1 results only after various noneconomic decisions have added more to project monetary costs than benefits.

The impact of this change in calculating benefit-cost ratios could be very significant for structural projects. For nonstructural projects, which are pursued primarily for noneconomic reasons relating to national environmental and social well-being goals, the effects would be far more profound. At Peachtree and Nancy Creeks, for example, logical reasoning extended a design level of flood proofing from the 15-year floodplain to the 100-year regulatory floodplain to provide for social equity and compatibility with the national flood insurance program. However, the true benefit-cost ratio lies at the 15-year economic optimum. Social and other non-monetary considerations which increase water resource project costs should not distort the benefit-cost ratio of a project.

Recent events in the Kickapoo River valley of Wisconsin provide a prominent example of how a variety of social goals promoted by several Federal and State programs could have been achieved by a multipurpose water resources project evaluated in this way. Once the La Farge Dam project appeared to have been stopped, residents of this valley were still faced with major flood problems. Communities were also declining economically because of these flood problems, as well as for other reasons.

The major flood of 1978 focused renewed attention on this region. The village of Soldiers Grove was able to capitalize on that attention and received grants from several different Federal agencies for rebuilding the community outside the floodplain. The funds provided by these Federal agencies were not limited or even related to purposes producing a favorable economic benefit-cost ratio, yet they were given

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With the full support of Wisconsin's political representatives and, no doubt, other national leaders. Each grant is focused on achieving the goals of a given agency and, collectively, the grants do not provide a complete solution to the problem. Under the proper authority and procedures, one agency could have worked to implement a single, coordinated and comprehensive plan that would have produced better results.

Contrary to the expectations of many, a change in benefit-cost analysis would not result in an unlimited demand on the Federal Treasury, either for structural or nonstructural projects. If current cost-sharing procedures are followed, local interests will have to contribute significantly to proposed projects. Unlike many other Federal programs, this cost sharing feature will serve to limit projects and the flow of Federal dollars to areas where the local desire is strong enough to pay some of the cost. For nonstructural projects in particular, this change in accounting would not result in a vast number of projects because most local communities do not perceive these projects to be especially in their interest as currently formulated. However, such a change in economic analysis would be necessary to permit more widespread Federal participation where these projects are truly wanted.

Altering one side of the benefit-cost ratio would increase the number of potential projects which survive the agency screening process. However, the ultimate decision on which projects, and how many, receive funding would still rest with the Congress and the President.

Many attempts have been made to quantify into monetary terms the so-called intangible benefits and costs associated with environmental, aesthetic, and social well-being impacts. Several different systems to quantify these impacts exist; some are in limited use by

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certain agencies. The major defect in all of these systems is that each is subject to judgmental determinations which can vary significantly from person to person and agency to agency. Thus, none of these systems has universal or even widespread acceptance.

By following the established principle of acknowledging the responsibility of the Nation's political leaders to adjudicate matters of opinion not susceptible to factual analysis by experts, the modified evaluation would result in resolving the national interest in these projects at the political rather than the bureaucratic level. Systematic analysis by the responsible agency would still be critical, but the decisions on intangibles would be made by those elected to make these decisions.

DISASTER RESPONSE CAPABILITY

To aid in the implementation of certain nonstructural alternatives, the Corps should be provided with continuing authority to move quickly after disastrous floods to acquire severely damaged structures and remove them from the floodplain. For several decades, various emergency authorities have encouraged private reconstruction in high flood hazard zones. This situation is changing. Still, no effective mechanism exists to acquire and remove floodplain structures at the moment when such removal would be most painless and most welcomed by the individuals and communities concerned. Authority is needed for the Corps to rapidly select and acquire rational units of heavily damaged properties that are in, say, the 15-year floodplain. An acquisition plan of this type could be subject to the approval and cost-sharing of the local community just as other projects are. The key, however, is speed of response. Delays of more than 1 or 2 months might be too long.

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Rochester, Minnesota, was the site of severe flooding in July 1978. It is an example of a location that could have made excellent use of a continuing authority to acquire damaged floodplain properties. A Corps channel and levee project is planned for the city and some of the damaged properties were likely candidates for eventual acquisition during its construction. The city and some of the affected residents considered local acquisition of some properties immediately after the flood, hoping that the acquisition could be included as part of their cost-sharing in the larger project. When the Corps could not give any such assurances, forcing the acquisition to be a totally local expense, enthusiasm cooled and only a few properties were acquired. If an ongoing program had existed, the city could have cost-shared with the Corps to remove some of the most flood vulnerable properties that are now being rebuilt. Similar events take place at various locations around the country each year.

Such a program could be implemented through the Corps or under the direction of an umbrella Federal disaster organization. In either case, its application would be most suitable in floodplains where the Corps has acquired significant knowledge of the area through past or current studies and projects. ⁽¹⁾ No other agency possesses:

1. The demonstrated ability to react swiftly in times of disaster.
2. The hydrologic and planning expertise to quickly determine sensible acquisition limits.

(1) Missouri River Division suggested a similar authority. The following is a quote from an inclosure to its 12 December 1978 letter to St. Paul District: "The emergency authority suggested could be expanded in concept, entitled 'continuing authority', and identified as another option. This option in concept, would authorize the development, in cooperation with local interests, of a long term plan for the ultimate solution of the flood damage problem. Nonstructural elements of the plan such as flood proofing and permanent removal of flood plain structures would be specified. Whenever specified structures are placed on the market by the owner or damaged by floods, the Corps would be authorized to participate with the local sponsor in the acquisition of the property and implementation of the removal, relocation, or flood proofing as specified in the plan. Other components of the plan would include emergency evacuation and flood plain zoning."

3. The real estate capability to proceed with rapid acquisition as desired.

The above discussion focused on Corps implementation of flood proofing and evacuation as now formulated. The recommendation based on these points is aimed at improving the chances for Federal participation in projects where these alternatives are deemed in the national interest.

CHANGE IN PLANNING CRITERIA

Nonstructural alternatives as now planned are designed to return developed floodplains to a relative "state of nature." A natural floodplain possesses a minimal economic value. Therefore, most communities eligible for nonstructural alternatives will not seek such projects unless they have no other choice. The following discussion is focused on increasing the use of floodplains as an economic resource. Floodplains form important parts of many communities and the Corps should use its engineering talents and expertise to encourage the optimum use of these valuable resources. The current national attention on eliminating human improvements within the floodplain needs to be balanced by the recognition that men can and do survive and thrive in environments both more harsh and more hazardous than the 100-year floodplains. Imagination, engineering, and money invested in safe economic uses of the floodplain can produce important dividends to specific localities and the country.

Residential floodplain areas can become better candidates for feasible nonstructural projects through certain changes in plan formulation criteria. Currently, in feasibility investigations for flood proofing or evacuation alternatives, each structure has been evaluated separately for economic, structural, and social feasibility for various flood proofing or evacuation measures. Particularly in the case of

flood proofing, substantial uncertainty exists as to which measures can be applied to which houses and how the legal questions surrounding the treatment of private property can be handled. In addition, during the public coordination stage, economic and structural considerations are altered by a negotiation with each affected homeowner. Such negotiations contribute to a socially acceptable plan. Unfortunately, they must be painfully repeated during postauthorization planning, often with different property owners and on several different occasions as the extended planning process continues through many years.

A single change in planning criteria could beneficially affect current difficulties associated with economics, local acceptance, and plan formulation. This change would be to plan for public acquisition of all properties in a design floodplain proposed for mixed evacuation and flood proofing measures. For structures located in especially severely flooded areas (for example, the 15-year floodplain), it may be possible to make the general statement that all structures are probably justified for evacuation, both on economic and social well-being grounds. In areas of less frequent and less severe flooding, however, it is often impossible to predict the optimum measures for a given structure without the kind of detailed inspection and freedom of action feasible only when that structure is publicly owned.

If all floodplain improvements were to be acquired, the decisions on relocation versus flood proofing (and on the nature of the flood proofing) could be made on more objective grounds and not strictly subject to the emotional views of private homeowners. Following public acquisition, the appropriate measures would be taken for each structure.

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Those structures to be flood proofed would be resold after flood proofing to private parties. First preference could be given to prior owners; it is anticipated that most would take advantage of the opportunity to remain in the same location they originally chose. An added bonus to project benefit-cost ratios would occur if we assume that the original owners repurchase their previous dwellings. In that case, much of the cost of flood proofing could be paid from the category of replacement housing payments of Public Law 91-646 and, therefore, excluded from the benefit-cost analysis. In any case, if the structures for flood proofing were properly selected and the job performed well, the approximate costs of acquisition and flood proofing should be recoverable through resale.

Those structures least suitable for safe flood proofing are likely to be those bordering directly on the stream in question and suffering the highest damages. Acquiring and removing these structures, thus clearing land along the waterway, and making easements available to the remaining (now flood proofed) floodplain structures, should further enhance the value of those flood proofed units for resale.

The whole purpose of such total floodplain acquisition would be to create a planned flood proofed community which would be returned to private ownership as an attractive, well thought out, water-oriented environment. A project of this kind would return combined environmental, aesthetic, social, and economic benefits in excess of those resulting from any plan that includes total evacuation. The attractions of this national policy include all of those benefits accruing to the local community plus the greater willingness of communities to consider, encourage, and participate in nonstructural solutions which do not adversely affect the natural environment or the everyday lives of upstream or downstream interests far removed

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from the project site. For those actually living in the project area, the social impacts would be no greater than they are under current plan formulation options. In addition, residents would know that, to the extent physically and economically possible:

1. Their own houses would be preserved in their present locations for future occupancy, and they would be able to choose to live there.

2. Their community could be preserved for continued occupancy.

Another promising alternative for accelerating the long-term evacuation of floodplains while reducing resident opposition to a mandatory project involves public acquisition from willing sellers as properties are offered for sale on the open market. Or, public acquisition and removal of structures could be insured by provision of a clause incorporated into the deed of flood prone properties giving first option to buy to the local government. Such an approach would involve an indeterminate length of time for complete floodplain acquisition. Often, however, the time could be less than the time required for formulating and obtaining approval for a mandatory evacuation plan. In Prairie du Chien, for example, this approach could have been very successful. Complications from conflicts with Federal or State acquisition laws could be resolved as needed in specific cases.

OPTIMUM FLOODPLAIN USE

Many of the Nation's floodplains are in or near the downtown centers of large and small urban areas. Early settlements were always located near water supplies, and the combined importance of

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rivers as sources of energy and modes of transportation has often meant that a city's first residential, commercial, and industrial developments were located in floodplains. Many of these areas have since been protected by structural works of various kinds; others, affected by the passage of time and its accompanying floods, have deteriorated.

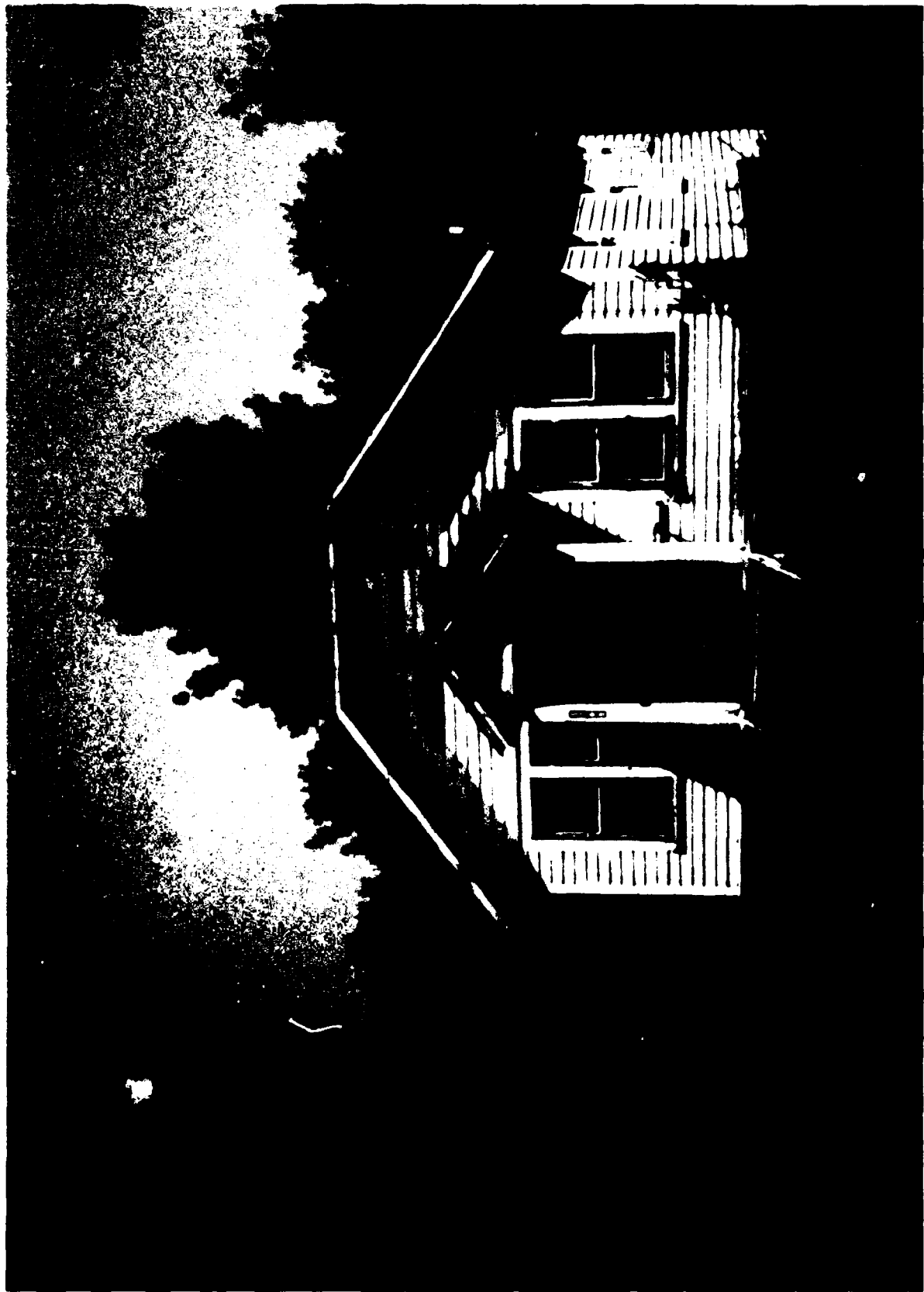
Floodplain zoning regulations discourage new development in such areas unless it is adequately flood proofed. Because few interests are willing to make the substantial investment required for a new, properly flood proofed structure in a neighborhood otherwise filled with older and deteriorating buildings, the prospects for any new development in these floodplains are poor until existing development has totally decayed and been razed. Yet, because of its proximity to traffic corridors and business centers and the aesthetic potential of its natural environment, this real estate has great inherent value limited only by the realities of recurrent flooding.

Existing development of such floodplains was usually made under different economic conditions and with limited appreciation for actual flood probabilities and severity. As such, it often represents a misallocation and inefficient use of the Nation's riparian land resources. The Corps, however, as the Nation's engineering consultant in the field of water resources, could plan, design, and construct economically efficient floodplain developments in conjunction with local and other interests.

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This photograph is of the floodplain at Midland, Michigan. While not precisely average for this or similar floodplains, the scene is typical of the inefficient uses of the Nation's older urban floodplains. Most were developed several decades ago. Their housing and commercial structures are older than the average for the larger communities they belong to. Repeated flooding has deteriorated these structures; there is little incentive for the owners to maintain or upgrade them.

At the same time, as the setting for this house shows, many of these floodplains now, or in the future could, possess fine aesthetic qualities. In some cases, as in Midland, the optimum development for such an area may be for recreational uses. In other cases, the optimum development could be a new, well flood proofed residential or commercial neighborhood planned from the beginning to be adapted to the hazards and advantages of the floodplain.



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A wide variety of potential developments could be beneficially built, as wide as the variety of urban settings combined with floodplain conditions. Similarly, varying degrees of Corps and other Federal involvement in furthering such development are desirable. It is also true that no intensive redevelopment is either practical or desirable for many floodplains, just as many sites are unsuited for reservoir or levee construction. Nevertheless, it is important that Federal policy temper its current emphasis on discouraging investment in every floodplain by also encouraging proper investment in selected floodplain areas.

Some of the considerations necessarily involved in the planning and design of intensive floodplain redevelopment are:

1. Minimal vulnerability to flood damages.
2. Minimal impact on upstream or downstream flood conditions.
3. Maximum adaptation to the environmental and aesthetic values of floodplains.
4. Adherence to sound economic and planning principles.

Minimal vulnerability to flood damages would mean neither zero flood losses nor unacceptably high levels of losses, but rather some low level of residual damages which are more than compensated for by the benefits of floodplain occupation. Engineering considerations dictate this minimal vulnerability be achieved by elevation of the structure to the given design flood level, plus whatever additional freeboard is judged necessary for a factor of safety. The residual flood damages accruing to such an investment in an office building, itself perhaps totally free of damages, could include such things as damage

to ornamental shrubbery, mud and other debris on the grounds, and the inconvenience of being unable to use a neighboring at-grade parking lot during or immediately after flood events. These damages are comparable to those resulting when normal uses of such open-space floodplain developments as golf courses, ballfields, and tennis courts are temporarily halted during periods of inundation, and are as acceptable.

The need to minimize impacts on upstream or downstream flood conditions would often dictate that piers, pilings, or other vertical supports rather than fill be used to achieve the proper elevation. Such structures would not obstruct flood flows or reduce natural flood storage volume appreciably for the utility gained from them, just as is true for the thousands of highway and railroad bridges built in and across floodplains nationwide. This type of construction has the added feature of creating a roofed open-space site beneath a structure suitable for aesthetic, recreational, or other ancillary uses. Importantly, unlike the use of fill, the cost of elevation by means of vertical supports does not rise in a linear fashion because some structural design modifications may be nearly constant for any reasonable raise.

The significant environmental and aesthetic values of floodplains could be preserved and enhanced in proposed developments for reasons of both national policy and the interests of the specific development. The creation of substantial open-space greenbelt areas surrounding structures, the preservation of vistas and access to the nearby stream, and even the preservation or re-creation of wildlife habitat would all greatly enhance the attractiveness of these developments in highly urban surroundings. These areas would not have the qualities of a pristine wilderness, but they would be superior to the existing environmental values in many floodplains.

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Adherence to sound planning principles would direct floodplain development away from certain areas of high hazard or other unsuitable sites and toward areas where good soil conditions, low flood velocities, and other factors increase the relative attractions for use. Developments would be designed and built to meet real demand, and construction would be staged over time. Uses and areas requiring uninterrupted access would be provided access as needed, whether by footbridge, light vehicle roadway, or other suitable means. Finally, consistent application of local cost-sharing requirements would ensure that such developments would be truly aimed at meeting local needs and desires.

The typical results of the design considerations involved in floodplain development would range from low to medium density residential units in smaller communities to high density office and commercial complexes in major metropolitan areas. In all cases, emphasis would be on vertical rather than horizontal development. The added costs of prudent floodplain development lie basically in the costs of elevated construction. The land required for such development is less, reducing real estate costs. Therefore, high-rise structures surrounded by abundant open space would seem practical. Similar developments are in demand and visible in suburban areas across the country because of the amenities they provide for residential and commercial activities. In floodplains, economic considerations would reinforce these aesthetic factors to create a strong tendency for this type of construction. Appendix A contains artistic renderings of sample structural types and developments likely to prove suitable for adaptation to a variety of floodplains.

If the types of flood proofed, planned, floodplain developments proposed here are economically feasible, as is believed, it could be argued that such capital investment would be undertaken by the private sector. The same argument could be applied to dams and levees which in some cases have actually been constructed by private interests.

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However, the Federal Government (and State and local governments to a lesser degree) possesses unique authorities and resources to acquire land and proceed with other important aspects of major projects. The condemnation authority of the Federal Government and the technical expertise of the Corps have been combined to produce many projects of great benefit to the Nation. The same ingredients are required in furthering proper use of the country's floodplains.

If optimum floodplain economic redevelopment were to become an authorized project purpose for Corps water resource projects, Corps involvement could be limited to planning or could extend to design and construction.

a. In terms of planning and project justification, navigation projects could serve as examples for limited involvement in floodplain redevelopment. The Corps designs and constructs navigation improvements to meet expected demand. Private or local concerns build docking and inland facilities. When these facilities are used, the economic benefits of the project are realized. Corps project participation in the facilities is limited to documenting the need for and interest in developing such facilities.

b. Using its technical expertise in floodplain conditions and construction methods, the Corps could be more actively involved with communities and other agencies in planning alternative uses for the inundated areas. This participation could include structure design and site layout.

c. The Corps could also direct construction. This involvement might be particularly appropriate where a public body, Federal or non-Federal, decided to locate offices in such an area.

At whatever level of involvement, Corps technical advice and assistance would be valuable to other agencies, municipal planning commissions, zoning administrators, and engineers, as well as owners of business and residential properties.

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...and the impact of recent national policies toward flood-
control, the National Flood Insurance Program and Executive Order
11988, on flood damage and development in the Nation's flood-
plains, and to show what the intent of such policies. These
...of the Nation's floodplains rather than limit floodplain develop-
ment to areas with low susceptibility to flood damages and to
...of the Nation's floodplains. These uses have been assumed to
...of low-intensity open-space developments with little eco-
...of higher intensity uses taking place in the
...of floodplains lands could often represent a higher and
...of the Nation's floodplains, still being in line with current
...of the Nation's floodplains.

...of the Nation's floodplains, large-scale developments will generally
...of the Nation's floodplains, a feasible nonstructural alternative be-
...of the Nation's floodplains. However, additional benefits of varying
...of the Nation's floodplains, from converting existing low intensity
...of the Nation's floodplains, to higher intensity uses. The potential of this en-
...of the Nation's floodplains, will vary with the marketability of the vacated land.
...of the Nation's floodplains, and other markets. However, floodplain lands
...of the Nation's floodplains, are often more valuable, and sometimes much
...of the Nation's floodplains, than in present use.

...of the Nation's floodplains, in urban centers are usually the parts of com-
...of the Nation's floodplains, with the most recent occurred near rivers to
...of the Nation's floodplains, for building and access to water
...of the Nation's floodplains, and for work. Today, many of these
...of the Nation's floodplains, are in poor condition due to the process of aging
...of the Nation's floodplains, and often, these areas of urban blight
...of the Nation's floodplains, present downtown business centers and
...of the Nation's floodplains, community development and growth. This proximity
...of the Nation's floodplains, of intensively developed land is the basis for some of the
...of the Nation's floodplains, floodplain reuse. An evaluation project can leave
...of the Nation's floodplains, the floodplains, thereby providing a unique
...of the Nation's floodplains, to a community. Land use needs for
...of the Nation's floodplains, open space, and urban or cultural amenities
...of the Nation's floodplains, of existing floodplain lands.
...of the Nation's floodplains, can translate into significant land value in-
...of the Nation's floodplains, related benefits result. (Continued on page 79.)

The acceptance of the above conclusions would represent a major change in the Federal attitude toward the true meaning and potential of nonstructural alternatives to flood control. Rather than surrendering all or much of the 100-year floodplain to nature as a region too hazardous for human occupancy, these recommendations view floodplains as a valuable water-related land resource. Through technical skill, this resource can often be safely used for a variety of national aims, including economic as well as environmental. Although safe, intensive use of floodplains will be geographically limited by the same sorts of considerations which restrict the number of useful reservoir sites, optimum floodplain occupancy should be viewed as a challenge to be met and not as a condition to prohibit.

(1) (cont)

These benefits are categorized as location and/or intensification benefits by ER 1135-2-351. For nonstructural projects, these benefits are described on page 6 of ER 1135-2-353 as "Benefits from Flood Plains in New Use." Benefit measurement identified is the annualized market value of urban renewal lands for uses compatible with the flood hazard. No adjustment for alternative development site values is indicated. Therefore, except for increased development costs needed to architecturally conform the floodplain construction, no unusual costs would have adverse impacts on land values. In fact, numerous developmental costs are avoided or minimized when considering reuse of evacuated floodplains.

Relocation costs for consolidating smaller parcels of land will have been eliminated during project implementation (evacuation). City improvements in and access to the area could remain in place and would probably be already sized properly. In addition, permits for new floodplain activities should be more easily forthcoming from the various regulatory agencies as part of the overall nonstructural planning process. Thus, land development costs will generally be much less than alternative floodplain development sites. The reduced development costs will increase the market value of these lands.

The spectrum of redevelopment land uses is so broad that one simple example cannot be expected to typify the location benefit potential. Economic variables are too numerous and quite site specific. However, in terms of land values used in the 1-acre hypothetical flood damage reduction evacuation example (see pages 50-57), certain ranges and expectations may be presumed.

AWARENESS OF NONSTRUCTURAL LIMITATIONS

Other agencies and the general public should be made aware of the limitations of nonstructural alternatives and of Corps participation in implementing them. Communications emphasizing nonstructural alternatives, whether in project reports, press releases, speeches, or other media, should stress that currently implemented nonstructural alternatives apply almost exclusively to undeveloped portions of floodplains. These measures are generally aimed at reducing future growth of flood damages, spreading the burden of loss more widely, or preventing loss of life; floodplain zoning, flood insurance, and flood warning systems can, respectively, accomplish these goals. None of them, however, is effective at removing existing damages from recurring floods.

The remaining two nonstructural alternatives, flood proofing and floodplain evacuation, are within the Corps authority for reducing flood damages and to reduce existing damages when they can be used. These alternatives will rarely be used because of problems generated by current policies and procedures for plan formulation, limited local acceptance, and general lack of economic feasibility. These problems should be clearly presented in communicating with interested parties. Increased awareness and understanding of the possible role of nonstructural alternatives is needed within and outside the Corps. Whether or not some of the recommendations presented later in this report are adopted and prove workable or other procedural changes are made, nonstructural alternatives will not prove to be a panacea to flood problems.

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RECOMMENDATIONS

1. ECONOMIC ANALYSIS

Recommendation

The Corps should seek legislation to modify economic analysis to exclude certain costs from the benefit-cost analysis, with particular emphasis on application to nonstructural alternatives.

Action Required

Congress must pass legislation such as the following:

"In the survey, planning, design, and implementation by any Federal agency of any project involving flood damage reduction through nonstructural measures including, but not limited to, flood proofing of structures, acquisition of floodplain lands, and relocation, that agency is authorized to expend funds allocable to the activities authorized by Public Law _____⁽¹⁾ when the project outputs identical to such activities would be, in any case, an integral part of said flood damage reduction projects."

2. DISASTER RESPONSE CAPABILITY

Recommendation

The Corps should seek legislation to give it the authority to quickly acquire floodplain property after disastrous floods.

Action Required

Congress must pass legislation such as the following:

(1) Appropriate public law(s) should be cited.

"That the Secretary of the Army is hereby authorized to allot from any appropriations hereafter made for flood damage reduction, not to exceed \$5 million for any one fiscal year, for the purpose of acquiring lands containing flood damaged properties in counties part of a presidentially declared disaster area for flood damage reduction and other public purposes at the discretion of the Chief of Engineers."

3. CHANGE IN PLANNING CRITERIA

Recommendation

Planning criteria for flood proofing and/or evacuation projects should be revised to emphasize total acquisition of design floodplains using technical criteria to determine reuse potential.

Action Required

OCE must revise ER 1165-2-122.

4. OPTIMUM FLOODPLAIN USE

Recommendation

The Corps should seek legislation to give it the authority to optimize floodplain use as a project purpose.

Action Required

Congress must pass legislation such as the following:

"In the survey, planning, design, and implementation by any Federal agency of any project involving flood damage reduction through nonstructural means including, but not limited to,

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flood proofing of structures, acquisition of floodplain lands, and relocation, that agency is authorized to consider and implement the highest and best use of the project floodplain, including economic, environmental, recreation, and other public purposes."

5. AWARENESS OF NONSTRUCTURAL LIMITATIONS

Recommendation

Educate those within and outside the Corps as to the characteristics of nonstructural alternatives and their limitations compared to structural alternatives.

Action Required

OCE must publicize information specifically relating to non-structural flood control alternatives through the preparation and broad distribution of an engineering pamphlet. OCE should also sponsor complementary seminars for planners and managers to insure this awareness.

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THE DEVELOPMENT
OF
NONSTRUCTURAL ALTERNATIVES

OPTIMUM FLOODPLAIN USE

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APPENDIX A

OPTIMUM FLOODPLAIN USE

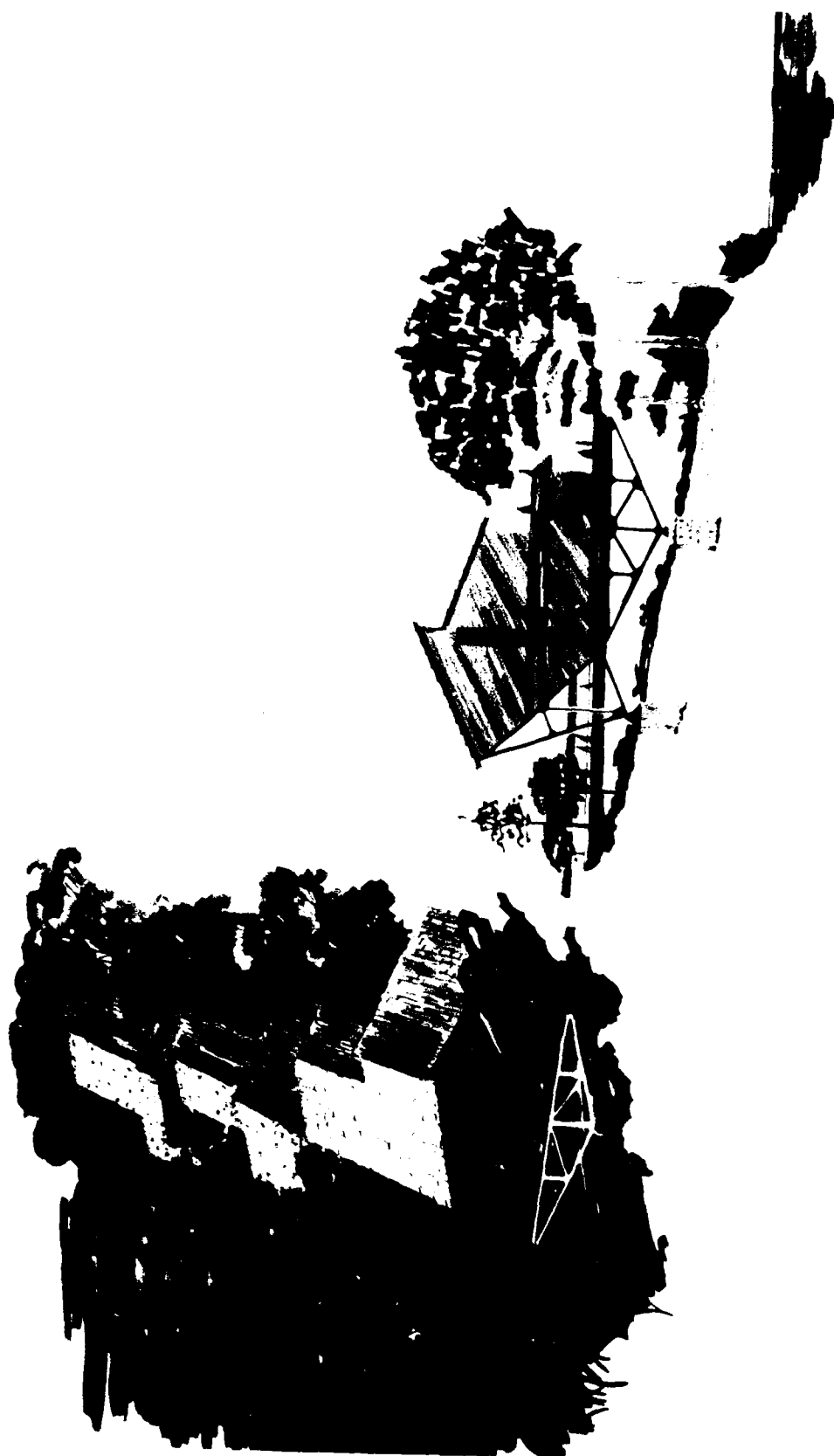
The following drawings depict sample structural types and developments likely to prove suitable for adaptation to a variety of floodplains. Nearly all of these scenes represent actual structures which have been designed to absorb a major cost of prudent floodplain occupancy - elevating the structures - and for aesthetic and other reasons totally unrelated to the avoidance of flood damages. If such structures can be built for reasons other than strict economic utility in nonfloodplain areas, surely they can be built and provide economic returns where flood conditions lend further rationality to this type of construction. cursory examination of many architectural and civil engineering publications will reveal many more examples of potentially suitable structures for floodplain occupancy already in existence at various locations.

1

This artistic rendering is of the Jones Bridge Headquarters of the Simmons Company in Georgia. It was designed and built in this manner for aesthetic and environmental reasons. This style appears particularly suitable for use in floodplains of moderate-size streams and in medium-size urban centers for office, retail, or residential purposes.

1

This artistic rendering is of the Jones Bridge Headquarters of the Simmons Company in Georgia. It was designed and built in this manner for aesthetic and environmental reasons. This style appears particularly suitable for use in floodplains of moderate-size streams and in medium-size urban centers for office, retail, or residential purposes.



1

This type of structure is commonly seen along the Gulf of Mexico and southern Atlantic coastal floodplains of the Nation, and, since it may be unfamiliar to most residents of the State of Louisiana, it is presented to illustrate that elevated, durable, single-family residences can be both practical and aesthetically attractive.

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THE DEVELOPMENT OF NONSTRUCTURAL ALTERNATIVES(U) CORPS
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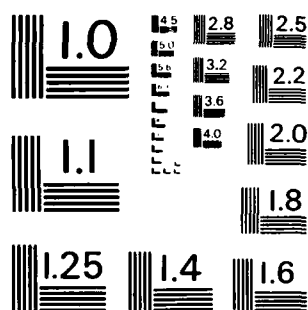
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



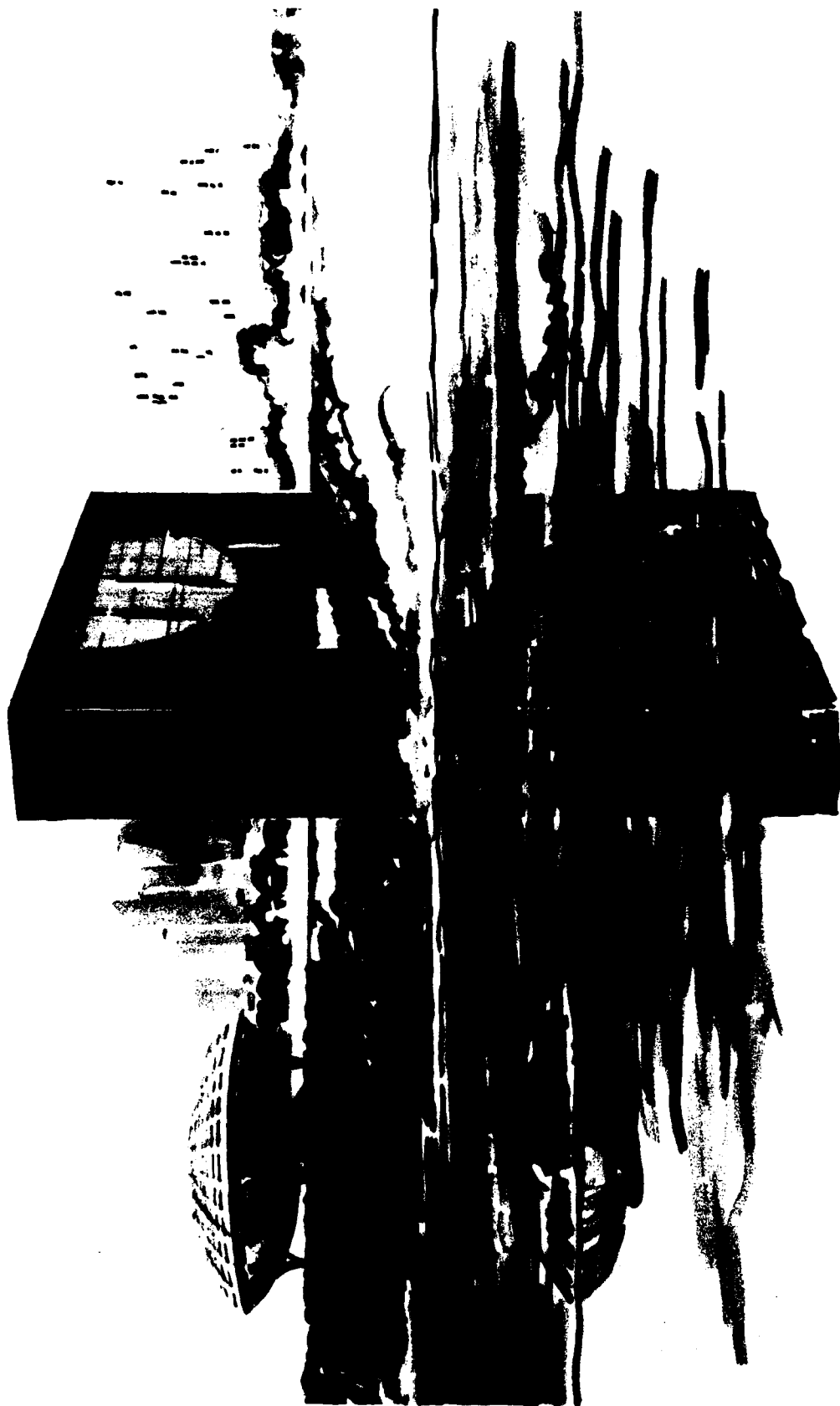
This structural concept is the only one of the five presented not known to currently exist in some form. It is derived from the architectural concept presented in "Elevated Residential Structures" (see bibliography under U.S. Department of Housing and Urban Development). It appears suitable for residential use in smaller communities.



1

Both of these structures are located in nonfloodplain areas in midwestern cities. The building on the left is the "Golden Rondelle". It was built by the Johnson Wax Company for Expo 67 in Montreal. Artistic license has been taken with the vertical supports which were similar but not identical with respect to elevation above grade. The structure has been moved to the Johnson Wax corporate headquarters in Racine, Wisconsin, where it has been anchored more firmly to earth.

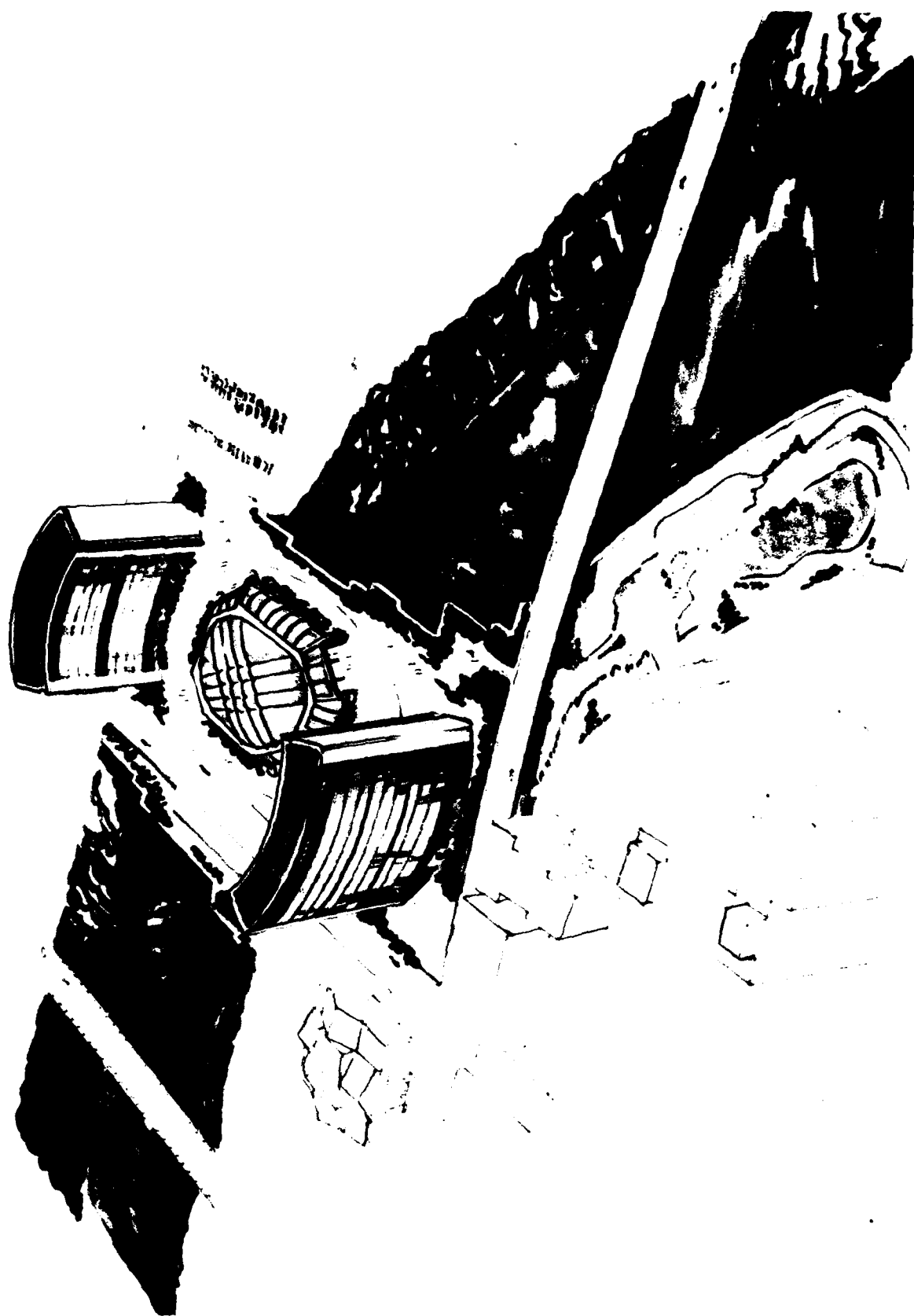
The massive office building on the right is the cable-supported Federal Reserve Bank Building in downtown Minneapolis, Minnesota. Structures of this scale and design would obviously be most suited for construction in major metropolitan centers.



1

This concept is presented to illustrate the degree of technical capabilities readily available, and in use, to build useful structures in urban environments even more rigorous than construction in, say, the 20-year floodplain. The stadium shown atop the "bridge" is taken from one of many such light, domed structures now appearing in numbers around the country.

The general setting is taken from a view of Seattle, Washington's Urban Freeway Park, which is built essentially in this fashion, spanning a major urban transportation corridor.



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THE DEVELOPMENT
OF
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BIBLIOGRAPHY

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APPENDIX B

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