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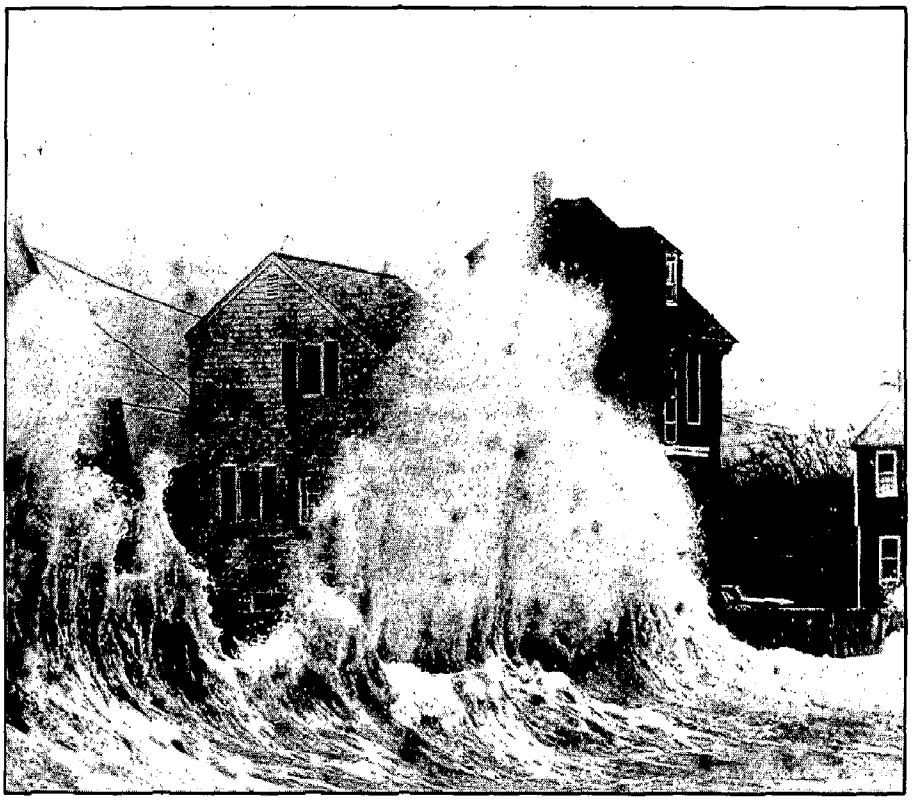
Managing High Risk Flood Areas

1985 and Beyond



Proceedings of the Eighth Annual Conference of the
Association of State Floodplain Managers

Portland, Maine
June 11-14, 1984

Association of State Floodplain Managers

Natural Hazards Research and Applications
Information Center Special Publication #11

Natural Hazards Research & Application Center

COASTAL ZONE

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MANAGING HIGH RISK FLOOD AREAS:

1985 and Beyond

Proceedings of the Eighth Annual Conference
of the
Association of State Floodplain Managers

June 11-14, 1984
Portland, Maine

Editors

Jacquelyn Monday
David L. Butler

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by John Goldie III

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PREFACE

The Association of State Floodplain Managers is pleased to be able to host technical conferences and develop proceedings volumes such as this one. The sharing and transfer of information among states, locals, and federal agencies and the private sector is extremely important. Today, development, disasters, and redevelopment occur too rapidly to allow each of us to develop our flood hazard management techniques by trial and error.

We must build off one another's experiences, whether they be successes or failures. This conference, as well as most Association activities, is directed toward facilitating this information transfer.

A theme running through these proceedings is the need to provide adequate technical assistance to local communities in order to map and manage flood hazard areas. States must take an active role in this effort. Decentralization of governmental responsibilities by the federal government places the states in a pivotal role in their relations with local governments. Those local governments need technical experts who are close enough to respond quickly, maintain contact, and monitor progress.

Many innovative actions to manage flood hazard areas--especially high risk areas--are undertaken at the local level. Assistance from both the state and federal level--for mapping, drafting ordinances, conducting analyses, and providing legal advice--are important to successful local efforts.

The Association will continue to sponsor technical conferences such as the one held in Portland, Maine. We extend our appreciation to the many presenters and participants who are responsible for making these workshops and proceedings successful and useful.

A. Jean Brown, Chair
Association of State Floodplain Managers

ACKNOWLEDGMENTS

These proceedings are being published with funding from the U.S. Army Corps of Engineers. The help of the Federal Emergency Management Agency in sponsoring the workshop session is also gratefully acknowledged. Many members of the Federal Interagency Floodplain Management Task Force made valuable suggestions for speakers and topics, and particular thanks are due Mr. Frank Thomas, Task Force Chair, Mr. Ross MacKay, Federal Emergency Management Agency, and Mr. William Donovan, U.S. Army Corps of Engineers.

A large share of credit for the workshop's success is due the State of Maine Planning Office, Departments of Conservation, Environmental Protection, and Geologic Survey, and the Land and Water Research Center, University of Maine-Orono. Lori Day and Susan MacPherson of the State Planning Office were responsible for the excellent conference organization. Mr. Richard Dutremble, Director of the Maine Bureau of Civil Emergency Preparedness, enabled his staff to provide a wide range of services to the workshop. The Maine Offices of the U.S. Geological Survey and the Soil Conservation Service also gave important support. Special thanks go to the High Risk Areas Committee of the Association of State Floodplain Managers for their advice and assistance and to the Natural Hazards Research and Applications Information Center, in particular Jacquelyn Monday (now with FEMA) and David Butler, for editing and publishing these proceedings.

In turn, the editors extend thanks to Bill Richardson for his research work in Boston, to Maureen Hobbs for her help in untangling the mysteries of word processing hardware and software, and to Barbara Schneider for her diligent and remarkably accurate typing.

Finally, the success of the workshop ultimately depended upon those who contributed their ideas, expertise, and experience: our speakers, panelists, and participants.

Once again, thank you all.

Fred Michaud
Conference Director

Jon Kusler
Workshop Advisor

FOREWORD

Much of the floodplain development taking place today in the rapidly growing areas of the United States is at high risk of damage or destruction due to the velocity, rapidity, duration, or debris content of flood waters. These and other complications create a "protection gap" in current floodplain management guidelines which usually address the depth of flooding but not other factors.

This symposium focused upon techniques for identifying and managing such high risk areas. At all levels of government progress in effectively reducing flood losses in high risk areas has been slow due to the lack of detailed flood data and the lack of development guidelines reflecting the full range of risk factors. Yet real progress has been made in a few community and state programs and in federal agency research.

The papers presented in this symposium define high risk area problems and document problem-solving approaches. We hope you will find them useful.

RESOLUTION 1984-1
HIGH RISK AREAS

WHEREAS, the Association of State Floodplain Managers has completed preliminary work to identify high risk areas and analyze the status of floodplain management for these areas; and

WHEREAS, simplifying assumptions for floodplain management made by Federal agencies, states, and local governments in the late 1960s have resulted in serious understatement of hazards in 20-30% of the nation's floodplains; and

WHEREAS, these simplifying assumptions include: 1) flood stage is the only damage factor; 2) only clear water flooding occurs; and 3) the channel (or shore line) configuration is stable; and

WHEREAS, these simplifying assumptions, while necessary at the time, failed to consider: 1) velocity, 2) debris in the water (ice, rocks, trees, etc.), 3) rapidity and duration of flooding, and 4) erosion and other changes in the flood channel; and

WHEREAS, as a result of these assumptions, flood mapping, regulatory standards, and insurance rating are inadequate for a significant portion of the nation's floodplains; and

WHEREAS, failure to correctly map and regulate high risk areas, without consideration of additional risk and loss potential, is causing and will cause an escalation of insurance claims and disaster losses; and

WHEREAS, growth potential is substantial in high risk areas including: barrier islands (e.g., much of the developed Gulf and Atlantic coastline); areas subject to subsidence (e.g., New Orleans and Houston-Galveston); alluvial fans (30% of the arid southwest and Colorado); and areas prone to mudfloods (California coast and Wasatch front); and

WHEREAS, increased market penetration for flood insurance in high risk areas will likely lead to massive increases in losses (out of proportion to premiums) in high growth areas such as Los Angeles County, Clark County, New Orleans, Houston-Galveston, Denver, and Salt Lake City, unless insurance premiums and land management standards are adjusted to reflect the special risk; and

WHEREAS, the state of knowledge with regard to mapping and management of high risk areas has progressed sufficiently in the last 15 years to permit a

variety of low-cost actions to reduce losses including mapping as part of the remaining map studies and remapping effort, upgraded land management, and increased insurance rates; and

WHEREAS, there are continued methodological problems which need research and field testing,

NOW THEREFORE BE IT RESOLVED, that this Association recommends:

1) That FEMA, in cooperation with other Federal agencies and states, develop a national policy for addressing areas where special risk factors (velocity, debris, unstable channels) pose significant threats to life and property.

2) That such a policy supplement rather than replace existing policies pertaining to flood stage.

3) That an interagency task force be established to develop this policy with Association assistance.

4) That such a policy not only recognize the importance of such areas but set forth a process to develop improved maps, land management standards, actuarially sound insurance policies, and postdisaster mitigation plans and guidelines.

5) That such a policy be based upon further research and investigation that will:

   a. Examine, in depth, disaster payments and insurance claims for high risk areas to determine the magnitude of existing losses.

   b. Determine growth potential in these areas (using the Donnelly Study and other approaches) and future damage potential, including potential losses due to increased flood insurance penetration.

   c. Determine the effectiveness of land management techniques in such areas (e.g., elevation on pilings vs. elevation on fill) and needed improvement through postdisaster surveys and laboratory modeling.

   d. Through demonstration projects, determine for individual types of areas cost-effective combined approaches including mapping, land management standards, insurance, etc. These might best be initiated in communities and states in need of immediate assistance and willing to assist in these efforts.

Adopted in draft form this 15th day of June, 1984, at the annual meeting of Association of State Floodplain Managers in Portland, Maine.

_____

Robert Hendrix, Chair, ASFPM

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PART ONE

OVERVIEW AND PERSPECTIVE

IMPROVING THE EFFECTIVENESS OF FLOODPLAIN MANAGEMENT IN HIGH RISK AREAS

Jon A. Kusler and Pat Bloomgren

Introduction

On the average, 200 lives are lost each year due to flooding. The U.S. Water Resources Council has estimated that property losses will exceed $4.3 billion per year by 2000, despite the mapping and regulation of floodplains in 17,000 communities during the last 15 years.

Inadequate maps, regulations, and other management approaches for high risk flood hazard areas and substantial new development in these areas are one reason for increased rather than decreased losses. High risk areas collectively constitute only 20-25% of the nation's floodplains, but account for much of the loss of life. When flooding occurs, structures are severely damaged or destroyed. Such high risk areas include barrier islands, bluffs and beaches subject to waves and erosion; alluvial fans; areas behind unsafe levees and below unsafe dams; and areas subject to mudfloods, inland and coastal subsidence, inland flash floods, ice jams, and fluctuating lake and ground water levels.

High risk areas occur in a broad range of geologic, topographic and hydrologic conditions:

Coastal Erosion/flooding

At least 2,700 miles of Great Lake, Atlantic, Pacific, and Gulf shoreline are subject to critical erosion with thousands of miles of other shores subject to lesser beach, dune, and bluff erosion. Tens and perhaps hundreds of thousands of structures are at risk. Most erosion occurs in major hurricanes and winter storms. Sea level rise compounds the problem. Most flood hazard mapping and regulation has not considered erosion. However, storm-related erosion is compensated by flood insurance despite a lack of mitigation standards for this special flood hazard.

Alluvial Fans

It has been estimated that alluvial fans constitute 30% of the arid Southwest land including even a greater percentage of the developable land. Fans have usually been mapped, regulated, and insured as shallow flooding areas despite severe flood hazards due to the velocity of the flooding, debris, and erosion.

Mudflows and Mudfloods

Mudflows and mudfloods often occur when heavy rains follow forest fires in the Southwest. They have accounted for hundreds of millions of dollars in flood losses in the last decade not only because of the depth of inundation but also because of the velocity of the water and the debris. Mudflows also occur in other areas of the nation.

Areas Below Unsafe Dams

At least 2,900 dams have been listed as "unsafe" by the Corps of Engineers. It has been estimated that more than 2,000 communities would be inundated to levels exceeding the 100-year flood by rupture of these dams.. The failure of a dam can cause major loss of life and property damage due not only to the depth of the water but also its velocity, debris, and the suddenness of onset.

Areas Behind Unsafe Levees

There are over 25,000 miles of levees in the nation. These levees range widely in terms of protection (e.g., 20-year, 30-year, 50-year, 100-year); construction materials; and adequacy of design and maintenance. Severe losses like the $500 million in flood damage in Jackson, Mississippi, in 1979 occur when levees are overtopped or fail due to the depth, velocity, and suddenness of the flood.

Subsidence

Flooding due to subsidence, which gradually lowers the land surface, is a serious problem in Louisiana, Texas, and California with lesser problems in other states. Subsidence is caused by extraction of ground or surface waters, compaction of organic soils, solution, or tectonic adjustments. Subsidence not only increases flood heights but also can cause permanent flooding as in Baytown, Texas.

Liquefaction

Liquefaction caused by earthquakes or other factors is a major potential cause of flooding in some areas of California and Alaska and along the Mississippi River. When earthquakes occur, unconsolidated sands and silts temporarily lose their strength and behave as viscous fluids. Levees fail and slumping and other ground failures occur.

Ice Jams

Flooding as a result of ice jams is a serious problem along rivers and streams in 35 of the northern and midwestern states. The jam can increase flood stage to heights far greater than the calculated 100-year flood elevation. Ice and high velocity also add to the destructive force of the flood waters.

Fluctuating Lake Levels

Long-term fluctuations in lake levels is a problem for the Great Lakes, many of the glacially created smaller lakes in the northern tier of states, and the "playa" or drainage lakes in the West and Southwest with no or limited outlets. Flood waters may rise for years at a time, rendering structures elevated on pilings useless. Common additional special risk factors for lake flooding include ice (northern lakes) and erosion (the Great Lakes).

Inadequacy of Existing Approaches

Existing maps, regulations, insurance and other management approaches adopted for flood hazard areas by FEMA, states, and local communities during the late 1960s and 1970s often underestimate the hazards in high risk flood hazard areas. Mapping, regulations, and insurance were designed to address a "normal" flood hazard situation where clear water flooding and the depth of inundation was the primary factor causing damage. Flooding was assumed to be temporary and the configuration of the flood channel relatively stable. Such areas include:

- Low velocity flow areas along major rivers and streams (e.g., the Mississippi and Missouri); and
- Relatively flat-lying and stable coastal areas inundated by the storm surge where waves and erosion are not major factors. These include large areas along the Atlantic and Gulf Coast.

Such a focus upon the "typical" or "norm" with little attention to special situations and high risk areas was needed during early phases of federal, state, and local floodplain management due to limited budgets and personnel, the need for consistency in standards, and lack of satisfactory mapping methods and regulatory standards for high risk areas. National criteria based upon such a concept of the "norm" have proven satisfactory for much of the country (perhaps 70-80% including most urban areas adjacent to major rivers and streams and the Great Lakes).[1]

The lack of attention to and the failure to consider other flood damage factors in special situations has resulted in serious deficiencies in floodplain management for high risk areas:

- Guidelines for mapping the "norm" and the resulting maps have often understated hazards in areas with velocity, debris, or other high risk problems and failed to provide the basis for realistic planning, regulation, and flood warning systems. For example, flood maps for alluvial fans designate them as shallow flooding areas, implying low risk. Risks are, in fact, serious--largely due to high velocities, debris, and erosion. Such maps give a false sense of security and may mislead landowners and local governments.

- Regulatory criteria designed for the "norm" underestimate the hazard in velocity, erosion, debris, and other high risk areas, often resulting in damage or destruction of structures built in compliance with regulatory criteria when a major flood occurs (e.g., during Hurricane Frederic, structures built in compliance with the 100-year storm surge elevation were destroyed by waves which had not been considered).

- Flood insurance for high risk areas has not reflected actual risk, resulting in inordinately high losses for such areas and an unjustified incentive for development.

In some instances, state and local opposition has developed to federal maps and regulations due to these deficiencies and the lack of credibility of approaches now being applied.

[1] Such approaches have not, without tailoring to local conditions, been satisfactory for smaller rivers and streams and other drainage areas, which are typically not mapped or regulated or which, if mapped or regulated, do not consider the impacts of urbanization on flood peaks.

Inadequate Attention to Risk and Damage Factors

Depth of inundation is unquestionably the most important cause of flood damage in many situations, and an important factor even in high risk areas. But other factors become important or dominant in certain contexts:

Velocity

The damage potential of flood waters increases dramatically and in some instances exponentially with velocity. Velocity is determined by slope, roughness, waves (coastal), and several other factors. Unless velocities are considered in building design, floodproofed structures often collapse from added pressures and stresses. Water moving at speeds of 10-15 or more feet per second will undermine pilings and slab foundations. Water velocity is a major damage factor for

- Coastal wave action areas (velocity zones) and coastal inlets and overwash areas during the rise and fall of the storm surge;
- Inland high gradient flood areas (usually along smaller rivers and streams). These are also often "flash flood" areas with additional damage due to the rapid rise of the water. Such areas include alluvial fans; some riverine floodways; and areas subject to mudfloods, mudflow, and high gradient sheet flows.
- Areas behind levees or dams where the protective structure suddenly fails or the design capacity is suddenly exceeded.

Rocks, Sediment, Ice, Other Debris

The "work potential" and damage potential of flood waters may be increased hundreds of times over clear water flooding where rapidly flowing flood waters contain substantial amounts of rock, sediment, ice, or other natural or human-made materials. Clear water standards for floodproofing and elevation are inadequate in these contexts:

- Alluvial fan flooding (rocks, mud);
- Mudflow and mudflood (sediment, rocks, trees, etc.);
- Meandering, unstable streams in the Southwest;
- Ice jam flooding (ice);

- High velocity flood areas along rivers and streams (rocks, mud trees, lumber, bridges, etc.);
- Areas subject to dam or levee failure (trees, portions of houses, lumber, etc.);
- Coastal wave action (rocks, gravel, portions of houses, etc.)

Rapid Rise of Water

Areas subject to rapid inundation by flood waters pose special threats to property and life because there is insufficient time for evacuation, emergency floodproofing, or other protection measures. Rapid inundation is a serious problem for:

- High gradient rivers and streams in mountainous or hilly areas subject to sudden rainfall (e.g., Big Thompson Canyon). Such "flash flood" areas are most common in the mountainous West but occur in the eastern mountains and elsewhere;
- Areas behind dams or levees subject to failure;
- Barrier islands and certain other coastal areas principally along the Gulf or Atlantic coasts, which may be subject to relatively rapid (2 to 4 hours) hurricane storm surge;
- Coastal areas (principally along the west coast) subject to tsunamis.

Long-term or Permanent Inundation.

Unlike the "typical" riverine or coastal flood situation where flood waters rise and fall quickly, certain areas are subject to long-term or essentially permanent flooding. Structures elevated on pilings or floodproofed in such areas are often permanently unusable and must be abandoned unless specially designed for long-term inundation with adequate access and services. Such areas often include:

- Barrier islands and beaches inundated by rising sea levels;
- Areas around lakes subject to long-term fluctuation of ground water levels; playa lakes and internal drainage lakes such as the Great Salt Lake; and lakes with inadequate outlets such as the Great Lakes;
- Erosion areas, such as bluffs, where the land itself is destroyed in a flood event;

- Subsidence areas such as Baytown, Texas, caused by ground water or oil withdrawals, isostatic adjustments, or gradual solution of the underlying strata (karst topography);

- Areas subject to high groundwater levels and those behind dikes and levees where high water levels may persist for months or years (e.g., lands in Arizona adjacent to dikes along the Colorado River).

Two or more of the special risk factors often occur in combination in high risk areas, exacerbating the problem. For example, high velocity, debris, and rapid rise of water cause severe damage in alluvial fan, mudflood, high velocity mountain stream areas, and areas subject to flooding by the failure of dams or levees.

Erosion of the flood channel or blockage of the channel by sediment or debris is also common in alluvial fan, mudflood, high velocity stream, and coastal velocity areas.

Progress in Addressing High Risk Areas

Progress has been made in identifying high risk areas and formulating or adopting special management standards for them.

1) FEMA has identified coastal velocity zones and is adding wave elevations to coastal flood hazard maps. FEMA now requires special engineering for structures in velocity zones although erosion is not considered. FEMA has also undertaken studies to develop mapping methods for areas below unsafe dams, mudslides, alluvial fans, and ice jams. However, few maps have been actually prepared.

2) The U.S. Army Corps of Engineers has identified coastal erosion areas including those subject to "critical" erosion. The Corps continues to plan and construct coastal erosion engineering works and to fund some private protection measures. Michigan, North Carolina, Washington, Massachusetts and several other coastal states have mapped coastal erosion areas and adopted setback lines and other regulatory standards.

3) The National Weather Service has identified, on a preliminary basis, communities with flash flood problems and is assisting such communities to develop flood warning systems and evacuation plans.

4) The U.S. Geological Survey has identified mudflood and mudslide areas in Utah, the San Francisco Bay Area, and some other areas. The Survey has also mapped "sinks," liquefaction areas and certain other geologic hazards in a few locations. Colorado has mapped and established regulatory guidelines for a wide range of special hazard areas. Los Angeles County and

some other local governments have also mapped and regulated alluvial fans and mudflood and mudflow areas.

5) The U.S. Army Corps of Engineers and some states have established dam inspection programs to identify unsafe structures. Iowa regulates areas below unsafe dams.

6) NOAA, the Corps of Engineers, FEMA, SCS, and the USGS have developed flood warning systems and evacuation plans for selected high risk coastal and inland areas.

Despite this progress:

1) Only a portion of the high risk areas have been mapped at federal, state, and local levels on even a preliminary basis. Maps for coastal velocity zones (the one type of area mapped) do not, in most instances, adequately consider erosion. There is no systematic high risk area mapping program in progress on a nationwide basis for even a single type of area.

2) FEMA, other federal agencies, and the states have, with a few exceptions, not adopted regulatory guidelines for high risk areas adequately reflecting the risk (except certain coastal velocity zones) or provided guidance to local governments with regard to high risk area management.

3) Federal and state programs for high risk areas are, in general, uncoordinated and fragmented. For example, many states are mapping coastal erosion areas, but such erosion information is not systematically considered by FEMA in mapping.

4) Available information concerning mapping methodologies for high risk areas, building standards and warning systems and other mitigation measures has not been widely disseminated. There are few reports, model ordinances or guidebooks. This problem is particularly critical for alluvial fans, ice jams, and coastal erosion areas where considerable methodological and technical information relevant to management of such areas has been developed but has not been supplied to potential users.

Opportunities

Having mapped and regulated most of the nation's low risk areas, is it not now time to turn federal, state and, local attention to special problems where the greatest present and future threats occur? Arguments that mapping and regulatory methodologies are not yet adequate and that more research is needed are not entirely honest or accurate. Enough is known to improve management approaches considerably! Arguments that mapping and regulation should wait until methodologies are fully perfected or until a nationwide program is

possible (from budget and personnel perspectives) fail to consider the enormous present growth in high risk areas, many of which will be developed in five to ten years (e.g., alluvial fans, coastal erosion areas, lakeshores).

Available methods for mapping and managing high risk areas could produce maps and regulations with accuracies exceeding many of the flood-prone area maps and flood hazard boundary maps developed by the USGS and FIA study contractors for 17,000 communities during the late 1960s and early 1970s. These maps have served as the basis for flood insurance and state and local regulations despite their many limitations.

High risk areas have been dismissed individually as regional or local problems not deserving national attention. But they are collectively important and should be collectively considered in national policy making.

If more research is needed to perfect map methodologies and land management guidelines for such areas, it should be undertaken. Budgets, manpower, and expertise are limited at federal, state, and local levels, but much more could be done with existing budgets. For example, map contractors could map those areas as part of ongoing new flood mapping and restudy efforts already scheduled.

Selective mapping and management of such areas is needed on a priority basis, beginning with the areas with the largest potential flood losses, and with communities or states most interested in improving management of the areas.

If budgets and staff are insufficient to develop detailed maps and management standards for specific areas, a portion of the data gathering and design burden may be shifted to those seeking to develop such areas. Such an approach has been applied with considerable success by states and communities in dealing with more conventional flood hazards. Such an approach involves:

1) Preliminary mapping of areas through use of historical data on hazard events, soils, topographic maps, elementary modeling, etc.;

2) Adoption of regulations for mapped areas requiring that anyone wishing to subdivide land or construct buildings within such areas a) carry out a more detailed examination of hazards consistent with guidelines in the regulation and b) prepare subdivision and building designs sufficient to provide protection for intended uses.

While not perfect, such an approach would be a major improvement over existing mapping and regulatory approaches which ignore risk factors.

Given limited budgets, a major opportunity for improved management of high risk areas also lies in better training and education and improved coordination and utilization of existing federal, state, and local personnel. High risk areas are the logical focus of not only floodplain managers but civil defense and emergency managers in their disaster preparedness and response programs and coastal zone managers and land use planners in preparation of coastal zone management and floodplain management plans. Management of these areas is also of great interest to natural resource specialists because high risk areas encompass some of the most ecologically sensitive barrier islands, beaches, and wetlands in coastal settings and the shorelands of scenic and wild rivers, riverine wetlands, and riparian habitat areas (in the West) along inland waters.

Better interagency coordination at federal, state and local levels for high risk areas concerning predisaster mitigation planning, regulation, flood warning systems, flood insurance, engineering works, training and education, and technical assistance efforts might be accomplished through interagency memoranda of understanding, executive orders, directives from Congress, or other approaches.

Other recommendations for improved management of high risk areas include:

- Improved technical assistance and training and education efforts are needed for communities. These should be undertaken by FEMA, the Corps of Engineers, SCS, NOAA, other federal agencies, the states, universities, and interest groups;
- Lists of communities with particular types of high risk areas should be prepared by states to help set priorities for mapping, technical assistance, flood warning systems, and other programs on an interagency basis;
- Predisaster plans, including master plans, should be prepared by states and localities for priority high risk areas (e.g., barrier islands, alluvial fans) to mitigate future damage and provide guidance for rebuilding after a disaster.

Although these measures would reduce losses, the most pressing need is coordinated and upgraded mapping and regulations and revised flood insurance policies for these areas. Suggestions for each of these include:

Mapping

1) Efforts at the federal, state, or local level to better address high risk areas must begin with an identification of communities subject to such risks and the actual areas. Once identified, regulations and other management measures can be adopted. Maps are essential if high risk areas are to be zoned (state zoning statutes require maps). Maps are also needed to inform governmental officials and private landowners of the locations of high risk areas. In general, the issue is not whether maps are needed if regulations are to be adopted for high risk areas but which map scales, degrees of accuracy, and other features are needed.

2) Generalized high risk maps should be developed even if detailed mapping is not practical. These might take the form of overlays. If maps are to be developed for regulatory and management purposes, it is desirable, but perhaps not essential, to distinguish between moderate hazard areas and the truly high risk areas, since regulatory procedure can be used in some circumstances to make this determination during administrative phases of a program (as suggested above). Such a procedure is incorporated in the single-district floodplain zoning ordinance proposed in Volumes 1 and 2 of Regulation of Flood Hazard Areas. With such an approach the map only serves to establish regulatory jurisdiction. The specific hazard at a site is determined through a case-by-case hazard analysis procedure as individual permit applications are submitted.

3) If maps are to be prepared for regulation of high risk areas, they must be prepared at relatively large scale (e.g., 1 inch = 1000 feet or larger). Large scales are particularly needed for urban areas, although smaller scales may suffice for rural settings. A quantified evaluation of hazard is desirable (e.g., the 100-year event) but not essential. Mechanisms should be available for resolving boundary disputes and carrying out more specific hazard and project analysis on a case-by-case basis, perhaps in the manner suggested above.

4) Historical data and other sources of available information should be used for identification of high risk areas if other, more detail information is not available or cannot be developed. Although high risk factors have not been systematically mapped, such factors often occur within areas designated as subject to flooding on more generalized floodplain maps prepared by the U.S. Geological Survey, the U.S. Army Corps of Engineers, the Federal Emergency Management Agency, and the U.S. Soil Conservation Service. Historical data (albeit unquantified) also exists for many areas that have suffered high risk flooding such as flash floods, mudflows, and coastal erosion. This data could serve as the basis for preliminary overlay mapping to supplement existing maps showing flood stage.

5) Any effort to map such areas by FEMA, by another federal agency, states, or local governments should not necessarily mean that these areas will be insured under the National Flood Insurance Program. It may be that for

some high risk areas, denial of all insurance or at least very high rates would be appropriate.

6) Without a massive new mapping effort, FEMA could begin to upgrade its ongoing mapping program by adopting clarified high risk area map guidelines for use by study contractors and training these contractors in the application of such guidelines. Restudy mapping efforts and mapping after disasters could also reflect high risk factors.

7) If FEMA does not wish to map high risk areas due to budgetary and administrative limitations, it may nevertheless wish to encourage state and local mapping and regulation. Such efforts could serve FEMA's loss reduction objectives, reduce disaster assistance, and reduce flood insurance payments. Such mapping and regulation could be encouraged not only through cost sharing and technical assistance but favorable community rating for flood insurance purposes. For example, a community that maps and regulates high hazard areas might be given lower overall flood insurance rates due to the overall lowered potential for loss.

8) Mapping of high risk areas could, perhaps, begin on a pilot basis. Such pilot studies could test mapping methodologies as well as meet management needs at particular sites.

9) High risk area mapping should be a multidisciplinary and, in some instances, a multiagency effort. Mapping of high risk areas often requires more than hydrologic information, complicating the mapping process and requiring cooperative multidisciplinary mapping. For example, geologic, as well as hydrologic, data is needed for the mapping of coastal erosion/flood hazard areas, mud flow, subsidence, and certain high risk dam failure areas. The separation of hydrologic and geologic study functions in federal and state agencies has discouraged such mapping.

10) Some combination of maps and technical studies on a site-specific basis is needed for project evaluation. Maps in themselves rarely, if ever, provide all of the data needed for design of protective works, floodproofing, and other adjustments in high risk areas since it is difficult to cartographically represent velocity, debris load, depth of inundation, and other relevant factors even if this information is available. There are also limits to map scale and accuracy (given limited budgets). Such site-specific data gathering could be undertaken by consultants, local governments, states or federal agencies.

Regulation

1) Perhaps 60% to 70% of the high risk floodplain areas are subject to at least minimal floodplain regulations consistent with the standards of the National Flood Insurance Program. However, with the exception of some coastal velocity and erosion areas subject to state or local setback or high velocity zone ordinances, regulatory standards substantially underestimate the true hazard and fail to prescribe adequate protection

measures. In some instances, such as ice jam flooding, protection elevations are inadequate. In others, the management approaches are inappropriate. For example, elevation of structures on pilings does not provide flood protection from long-term lake level fluctuation unless roads and utilities are also elevated and the pilings and structures are designed for permanent or semipermanent inundation.

2) The lack of local regulatory guidelines specifically addressing high risk problems has been due to lack of maps; lack of model ordinance approaches, manuals or other information setting forth management approaches for high risk areas; lack of expertise at local or state levels; lack of incentives to encourage special regulation; and failure of state or national regulations to require or encourage special regulations.

3) Despite the relative lack of local regulations on a nationwide basis, several hundred communities have, on their own initiative or at the urging of states, adopted special hazard regulations for alluvial fan, mudflood, coastal erosion, and other types of areas. Regulations are usually part of broader zoning, subdivision control, building code, or other regulations. These regulations serve as valuable precedents for other programs.

4) Strengthened regulatory approaches needed for high risk areas may include:

   - Complete prohibition of development in certain areas with substantial risks to safety, where development will substantially increase flood heights or erosion on other lands, or where engineering solutions are impractical (e.g., bluff erosion, mudslide below unsafe dams). Such prohibitions may be accomplished through setbacks or open space zoning.

   - Added elevation requirements through freeboard or increased base load elevations to reflect the special risk (e.g. wave heights, ice jams).

   - Strengthened performance standards to reflect not only water depth but velocity, debris, and other risk factors. Such performance standards could require that anyone desiring a building permit or subdivision plot approval first undertake a hydrologic or combined hydrologic/geologic investigation to more specifically determine hazard at the site and then design the proposed structure to withstand the identified hazard.

5) After flood disasters, upgraded regulations should be adopted for high risk areas to prevent rebuilding without consideration of special risks. State or local regulations could take the form of interim "freeze" ordinances and longer-term enhanced setback of elevations and performance standard guidelines. FEMA could encourage such regulation by requiring that federal postdisaster teams address special hazards and by incorpora-

ting special hazard provisions in the Section 406 guidelines for state and local postdisaster mitigation planning.

6) States could strengthen regulations of high risk areas by mapping and directly regulating or requiring local regulation of such areas pursuant to existing broader floodplain management legislation now in effect in many states; or through new legislation authorizing state mapping and regulation or state-supervised local regulation of such areas.

7) FEMA and other federal agencies could encourage local and state regulation of high risk areas through manuals, ordinances, technical assistance grants-in-aid, training and education programs, and community rating systems for flood insurance (described below). Existing FIA regulatory guidelines for mudslide and erosion areas could be implemented by actually mapping such areas. Broader mapping would also encourage state and local programs even if FEMA did not require regulation of such areas. Strong fiscal arguments can be made that over time FEMA should require special state or local regulations of all high risk areas if subsidized insurance is to be continued for such areas.

Insurance

1) Solid estimates are lacking of the total number of structures in high risk areas insured by National Flood Insurance Programs, claims to date, losses per claim, the adequacy of protection and management standards, and anticipated future trends. FEMA should begin to systematically gather and analyze insurance data (and perhaps disaster assistance data) to provide such information which is needed not only for future insurance rating but also for the establishment of mapping priorities, regulatory guidelines, and other management approaches.

2) It is likely that many existing structures in high risk areas are now insured under the National Flood Insurance Program because the areas are contained within broader areas subject to preliminary flood maps or flood insurance rate maps or because the occupants have applied for such insurance, despite their location outside of mapping risk zones.

   Although flood insurance rates have been made more nearly actuarial for coastal velocity areas, no special risk rating has been applied to other high risk areas, due in part to lack of maps for these areas or the identification of special risk factors on existing maps and the lack of special risk-rating procedures related to actual hazard. Such insurance has the potential for encouraging unsound development since rates in some instances (e.g., alluvial fans) grossly underestimate risk.

3) Any effort to increase flood insurance rates for unidentified high risk areas would require, as a starting point, the identification of such areas with a degree of accuracy considered satisfactory for insurance rating. Relatively poor initial data might be used if techniques are available to refine hazard data and insurance rates on a site-specific basis as has

been done with coastal velocity zones. Another approach might be to apply high insurance rates on a uniform basis for identified areas with the option of the community or developer applying for lower rates if they could provide information indicating lower risk or satisfactory master planning or engineering to address risk.

4) FEMA might encourage local or cooperative state/local mapping of high risk areas through an "incentive" insurance rating scheme. Lower overall insurance rates would be made available to a community willing to map and regulate high hazard areas with more specificity than now is required by FEMA regulations. Such an approach would encourage community and state initiatives in reducing losses and would make sound financial sense, since additional community mapping and regulation of these areas would reduce federal insurance claims and disaster assistance payments.

5) Congress could eliminate insurance for certain high risk areas through amendments to the flood insurance act or special legislation such as the Coastal Barrier Resources Acts of 1982 (which prohibits flood insurance and certain other federal subsidies for new development on certain undeveloped barrier resources.) If present rating procedures are not revised to reflect actual risk, such an approach may be needed to prevent further encouragement of unsound development.

SIMPLE TRUTH IN PUBLIC POLICY

James E. Tierney
Attorney General, State of Maine

The first elemental truth with which I would like to leave you this afternoon is that I am far from an expert in managing high risk flood areas. So the most I can do to keynote this conference is to help you place your tremendously important work in a broader context--a context within which public policy will be made for the rest of our lifetimes.

Your work and responsibilities were an unknown governmental function during the early days of our country when we moved from an agrarian to an industrialized society. When our parents, grandparents, and great grandparents came as "huddled masses" to these shores, their everyday problems were so immense that few were concerned either about protecting the natural environment or protecting themselves from it.

History books are filled with references to the human suffering which resulted from those early decisions. The growth of industrialism in the late 19th and early 20th centuries was hard, bloody, and filled with pain. It was only as individuals began to claw a semisecure niche in our country that they began to feel comfortable enough to assert that, indeed, they did have a right to a government that provided basic health facilities, that provided an economic and natural environment in which they could be happy while they raised their families, and that all had the right to live to a prosperous old age in peace and dignity.

So it was that when Franklin Delano Roosevelt swept into office, it was with the belief that government itself could be a positive force in people's lives. Surely government could be designed to do more than provide for the common defense and deliver the mail.

The first task was to correct the gross disregard previously shown for our human and physical environment as a result of the rapid capital formation; government had to address the human suffering that prevailed in the land. The New Deal and all it meant for America, from social security to electricity in rural America--which, of course, also marked the beginning of 20th century flood control--was clearly only the beginning.

After World War II, as our society grew in strength and wealth, the American public demanded and received an even higher standard of living. Essential to that, and relevant to our discussions today, was the rise of environmentalism. Many point to Rachel Carson's Silent Spring, published in 1962, which showed the destructive side effects of a number of "miracle" pesticides, as the beginning of contemporary environmentalism. This nation began to pay attention to a new grass roots movement called "ecology." Earth Day, in 1970, provided a clear indication that environmentalism was strong, politically powerful, and here to stay.

Americans were demanding strong laws and were willing to put their dollars behind solving some of our most apparent environmental problems. Americans refused to allow their rivers to remain open sewers; Americans refused to allow their air to be choked with smog; and Americans refused to see precious wildlife brought to extinction.

Public officials eagerly joined this movement. They did so because of the voices of their constituents, and they did so because immediate action was long overdue. They did so also, however, safe in the realization that they would not have to make very difficult choices in defending the environment because America during this period was sustaining a long and uninterrupted period of economic growth.

From 1950 to 1973, the gross national product doubled in real dollars, national productivity increased on an average of 3% per year, and inflation was virtually nonexistent. During this period, the price of oil actually fell in real dollars. While the balance of foreign trade was generally positive, it was not deemed essential to economic health because 93% of the gross national product went into domestic sales.

American technological ingenuity powered these increases in productivity and the resulting economic growth. People all over the world used our steel, drove our cars, and we stood as the world's economic colossus.

Lest we forget, the outcry for increased environmental protection was only part of what Americans were demanding from government. Increased--and I might say unfunded--social security benefits were passed on an annual basis. Workers were demanding a safer work place. Consumerism raced into vogue at least as rapidly as environmentalism. Everyone demanded shorter hours and more pay and no one seemed to really care about productivity, growth and competition.

Politicians were happy to accommodate, and the nation's economic growth sustained these new demands. Great successes were made in all areas, but especially in the environment as Maine's own Ed Muskie championed the environmental cause with the result of dramatically improved air and water quality.

Leisure, recreational opportunities and cleaner beaches caused a national rush in the 1970s towards the construction of second homes and cottages along our now clean rivers and beckoning oceans. The wealth of our nation generated the construction, and clearly good things were waiting for us all.

What does all this mean for us today? Where are we now? Why do my remarks seem to evoke a time which, although we all remember it, seems so far away?

My friends, those times are indeed far away, and, I would state as a hypothesis, they will not return. There is no doubt that the United States will, for the rest of our lifetimes, have an economy of scarcity within which every dollar granted by the public sector will be closely scrutinized.

I am sure we all wish it were different. I am sure we all wish that we were sustaining greater economic growth when we are not. I am sure we all wish that our federal government was not sustaining deficits of almost 200 billion dollars a year which threaten continually to send us into an inflation/unemployment spiral. I am sure we all wish that our nation's goods and services were more competitive in the international market. I am sure we all wish that Adam Smith's invisible hand would appear with enough money in it to provide for a dignified life for the elderly, the abolition of ignorance and child abuse, full employment, educational opportunities for our youth, and markets for goods that are made in America--that are worth what we pay for them, safe to use, and made to last a lifetime; and enough money to create easily not only a clean environment but also the opportunity to avoid environmental risks that are within our control and to mitigate those which are not.

As mature leaders we must realize this is not to be. This is not because of some mysterious evil force or a political malaise; but rather because other nations in the world--both friends and enemies--have worked hard to achieve the same goals we have--security, peace, and a clean and safe natural and physical environment. These nations, especially since the oil crisis in the early 1970s, have become technologically sophisticated and diplomatically wise so as to create competition that means our nation will always face difficult choices.

What then is my message to you as you step back from your hectic schedules to begin this conference? What is your message and how do you carry it out into a public that is so concerned and so worried about other things? Allow me to make a few suggestions.

1) Regardless of your political preference, insist on a government that is clean, active, and strong. Against those people who do not believe that government must play an active force in the daily lives of us all, I urge you to stand up and be heard. When politicians and cynics from either the private or public sector berate the efforts of the millions of dedicated public officials in this country, then it behooves you and me to stand up and tell them that they are wrong--tell them with our voices, with our feet, with our money, and with our votes.

2) Clarify your message. The efforts that you take and the requests you make of public officials--elected and appointed--must be done with a basic understanding that their choices are difficult ones. You therefore have a special responsibility to make your points clear, concise, and based on a realistic listing of priorities.

The facts are clear enough. Hundreds of lives and four billion dollars a year are being lost to our nation because of inadequate planning and management of high-risk hazardous areas. Much of this is avoidable if this society, which has the capacity to do so much, takes it seriously. Refine your message. Make it clear. Drive it home.

3) Accept responsibilities for your failures. Be willing to admit your mistakes. If in the past you have recommended too much or too little say so now. I know I am joined in this by millions of Americans who are tired of people who are more willing to point to "the other guy" than they are to say that answers they thought were appropriate before are not appropriate now. The economics have changed, the culture has changed, and the technology has changed in a remarkably short period of time. Don't be afraid to stand up and say so.

4) Don't be afraid to tell the public that they should not be foolish. Clearly there are areas in this country that are so environmentally sensitive and dangerous that development should not occur there. Be it the floodplain of a river; be it the base of a volcano; or be it atop a sand dune--you must be willing simply to say that you cannot build in or live in this place, in this time, in this way and, if you do, then the government will not be there to help

you. These are tough words and tough medicine. If you do not say it, no one else will.

In conclusion, my remarks roll down to a simple message: The times have changed and changed permanently. Our resources are scarce and our choices difficult. And finally, to borrow from Confucius, while all truthful people are not in government, all people in government must be truthful.

I truly hope you enjoy your time with us here in Maine. I hope you learn from each other and from us, and that you leave more professional and proficient than when you came. Thank you for asking me to speak and thank you very much for being with us here this week in Maine.

A NOTE ON INTEGRATED EMERGENCY MANAGEMENT: FACT OR FANTASY

William J. Petak
University of Southern California

Albert Einstein stated many years ago that "a perfection of means and a confusion of aims seems to be our main problem." If the problems associated with the implementation of an integrated emergency management system (IEMS) are looked at in a broad context, one has to agree with Einstein. Although technical, bureaucratic, and procedural methods of dealing with disaster management problems are being perfected, application of these methods in many cases lacks clear direction. However, even if the perception of aims were clear, the wide choice of means makes accomplishment of the aims a very complex undertaking.

IEMS is seen by many as "old wine in a new bottle," in that Comprehensive Emergency Management, promoted more than a decade ago, is the same thing. Others see IEMS as legitimizing preparation for nuclear war by diverting the focus to major catastrophic events such as earthquakes, hurricanes, and floods. Still others see IEMS as the application of a more rational systems approach to understanding and developing solutions to a complex set of problems.

Whether IEMS is a fact or fantasy is highly dependent upon one's perspective, which is generally based upon past experience (successes and failures); knowledge, skills and attributes; political support within the responsible jurisdiction; and the availability of data and information. There appears to be little question that, in a time of severely limited resources, economic growth as evidenced by increased land development is highly valued, and the governmental focus is on limited regulation and more freedom of choice, much effort will be required by state and local officials to achieve the aims of IEMS.

There are many factors working against developing and implementing policies that will make IEMS a workable system. Included in this list of factors mitigating against developing policy support are 1) the absence of sufficient supportive political constituencies; 2) absence of effective inside advocates; 3) significant problems of complexity and uncertainty; 4) confusion of issues

of fact and value; 5) administrative inadequacies; and 6) failure to see the benefits of multihazard approaches and coordination.

Once policies have been adopted, implementation is handicapped by 1) slow progress in identifying and mapping hazard zones; 2) poor procedures and data bases supporting cost/loss reduction analysis; 3) significant turf difference across jurisdictions in building code and development policies; 4) inadequate codes; 5) limited technical capacity on the part of many jurisdictions' personnel; 6) emphasis largely on demands for financial assistance and area protection works; and 7) past coordination inadequacies on the part of the federal government.

Necessary critical actions on the part of those involved in the emergency management system are to 1) develop a positive and creative attitude toward IEMS; 2) integrate IEMS into the comprehensive (urban/regional) land use planning process and engage in pre-event planning; 3) create a participatory system designed to help overcome the internal turf issues; 4) apply technical expertise early in the process; 5) develop multijurisdictional relationships and memorandums of understanding; and 6) develop and implement training and education programs for both jurisdictional staff and the citizenry.

Only when we increase our level of professionalism will we begin to both see and understand the benefits of IEMS. It is important that we learn from our successes, share limited resources, overcome turf problems, and, finally, emphasize solutions. Agreement on aims and implementation of means is our main purpose.

FEDERAL INSURANCE ADMINISTRATION INITIATIVES TO RESOLVE INCONSISTENCIES IN FLOODPLAIN MANAGEMENT REGULATIONS

William L. Trakimas
Indiana Department of Natural Resources

The main issues that confront us today are the complexities and inconsistencies that exist at the local level for administering an effective floodplain management program. This issue is magnified when we start addressing high risk areas.

Problems already exist with the basic terminology and management procedures for dealing with the "normal" floodplain as shown in the Flood Insurance Studies. The introduction of terms like liquefaction, alluvial fans, and fluctuating lake levels has the potential of confusing the part-time local official who is the foundation of a successful floodplain management program.

This does not mean, however, that we should forget these issues in the name of simplifying the program. Rather, we should strive harder to work with each other to incorporate these ideas into implementation strategies that simplify this program, into a framework that truly shows the federal/state/local partnership working together instead of in segmented efforts, each trying to protect its own turf. This will require sweat and compromise by everyone if we are serious about reaching our goals.

An effective partnership is beginning to be realized. The FIA planning cycle is an excellent example whereby we now know when policy and program changes will occur and how we can plug into that cycle. This cycle allows us (the ASFPM) as a volunteer group to make wise use of our limited time and resources to achieve the biggest results.

The Producers Services Review Committee is another avenue by which we can provide valuable input on insurance issues to local producers. This group has been successful in getting the FIA to revise definitions, develop better claims procedures, and make the insurance program operate more like the private industry.

The goal or challenge for us is to begin to make better use of these avenues that already exist. Through our past efforts we have seen the NFIP

become a program better adapted to local administration. Change has been slow in some areas, but it has occurred. Only through a concentrated effort by all those involved can we begin to resolve the remaining inconsistencies and make the NFIP a program that truly meets the needs of those who need it most--the local officials and their citizens who live in high risk areas.

PART TWO

SPECIAL HIGH RISK FLOOD AREAS:

Ice Jams

THE COLD FACTS OF ICE JAMS: CHARACTERISTICS AND INCIDENCE

R. Gerard
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The Problem

In cold regions, floods are caused either by high discharge (an open water flood), or the effects of ice, of which ice jam floods are most common. In New England "...ice jam flooding is a frequent occurrence.... Since 1970, 249 communities in these states have suffered from ice jam flooding. Of the 249 communities documented, 49 were identified as having frequent ice jam floods which caused substantial damage" (McLoughlin, 1980). Oil City, Pennsylvania, provides another example. There, ice jam flood stages far exceed open water stages in both magnitude and frequency (Deck and Gooch, 1981).

Such ice-related flooding should be anticipated anywhere north of the 0° January isotherm, an area that includes some 80% of North America and 50% of the contiguous United States. It should be kept in mind that such a limit is just a guide: there have been ice jams on the Mississippi River at New Orleans.

A breakup ice jam flood frequently resembles a flash flood, with extremely rapid water level increases with little or no warning. A description of events during the severe ice jam flood from the Delaware River at Port Jervis, New York, in 1875, illustrates this point.

"...The volume of water in the river appeared to increase as if by magic, and within ten minutes a raise [sic] of eighteen feet occurred" (Port Jervis Daily Union, March 1, 1875). Later the same month, in a separate but related event:

> Just at this moment, the Erie dispatch engine, which had been sent to Delaware Bridge, four miles west of the village, came thundering down the track, the shrill whistle announcing the approach of the avalanche of water and ice.... Men, women and children were fleeing in every direction for safety... (Port Jervis Daily Union, March 18, 1875).

Similar events have occurred at this location since, the most recent being in 1981.

In Alaska,

> An example of a flash flood from rapidly rising backwater occurred in the 1975 spring breakup, when a major ice jam formed at Holy Cross on the Yukon River. Record flooding occurred upstream at Anvik and Graylin as the Yukon River rose suddenly. The ice jam held for six days and the water dammed upstream from Holy Cross inundated the tributary Innoko, Bonasila, and Anvik Rivers creating a large lake. The lake was estimated to have an area of 1,000 square miles. This is comparable in size to Lake Iliamna, Alaska's largest lake. The description of this flood through the personal experiences of residents was "worst in the history of the villages." Multiple flash flooding by waters suddenly released by an ice jam occurred at Anik on the Kuskokwim River during the 1972 breakup. The town was flooded four different times as the ice jam, that had formed a lake extending 30 miles upstream, shifted, releasing sudden surges of the impounded waters.
>
> The art of river forecasting using the best meteorological and hydrologic scientific technology has not yet mastered the prediction of times of formation and disintegration of moveable ice jams forming suddenly in random locations (Bowers, 1978).

Freeze-up jams are considerably more placid and predictable but, once the situation is ripe, can be as inexorable.

Ice jams are a very site-specific phenomenon. One location can be plagued with ice jam flooding while sites a short distance upstream or downstream can be completely free of the problem. This differs significantly from open water floods. A related feature is that ice jam formation can be very sensitive to river changes. After construction of even a small dam, ice jams may begin to form at the backwater in the channel upstream; after removal of the dam, ice jam flooding may begin at sites downstream that were previously untroubled. Gravel removal from the Allegheny River downstream of Oil City changed a significant ice jam problem into an extremely severe one, while the simple act of installing an inexpensive boom a short distance upstream of Oil City will likely completely remove the problem.

Another ice jam feature that follows from this sensitivity is that it is very difficult to anticipate ice jam frequency and magnitude, particularly for breakup.

Causes of Ice Jams

Ice jam formation is an integral part of the freeze-up and breakup processes and is therefore subject to all the vagaries of these phenomena. Nevertheless there are some features commonly associated with sites subject to repeated ice jam formation.

Freeze-up jams are usually associated with steep, shallow streams which resist formation of a solid ice cover and therefore produce large quantities of frazil ice that eventually must be stored somewhere in the stream channel for the winter. It is this storage that reduces, or even eliminates, the waterway and hence causes flooding. Harkwick, Vermont, provides an example of this (Calkins, 1984). In other cases, the slope may be steep but the velocities are low enough that an ice cover forms a thick initial accumulation that increases the stage sufficiently to cause flooding. The recent flooding from the Salmon River at Salmon, Idaho, provides an example of this (Cunningham and Calkins, 1984).

Most breakup ice jams are caused simply by stalling of the breakup front. That is, either the front meets a portion of the solid ice cover that is more resistant than elsewhere--is thicker or more shore- or bottom-fast--or the channel geometry enlarges downstream so that the breakup surge loses its impetus. Freeze-up or winter ice jam accumulations obviously result in much more resistant ice covers and therefore pose a strong impediment to breakup. Likewise, a thick ice cover locked into a sharp bend in the channel may resist breakup sufficiently to initiate ice jam formation. On the other hand, a breakup surge is attenuated as it moves into the headwater of a reservoir, a lake or even a larger main channel, so that even the normal ice cover may be sufficient to resist breakup and initiate an ice jam. A similar circumstance applies to the sudden reduction in a channel slope, a change usually accompanied in an alluvial stream by enlargement of the channel. The Port Jervis, New York, site seems to be an example of this. These various factors have combined to produce the rule of thumb that the vicinity of a sudden reduction in water surface slope is a likely ice jam location.

An obvious cause of ice jams would seem to be ice floes jamming in a contraction. While this is the usual reason for initial lodgement at freeze-up, and hence initiation of freeze-up, and possibly even of freeze-up jams, it is not often the cause of major ice jams at breakup. Likewise, bridge piers of

modern bridges over streams wide in relation to the ice thickness rarely seriously hinder passage of ice at breakup.

Characteristics of an Ice Jam

When fully developed, an ice jam profile will appear as shown in Figure 1. Its components are the jam key, which in this case is the solid ice cover; the thickened toe region, a result of the steeper water surface slope in this gradually varied flow portion; the body of the jam which, if the accumulation is long enough, will contain a uniform "equilibrium" section that gives the maximum depth that can be caused by such a jam and that plays an important role in the simple analysis of ice jam levels described below; a thinning of the accumulation to the head of the jam; and a classic backwater curve as the water depth decreases to the uniform flow depth some distance upstream. The increase in water level caused by an ice jam has two sources: the thickness of the ice accumulation, and the increased flow resistance of the much rougher accumulation "ice cover." A fragmented ice mass behaves much like a cohesionless accumulation (the ice fragments in a jam are simulated in hydraulic model studies by small plastic pellets). Thus the accumulation thickness depends on its "geotechnical" strength, and on the drag exerted on the accumulation by the flow and the downslope component of its own weight.

The accumulation thickness, the waterway depth and, therefore, the water level, depend mostly on the discharge per unit width of channel, q, the energy slope, S (roughly the water surface slope), and the hydraulic roughness, k, of the waterway under the accumulation. For example, the maximum depth, h, that can be caused by a steady, floating ice jam is given very approximately by

$$h \approx \frac{1}{2}\left[\frac{qk^{1/6}}{\sqrt{gS}}\right]^{3/5}$$

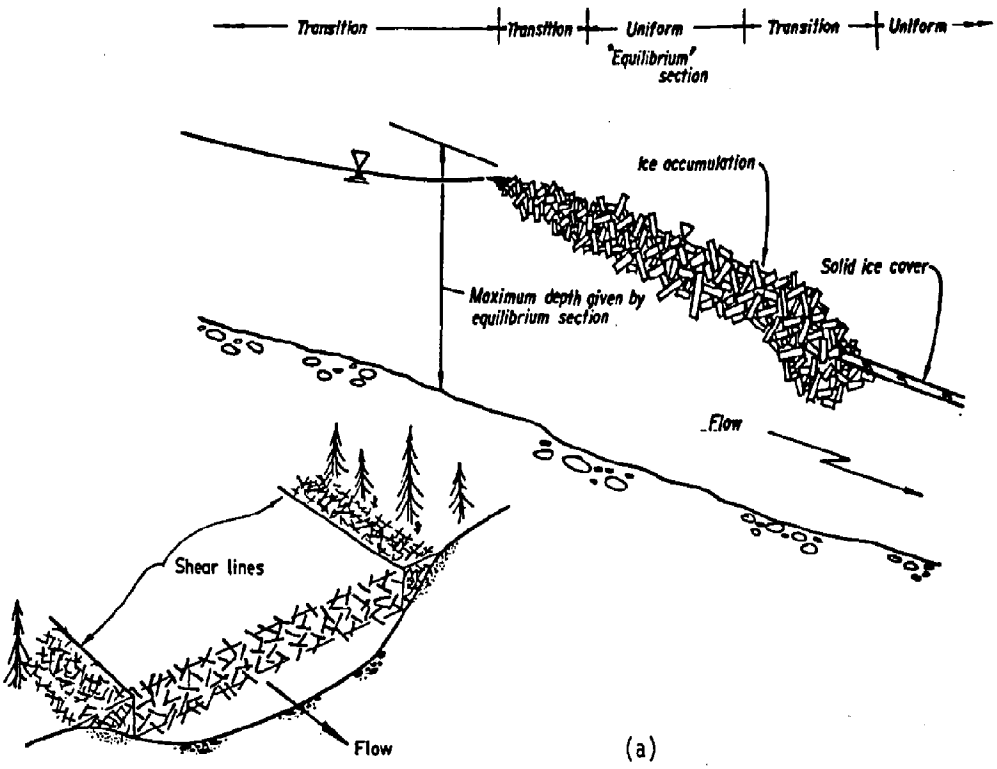
or

$$\approx 2\left[\frac{ng}{\sqrt{S}}\right]^{3/5} \quad \text{in SI}$$

where g is gravitational acceleration and n is the Manning coefficient. (Indeed, it might be noted that the above relations provide the following useful rule of thumb: the maximum depth to the water level in a floating jam is given simply by calculating the flow depth under the accumulation using a regular uniform flow formula (e.g., Mann's equation) and adding 50%.) As mentioned, this depth occurs in the equilibrium, or uniform flow, portion.

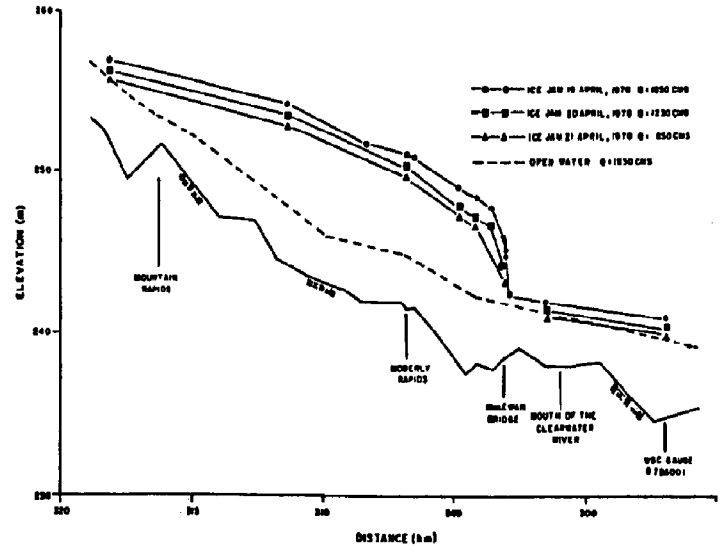
Figure 1(a) TYPICAL ICE JAM CONFIGURATION

(b) MEASURED WATER LEVEL PROFILE THROUGH AN ICE JAM (Andres, 1980).



(a)

(b)



Variations from the profile shown in Figure 1 can occur. If the volume of ice is limited, the jam may not be long enough to develop an equilibrium portion, and hence the maximum depth along the jam will be more shallow. On small, steep streams the required accumulation thickness in the toe region may be larger than the depth; the accumulation will then ground, over some length, across a good portion of the channel width. The flow resistance over this length will increase substantially which may cause a maximum depth along the jam greater than the equilibrium depth for a fully floating jam. However, analysis of jams in the field to date suggests that the equilibrium depth is not often exceeded by much for streams more than about 50 meters wide, even if there is a grounded portion near the toe.

Ice Jam Failure and Reformation

Probably a greater limitation to using depths calculated assuming a fully developed floating jam under steady flow conditions is the possibility of a very unsteady flow as a result of ice jam formation and failure. Breakup, in particular, is by nature a very unsteady phenomenon. When an ice jam forms, it is literally like a dam in the river and, if it fails suddenly, a surge of fast moving water and ice will be released. Depending on the nature of the jam and the channel downstream, such surges can travel long distances, carrying with them, with little attenuation, the increase in water level caused by the jam. If the surge encounters another jam, or the jam reforms, the water level may rise even further, creating a surge that moves upstream. Such happenings explain the dramatic water level increases often associated with ice jam floods. For at least some sites--Port Jervis, New York, being one of them--there are strong indications that the maximum recorded ice-related water levels have been caused by such events, rather than by the increase in water level caused by a jam at or downstream of the site.

Ice Jam Flood Frequency

Before planning ice jam flood mitigation measures, it is necessary to define the significance of the problem at a particular site. This will usually require estimation of the ice-related flood frequency distribution. There are several problems with this, particularly for breakup jams. As mentioned above, the location and frequency of breakup jams are difficult to assess without historical data. As a result analytical techniques, analogous to rainfall runoff simulations for open water floods, are much less definitive for ice-related floods with regard to frequency. On the other hand, because ice jams

are site-specific and historical records of ice jam floods cannot be transposed, historical records must be available for the vicinity of the site at issue. On balance, although analytical estimates of frequency distributions may be tenuous, they may be more necessary because of the absence of reliable historical data, particularly for shallower floods.

One reasonable compromise between the limitations of analytically derived ice jam flood-frequency distributions, and their necessity, is that outlined by Gerard and Calkins (1984). In this approach, analytical techniques are used to derive upper and lower bound frequency distributions, and what historical data are available are used to assist in deciding on a compromise frequency curve. Alternately, if a reasonable amount of historical data is available, such analytical techniques can assist in the reasonable extrapolation of the historical frequency curve, as is commonly done for open water floods.

It should be noted that the tenuous nature of analytical frequency estimates, and the general lack of gauge records, make historical ice jam data far more valuable than for open water floods, and the luxury of discarding all but data for the most extreme events can rarely be afforded. This means that historical data from sources of varying reliability and "record length" usually must be utilized. The analysis of such data is discussed by Gerard and Karpuk (1979). The general problem of flood frequency estimates for cold region sites is discussed in more detail by Gerard and Calkins (1984).

Conclusions

- Ice jam floods are much more common and widespread than generally appreciated, and their often substantial contribution to the flood population generally has been either overlooked entirely or poorly treated in past flood studies.
- The characteristics of ice jams are much better understood now than two decades ago.
- Ice jam floods can and should be incorporated quantitatively in future flood studies.

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COLD FACTS OF ICE JAMS:
CASE STUDIES OF MITIGATION METHODS

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Introduction

There are very few "classic" analyses of mitigation methods for ice jam problems. Unfortunately, the sole approach often has been to treat the symptom rather than to identify and remove or prevent the cause.

It is fair to say that half the battle in mitigating ice jam floods is understanding the cause of the problem. Once that has been achieved, solutions should be evident. The recent ice control structure placed in the Allegheny River provides an excellent example. The problem was obvious: ice jam flooding at breakup. The cause was not known until winter field investigations revealed that too much ice in a pool in the mainstream prevented the tributary ice run from entering. Once the cause was identified, the solution was simple: reduce the volume of ice in the pool by initiating the ice accumulation at freeze-up in the next upstream pool.

Understanding the cause requires some knowledge of river/ice hydraulics, but equally important is keeping an open mind when reviewing the written accounts of ice jam floods. Observations of river and meteorological conditions leading up to and including the event can be very informative. Newspaper accounts and diaries can be useful. Another source of information is the environmental evidence along the river banks. Moving ice or ice that has been pushed against the banks often leaves scars on the trees lining the banks. These scars can be dated, surveyed for elevation, and used in the frequency analysis of ice jam stages when direct observations are not available. It generally takes a lot of time and investigative work to get information on ice jam flooding.

Causes of Ice Jam Flooding

It is often difficult to define the cause(s) of an ice jam. In almost every case, an ice jam forms as a result of an existing ice cover blocking the

ice run as it moves downriver. The channel geometry plays a role, but an ice run moving down an ice-free river will not suddenly stop and jam. A full-width or nearly full-width barrier is necessary to halt its movement.

Once the ice cover has been set in motion downriver, surges of water and ice accompany the breakup. As new ice is broken and set in motion, the ice run almost feeds itself. In some areas the ice cover breaks up and moves away, while other sites initiate ice jams that create water level differences of several feet before the jam breaks and the process is repeated.

One classic location for ice jams is in the upper end of the backwater behind a dam. The bed slope and the water surface slopes are changed to a milder condition than existed in their natural state. Again, the ice cover in the pool often retards the movement of the ice jam.

Even though bridge piers are often thought to cause ice jams, a careful look usually reveals that the ice run actually passed the bridge piers, only to be stalled by the ice sheet downstream. That is, the toe of the jam was well below the bridge piers.

An important cause of increased flood levels associated with ice jams is floodway encroachment. When a river channel is packed with ice (when 50% to 70% of its depth is ice), the floodway becomes the major channel for conveying the water. Unfortunately the designs of many highways have created much higher ice jam water levels. In areas prone to ice jams, problems can be caused by an approach embankment that constricts or cuts off the floodway or by a highway that is elevated and runs parallel to the channel bank. Denial of the floodway causes higher ice jam stages. I have seen the "500-year" open-channel flood stages exceeded at three sites as a result of floodway encroachment by an ice jam stage whose flow might have a frequency of only a 10-year open-channel event.

Once the ice cover has been broken up, ice jams typically are caused by:

- Backwaters of reservoirs;
- Major changes in channel gradient, usually a decrease;
- Low overbank floodways;

- Building of dams and regulation of the flow, especially in the winter;
- Removal of dams from the river;
- Peaking by hydropower dams;
- Water supply reservoirs altering the winter flow distribution;
- Major sediment deposition;
- Tributary junctions; and
- Excessive freeze-up ice cover thicknesses prohibiting channel storage of breakup ice.

For any of these typical jams, an ice cover must exist downstream of the ice jam toe to key it in place.

Potential Solutions

Once the cause (s) of the ice jam has been determined, solutions can be evaluated. Unless the cause is known with a reasonable degree of assurance, attempts to solve the problem can be inappropriate and wasteful.

A modification in the ice conditions at freeze-up can have a significant effect on the breakup conditions and any resulting ice jams. A corollary of this is that one ice control measure for breakup jams might be the alteration of the ice regime during freeze-up.

A structural solution is defined here as a permanent or temporary modification to the river channel and/or the floodplain, including structures that are meant to minimize or contain flood levels. Structural solutions include:

- Ice booms;
- High/low head structures; i.e., reservoirs, weirs, etc.;
- Levees, berms, etc.;
- Floodplain storage facilities for ice;
- High level diversion channels;
- In-stream channel improvements; and
- Thermal suppression.

Nonstructural solutions use existing structures or temporary measures to control the ice and flood conditions. Nonstructural solutions include:

- Flow control at existing reservoirs;
- Ice control at existing reservoirs;
- Dusting;
- Mechanical removal;
- Vessel assistance;
- Removal of structures within the floodplain;
- Flood warning system;
- Blasting; and
- Thermal suppression.

Case Studies

Allegheny River

Report: Deck and Good (1981).

Location: Oil City, Pennsylvania

Problem: Ice jam flooding at the confluence of Oil Creek and the Allegheny River.

Cause: A river dredging project on the Allegheny created a long, deep pool just downstream of the confluence with Oil Creek, which caused a large accumulation of ice. The ice run from the smaller tributary could not penetrate the Allegheny River ice cover. The ice jam would remain in the tributary channel and the floodplain (Oil City business district) would handle the flow.

Solution: Winter field investigations revealed an excessive ice buildup--15 feet at the confluence during freeze-up. A relatively inexpensive ice boom just upstream of the confluence was designed to start the freeze-up ice cover at that location and minimize the ice volume at the confluence area.

Implemented: 1982

Performance: The volumes of ice have been dramatically reduced. Although conditions have been favorable for ice jam formation, no ice jam flooding has occurred, as the tributary ice run can now move into the main river.

Salmon River

Report: Walla Walla District (1984). Cunningham and Calkins (1984).

Location: Salmon, Idaho.

Problem: Ice jam flooding at freeze-up and breakup on both the main river and a tributary.

Background: The river is designated as wild and scenic. Hydraulic mining activities created the problem in the late 1800s by altering the natural channel characteristics of the Salmon River 26 miles downstream of Salmon, Idaho. Winter river observations will be expanded to analyze the environmental impact and assess the performance of the possible alternatives with respect to the ice regime.

Causes: Thick ice cover results in stage increases of 8 to 12 feet; low temperatures must occur in the basin;

Floodplain encroachment; and

Breakup ice conditions occur with a higher flow discharge, which creates even higher stages; mild weather must occur to create high flows.

Solution: Alternatives are being evaluated under the 205 program.

Israel River

Report: Frankenstein and Assur (1972). Northeast District (no date).

Location: Lancaster, New Hampshire.

Problem: Breakup ice jam flooding in the business district and some residential areas.

Causes: Removal of two old mill dams upstream;

The flooded area is located at a transition from steep to mild slope; and

A thick accumulation of ice develops in the mild slope reach during freeze up, reducing breakup ice storage.

Storage: Install submarine net one mile above the flooded area where the river changed slope and floodplain relief for water and ice was available.

Israel River cont'd

Implemented: 1974.

Performance: The structure has held back ice each year, primarily because floodplain relief for the water is available. This was a good solution for holding back ice at this location. However, the one mile of ice between the net and the town was still sufficient to cause ice jams in flooded area.

Solution: Construct a low head weir 0.5 mile upstream of the flooded area near the site of the first old mill dam to serve as a replacement.

Implemented: 1982.

Performance: The structure does not hold back ice because the pool length is too short. Ice jam flooding still exists. Additional modifications may be necessary.

Delaware River

Report: Philadelphia District (1984). Calkins (1984).

Location: Port Jervis, New York; and Matamorous, Pennsylvania.

Problem: Breakup ice jam flooding in two communities.

Causes: Not fully understood yet; only three major events have occurred in the last 100 years, with the jam of record occurring in 1981, causing $18 million in damage. A midwinter jam at Port Jervis followed by the spring breakup appear to cause this flood.

Solution: Several alternatives are being considered: Permanent hydraulic structure;
Flow control, freeze-up and breakup;
Ice control at freeze-up with ice booms;
High level diversion channels; and
Levee protection.

Peace River

Report: Neill and Andres (1984).

Location: Peace River, Alberta, Canada.

Peace River cont'd

Problem:	Freeze-up ice cover flooding.
Causes:	Construction of hydropower dam 100 miles upstream; Release schedule of flow (surges); and
	Increased winter flows versus the natural condition (factor of two to three).
Solution:	Modify release schedule during freeze up.
Implemented:	Some modification of the releases.
Performance:	Insufficient data have been collected.

Chaudiere River

Report:	Deslouriers (1965). Michel (1965).
Location:	Quebec, Canada.
Problem:	Ice jam flooding at breakup.
Causes:	Thick ice accumulations at freeze-up; and
	No river channel storage for the ice at breakup due to thickness of the ice at freeze-up.
Solution:	Construct a 60-foot-high dam upstream of the flooded area.
Implemented:	1967.
Performance:	Ice jam flooding occurs now in the pool behind the structure and not in the community. The dam is considered very successful.

Other case studies have been completed, and several are in the analysis/design phase. In each case study listed above, field observations by experienced personnel have played the major role in identifying the cause of the problem. Such personnel are few. Unfortunately the engineering and planning communities at large are unaware of the significance of ice problems, let alone the details of the ice processes. This situation should not be perpetuated, and the burden rests with those who can narrow the gap.

Emergency Operations

Generally, once an ice jam has formed and flooding has occurred, remedial solutions for the ice in the river are not practical. There are times when

mechanical removal, such as blasting, or vessel assistance may be used with good results. However, the implications of each method must be fully weighed before a method is chosen. One may refer to the Ice Engineering Manual published by the Corps of Engineers (EM 1110-2-1612) for more details.

It is obvious that residents of areas subject to ice jam flooding should be aware of the potential for flooding and the conditions that cause ice jams. Stage increases caused by ice jams can occur very quickly, depending upon the river. Rates of water level rise of one foot per minute downstream of an ice jam failure are common. Stage increases of 10 to 20 feet within 10 to 30 minutes due to a jam have been reported.

Conclusions

Ice jams are natural occurrences and the misconception that little can be done to minimize their impact is disappearing. The causes of ice jams are now better understood, and remedial measures are being designed and constructed to address them.

The analytical techniques for ice jams are improving, but technology transfer is moving slowly. Alteration of the existing river ice regime by any external force will have an impact somewhere; fortunately the tools necessary to assess the impact are now being developed.

The evidence presented in these case studies demonstrates to those responsible for floodplain management that a change in the winter flow regime or modification of the existing river hydraulics will affect the ice regime. This impact has to be assessed to be certain that both the negative and positive effects are identified. Simple ice management schemes can nullify the initially negative impacts. For example, by simply altering the hydropower releases below a dam, one can reduce the potential for ice jam flooding.

- The general lack of data, particularly high quality data, inhibits ice jam analysis and makes the causes more difficult to determine.
- Ice jam flood levels are just beginning to be incorporated into "stage frequency" analysis. Several techniques for developing the data base may be necessary to ensure that what little data might be available are included.
- The stage damage curve for ice jam flooding has long been assumed to be similar to the "open water" damage curve. This may be false. The damage can be significantly greater because the high water velocities cause erosion and the moving ice floes can damage the structures on impact and move objects around like match sticks.

- The risk to life in ice jam floods is high because the water levels can rise quickly and residents can become trapped in their houses.

- There are many remedies for ice jam problems, and care must be exercised to ensure that the solution will address the cause. The projects will take longer to investigate because at least one and probably two years of winter observations are required to ensure that the problem is fully understood. These studies cost more than traditional "open water" flood investigations.

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PART TWO

SPECIAL HIGH RISK FLOOD AREAS:

Dams

MANAGING RISK BELOW UNSAFE DAMS

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Introduction

One of the emerging "special hazards" issues of the 1980s is the regulation of areas subject to floods resulting from dam failures. Of course neither floodplain management nor dam safety programs are new initiatives. It is the idea of linking them together in a coordinated approach to hazard management that is a recent development. Before exploring the specifics of what Wisconsin is now doing to address this problem, some of the basic concepts should be outlined.

Basic Issues

What is an "Unsafe Dam?"

There are certainly a variety of ways to define an unsafe dam. For our purposes, an unsafe dam is one that poses an unacceptable level of risk to life or property through potential failure of the structure. No dam is 100% safe. In fact, in a very real sense, the term "unsafe dam" is redundant. Also, a dam might be safe now but unsafe in a few years.

What Can Make a Dam "Unsafe?"

There are three ways in which this can happen. First, the dam may not be designed to pass a large enough flood without "overtopping" (having water flowing over parts of the dam that are not designed for that purpose). Second, a dam may not be properly maintained. This can lead to failure at flows well below the design flood. And third, the dam may not be operated properly. An example of this would be failure to open gates or spillways quickly enough. This could undo assumptions made by the designer.

Can We Predict the Likelihood of a Dam Failing?

The only way to be absolutely sure of a dam's failure is to go out after the flood and see if the dam is still there. We can predict with reasonable certainty that the likelihood that a well-operated, well-maintained dam will fail is pretty close to the probability of its design flood being exceeded. At

the other extreme, a dam which is obviously ready to collapse at any time can easily be called "unsafe." The problem lies with the ones in between that, we feel, could be a sizeable percentage of the dams in this county. For these, we may not know what condition the structure is in and thus have little idea how "unsafe" it is. Because of all the variables involved, using a frequency analysis based on the number of dam failures would probably be misleading. So each situation is unique, and there is no approach to assess the likelihood of failure. This is in sharp contrast to our usual approach (admittedly far from perfect) of predicting flood frequencies from statistical records.

Do Dams Only Fail During Floods?

Of course not. While floods and other natural disasters (e.g., earthquakes) have certainly caused their share of dam failures, many dams fail under much more "normal" conditions. In Wisconsin, out of 30 failures documented between 1973 and 1983, 19 were of the "sunny day" variety. Presumably many of these failed because they were improperly maintained.

What Kind of Flooding Results from Dam Failures?

While gradual failures can occur (these obviously attenuate the surge of water and lessen the amount and severity of flooding), a more sudden failure can lead to rapid increases in water levels, high velocities, and debris damage (including the possibility of debris jams). There may be little or no warning, and sudden failures can occur under conditions (e.g., at night) where their detection is almost impossible until it is too late.

Can Flooding from Dams be Prevented?

As you might guess, the answer is both "yes" and "no". Proper operation and maintenance, along with adequate spillway capacity and storage, can go a long way towards minimizing the risk, but the plain fact is there are no guarantees. At the least, a "bigger and better" flood can always come along, yet people historically have put a lot of trust in the "protection" offered by dams.

My sense is that what they really have done is to replace a more likely but less serious risk with a less likely but potentially much more serious hazard. So while the safety of most dams can be improved, we think it is also important to take steps to minimize loss of life and property damage in the event the dam fails anyway.

Extent of the Problem

How large a problem are we dealing with? Ignoring the small dams (in Wisconsin these make up about 70% of the total), there are about 67,500 large dams in the United States. Based on the potential for loss of life from failure, the Corps of Engineers identified 8,800 "high hazard" dams and found 2,900 (33%) of them to be unsafe (most of these because of inadequate spillway capacity). If the same percentage of the other large dams were also found to be unsafe, there would be over 22,000 unsafe large dams (by Corps' standards) in the country (well over 400 per state on the average). This is probably a high estimate.

To go one step further, if failure of each unsafe high hazard dam could affect two downstream communities (Dewberry and Davis, 1982), there would be around 6,000 communities facing a degree of risk to life and property from dam failure that the Corps' standards say is excessive. It is also estimated that 2,000 communities could experience floods greater than the 100-year event due to dam failures. All of these figures are "guesstimates".

Managing The Risk: Now

What are we doing about this potential time bomb? We are still in the process of developing our awareness. Most states have floodplain management programs, and quite a few have dam safety programs. Fewer have both, and these often are not housed together; my impression is that not that many states are closely coordinating the two efforts. To add another factor, the emergency management agency should play a role as well, and this probably is not happening very often. In Wisconsin, we are just starting to work on coordination with our Division of Emergency Government.

On the federal side, some things are starting to happen. One agency (FEMA) has been given responsibility for dam safety. Since FEMA also houses floodplain management and emergency preparedness, there is a potential for some melding of these programs into an integrated approach. Indeed, integrated emergency management efforts could help us get there. Realistically, there is much to be done to address the problem fully. One of our biggest difficulties is identifying and mapping the hazard areas accurately so that regulations and insurance ratings can be realistic and reasonable.

Managing The Risk: The Future

Here are some key steps to be taken:

1) Identify the potentially affected areas below dams.

   - Assume any dam can fail and will eventually be removed.
   - Perform a "dam break" analysis at a specified flood frequency. (Note: water surface elevations resulting from failure during a flood will almost always be higher than those caused by "sunny day" failures.)
   - Do not neglect upstream areas. These should be regulated on the assumption of the dam not failing since this causes a higher upstream profile.

2) Take steps to limit the risk in the identified hazard areas.

   - Hold regular inspections to encourage improved dam maintenance.
   - Establish dam design standards to set an appropriate level of risk, assuming proper operation and maintenance.
   - Develop emergency preparedness plans (required by FERC for licensed dams) and warning systems where appropriate.
   - Require proper dam operation (set limits and criteria).
   - Require proper design and construction for new dams and for significant repairs or alterations to existing dams.
   - Guide land use and development to reflect the hazard (zoning). Insurance "disincentives" would be helpful, but it is difficult to assess the risk to damage unless major simplifying assumptions (e.g., all inadequately maintained dams will fail during the 100-year flood) are made.

Wisconsin's Current Initiative

While we have not addressed all of the above program elements, the Wisconsin Department of Natural Resources has recently proposed two administrative rules that deal with this issue.

1) NR 116--Floodplain Management: Revisions to existing rule to require zoning of areas downstream from dams. If the dam can safely pass the 100-year flood, zoning will be based on the "no-dam" condition to ensure that future removal of the dam does not jeopardize downstream development. If the dam cannot safely pass the 100-year flood, zoning must be based on failure of the dam during that event.

2) NR 333--Dam Design and Construction Standards: Requires identification of area affected by failure of the dam during the 100-year flood. Establishes a hazard classification based on existing development in this area.

The higher the hazard classification, the larger the required spillway capacity. When someone wants to build a new dam or undertake "major reconstruction" of an existing dam, the rule provides the option of controlling downstream land use to maintain the present hazard classification or providing the greater hydraulic capacity required for a "high hazard" dam.

What Might Be Done Under the NFIP?

Given the variability of dams and how well or poorly they are operated and maintained, having an actuarially-based rate structure for insurance in affected downstream areas seems out of reach. Instead, I suggest that FIA concentrate on:

- Mapping potential hazard areas during new studies or restudies using both dam break analysis and the "no dam" condition.
- Providing some kind of rate incentive for proper dam maintenance (e.g., failure of a periodic certification by a public agency or qualified consultant that a dam meets acceptable standards might result in no insurance or increase the rate).
- Avoiding the creation of an incentive to build below dams by limiting recognition of the protection they offer. The approach Wisconsin is proposing may be a model.
- Alternatively, considering whether insurance for protection of downstream development might not be considered a responsibility of the dam owner (the problem here is separation of "natural flooding" damages from the added ones that may be caused by dam failure).

What Can the States Do?

- With local input, identify areas (or at least communities) at risk from dam failure and develop priorities for mapping and corrective/preventive measures.
- Ensure an adequate dam safety program that includes regular inspections plus other inspections as needed; engineering review of plans for construction, alteration, and major repair; the ability to prescribe methods of operation; and the ability to take necessary action to correct violations.
- Establish appropriate standards for land use control in affected areas and assist locals to adopt and administer zoning based on them.
- Assist locals and dam owners to develop emergency action plans.
- Within capabilities and based on the level of federal assistance, conduct analyses of dams to delineate the hazard areas.
- Inform the public of the risks.

What Can Locals Do?

- Be aware of the problem. Help maintain citizen awareness.
- Plan community growth around (not in) the hazard area.
- Encourage proper dam operation and maintenance by the owners.
- Help the state identify hazard areas.
- Take the lead in hazard mitigation planning and implementation.
- Adopt and administer adequate zoning ordinances.

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DAM SAFETY AND LAND USE
AN IOWA CASE

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The purpose of this paper is twofold: first, to present the facts of a case in point about dam safety and downstream land regulations; and second, to discuss the implications of that case on dam safety regulations not only in Iowa but across the nation. This situation is somewhat unique in that it involves dam safety litigation resulting from restrictions placed on land use downstream of a dam and not from actual damages sustained from the failure of the dam.

Facts of the Case

The Dam

Yeader Creek is a small creek (10 square mile drainage area) with its upper watershed located in a heavily urbanized part of Des Moines, the capital city of Iowa. From the urbanized portion, Yeader Creek flows out of the city limits into a relatively undeveloped part of Polk County, back into the city limits briefly and into the Des Moines River a short distance thereafter.

In 1965, the Polk County Conservation Board proposed the construction of a dam across the lower portion of Yeader Creek to create a recreational impoundment as part of a county park. Plans called for the construction of a compacted earth fill dam 1850 feet long and 39 feet high; a concrete chute spillway with a 30-foot long sharp-crested weir; and an SAF-type stilling basin. Water storage was estimated as 3,200 acre feet at normal pool and 6,200 acre feet at the top of the dam. In essence, the dam proposal was for a well designed structure typical of many dams in the Midwest.

Since 1957, the State of Iowa has had legislation regulating dams and other floodway construction. Administered by the Iowa Natural Resources Council, the law required approval of the Council prior to construction. The plans for the proposed dam were submitted to the Council for review in 1965. In view of the low damage potential of downstream lands at the time of review, the dam was assigned a low hazard potential.

Design standards then in effect required that low hazard dams be able to safely pass a design flood resulting from a rainfall of 7.55 inches in six hours over the upstream watershed. The review showed the dam could safely pass a flood resulting from a rainfall of ten inches in six hours, thereby exceeding Council standards. All other design standards were met and the Council approved the construction of the dam. The dam was completed in 1967 and has since been well maintained and is considered structurally sound. As part of the County's Easter Lake Park, the dam became known as the Easter Lake Dam.

Easter Lake Estates Mobile Home Court

In 1972, Ronald Woods purchased land along Yeader Creek a short distance downstream of the dam. Inquiring as to the feasibility of building a mobile home park on his land, Council staff informed Mr. Woods that approval of the Council would be necessary prior to construction. Notwithstanding, he constructed a mobile home park in 1976 and 1977 as Easter Lake Estates, Inc. and began renting spaces for mobile homes. The mobile home court is located within the Des Moines city limits and was permitted by the city, which had no floodplain regulations at the time.

National Dam Safety Act

Pursuant to the directives of the National Dam Safety Act of 1972, 33 U.S.C., Sec 47 et seq. (1976), the Council, under contract with the Corps, began inventorying all nonfederal dams in Iowa. Initial investigations showed that the Easter Lake dam should be classified as a high hazard dam due to the presence of the mobile home court downstream.

A more detailed investigation of all high hazard dams in 1979 showed that the Easter Lake dam would overtop during the probable maximum flood (PMF), the nearly universal design standard for high hazard dams. In fact, the dam would overtop during the occurrence of the 1/2 PMF. Floodwaters flowing over the dam would first cut off access to the mobile home court and progressively flood the mobile homes by as much as nine feet as the dam embankment eroded. Clearly, loss of life and substantial property damage could result. The dam safety report classified the dam as a "nonemergency high hazard dam" and recommended removal of the mobile home court.

Agency Action Against Easter Lakes Estates

Prompted by the dam safety report recommendation, the Iowa Natural Resources Council commenced proceedings against the mobile home court. Various

alternatives to removal of the mobile home court were considered (e.g., modification of the dam) by the Council but rejected as infeasible. The Council found that the mobile home court constituted a nuisance and ordered it removed within five years. Under Iowa law, the Council had specific powers to abate nuisances related to floods and floodplain construction. A flood warning system and other safety measures were also ordered by the Council for the interim period.

Court Action

Easter Lake Estates, Inc. appealed the Council's removal order to district court, which affirmed the order, and to the Iowa Supreme Court which upheld the district court's ruling Easter Lake Estates, Inc., vs. Iowa Natural Resources Council, 328 N.W. 2d 906,909 (Iowa 1982).

Although the removal apparently is proceeding as ordered, the mobile home court has now filed suit for damages against the state, Polk County, the City of Des Moines, and the assessor who determined the value of the property prior to purchase. A court date has not been set at this time, but information available indicates that a variety of allegations have been made, including an unconstitutional "taking." The order approving the dam contained a condition that the applicant, Polk County Conservation Board, obtain necessary easements prior to construction, but downstream easements were not specifically required by the Council.

Apparently, the plaintiff feels downstream easements should have been obtained as the presence of the dam encumbered downstream lands. Needless to say, the suit raises some interesting questions and bears watching.

Implications of Easter Lake Estates vs. INRC

The supreme court decision, while not addressing all relevant issues, did endorse some issues that could have relevance in other states. Some of these are discussed below.

Public Nuisance

The court agreed that the danger to the mobile home occupants was sufficient to constitute a nuisance which in turn justified the removal order even though the dam was structurally sound. An earlier Iowa case, Iowa Natural Resources Council vs. Van Zee, 261 Iowa 1287, 158 N.W. 2d 111 (1968), established that the lack of a permit in itself was not sufficient to compel removal of an illegal levee. Therefore, removal was justified on the merits of the nuisance finding alone. Based on this, other states may be able to take

similar actions under a nuisance clause even if they have no state permit system.

Stringent Design Standards for Dams

The court substantiated the use of an extreme flood event (i.e. probable maximum flood) for dam design standards. In view of the catastrophic consequences inherent in a dam failure, the court found the stringent design standards to be reasonable. This, of course, contrasts to the usual 100-year flood standard used in typical floodplain delineation and regulation.

Recognition of the Public Use Aspects of a Dam

Accepting the stringent design standards as reasonable, the court then realized that either the dam and lake had to be removed or substantially modified (which was not feasible) or the mobile home park had to go. Weighing the merits of both sides, the court recognized that removal of the dam would impair or affect a beneficial, public use. And the court found that the mobile home court had to go, although the illegal nature of the mobile home court was given considerable attention. The implication is that courts will recognize the public benefits provided by dams.

Other Questions Raised by Ensuing Litigation

The suit now filed against the state, Polk County, the City of Des Moines, and the assessor raises some interesting questions. Should easements automatically be required downstream of dams that could fail? In mapping floodplains below dams and implementing appropriate land use restrictions, should state agencies accept conditions as they exist and ignore the broader liability questions that would result from implementing stringent land use restrictions? Are assessors responsible for recognizing the inherent safety dangers and land use restrictions below dams (or, for that matter, on any floodplain)?

As this matter is in litigation and the state is a party, prudence prohibits a more weighty discussion of the merits of the case, but the implications of a decision are evident.

Summary

In closing, let me remark that dam safety issues and programs must be an integral part of any floodplain management, flood insurance, or flood hazard mitigation program. Hardly a year goes by without a report of a dam failure. Many dams built in the 1920s and 30s or earlier are aging, were under-designed,

and certainly will not last forever. We, as floodplain managers, cannot ignore dam safety hoping it will go away, because, quite simply, it will continue to haunt us unless we take positive steps to address it.

NATIONAL DAM SAFETY

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Background

The National Dam Inspection Act (P.L. 92-367) was enacted in August, 1972, after a series of dam failures and near failures: the near failure of the Lower Van Normal Dam in San Fernando, California, on February 9, 1971; the failure of the Buffalo Creek, West Virginia, mine refuse embankment dam a year later; and the dam failure at Rapid City, South Dakota, in June, 1972. The law required the Corps of Engineers to compile an inventory of all the dams in the United States and to perform safety inspections of them.

Congress, however, did not fund the inspection program until late 1977 after the failure of the Kelly Barnes Lake Dam in Toccoa, Georgia. The results of the program show that there are over 68,000 dams meeting the size criteria of 25 feet in height or impounding 50 acre-feet or more of water if six feet or more in height. Over 95% of the dams inventoried, or about 64,000, are non-federal. Of these, the Corps inspected some 8,800 high hazard dams. About one-third, or more than 2,900, were determined to be unsafe, and 131 were classified as emergency unsafe.

In July, 1979, FEMA was assigned the responsibility of coordinating and promoting dam safety by Executive Order 12148. FEMA's most challenging task is to encourage the establishment and maintenance of effective nonfederal dam safety programs to reduce losses from a dam failure.

Issues

To reduce potential losses downstream of dams in the event of failures, certain tasks, similar to those undertaken by the National Flood Insurance Program (NFIP), are being addressed by dam safety programs. These tasks include but are not limited to the following:

Hazard Identification

As the NFIP produces flood hazard maps showing the affected areas of the base flood, FEMA recommends the mapping of potential inundated areas downstream of dams to notify communities of the potential hazard and to designate areas

requiring emergency action plans. To assist states, locals, and dam owners to perform such planning, we will be providing a method developed by Danny Fread of the National Weather Service for determining downstream flood areas as a result of a dam break. This effort will be carried out in addition to those undertaken by states that received awards from FEMA's Dam Safety Financial Assistance Program during fiscal years '83 and '84.

Emergency Preparedness Planning

If a dam should fail, it is important that anyone immediately downstream be notified as soon as possible so that measures can be taken to reduce the potential for loss of life resulting from the impact of the flood wave and extensive flooding. Downstream communities should have warning and notification procedures, along with plans to evacuate, available and ready to implement. Guidelines will be published this year to assist communities downstream of dams in the development of flood preparedness plans or to evaluate the effectiveness of existing plans. FEMA also will be providing, through the efforts of the Interagency Committee on Dam Safety (ICODS), guidelines for emergency action planning.

Training

One identified need in the nonfederal sector of dam safety is for training assistance since many states lack personnel competent to conduct inspections and other safety activities. FEMA encourages states to establish their own training program. For states with constraints on funds and staffing, a catalog of training courses available from federal agencies will be published this summer. Most agencies will allow nonfederal personnel to attend such courses on a space-available basis and, in some cases, without a fee.

Public Awareness

Increasing public awareness is one of FEMA's biggest efforts. Reduction of loss of life and property can be improved through such public awareness efforts as simply notifying communities of upstream dams and the status or classification of the dams. Inundation maps and warning and evacuation plans are two means of increasing public awareness of the hazards associated with dams. Earlier this year FEMA funded the state of Colorado to develop an awareness program through the Dam Safety Financial Assistance Program. It is hoped that the results of this project will be transferable to other states. One of FEMA's most successful efforts has been a series of workshops conducted in

conjunction with the states to inform participants of not only the hazards but also of the responsibilities and liabilities associated with dam ownership.

Risk Management

The flood associated with a dam failure may well exceed the base flood elevation immediately downstream of the dam and possibly farther downstream as well. Yet the flood maps of communities in the NFIP do not take into account dam failure. Randomly selecting 100 dams, a Dewberry and Davis study showed that 219 communities in both the emergency and regular programs would be affected by flooding above the 100-year flood level in the event of dam failure. The identification on flood hazard maps of the areas at risk from a dam failure would be a means of reducing the potential losses of life and damage to property, because such identification would facilitate sound local land use management and emergency planning.

Summary

This focus on the common areas of the Dam Safety Program and the NFIP demonstrates how the Integrated Emergency Management System can be beneficial. Through IEMS, emergency management organizations, states, and local governments can maximize their available resources to achieve overall protection of citizens from interrelated multiple hazards.

PART TWO

SPECIAL HIGH RISK FLOOD AREAS:

Coastal High Hazards

SEA LEVEL RISE, COASTAL EROSION, AND WETLAND LOSS IN LOUISIANA: THE NEED FOR A COMPREHENSIVE POLICY STUDY

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Introduction[1]

Since the beginning of recorded history, sea level has risen so slowly that, for most practical purposes, it has been constant. This slow rate of rise has allowed plants and animals to thrive along the coast, encouraging a biological diversity that was not possible when sea level was rising three feet per century after the last ice age. At the mouth of the Mississippi, for example, it permitted the sediments delivered by the river to form a delta with thousands of square miles of wetlands ranging from salt marshes to cypress swamps, supporting alligators, eagles, fur-bearing animals, and one-quarter of the nation's seafood harvest. Civilization has also prospered along the water. Aside from temporary increases in water levels during major storms, we have had little reason to be concerned about rising seas.

Recently, however, the view that sea level changes are unimportant to today's activities has been called into question. Tidal gauges have recorded a relative rise in sea level of three feet per century along the coast of Louisiana (Hicks et al., 1983), and the wetlands there are eroding at a rate of 40 square miles per year because society has thwarted the processes by which

[1] The views expressed herein do not represent the official views of the Environmental Protection Agency, the Fish and Wildlife Service, or any other agency of the United States Government.

the Mississippi delta formerly kept pace with rising sea level (Gagliano et al., 1981; see also Jantzen, 1981; Baumann et al., 1984; Louisiana Coastal Commission, 1982; and U.S. Army Corps of Engineers, 1984). (Tidal gauges measure relative sea level rise, which includes land subsidence and global sea level rise.) The rate of relative sea level rise along the highly developed Atlantic Coast has been one foot per century (Hicks et al., 1983), enough to cause significant erosion along most recreational beaches (Pilkey et al., 1981; New Jersey Department of Environmental Protection, 1981; and State of Massachusetts, 1981).

The expected greenhouse warming could accelerate these trends. Increasing concentrations of carbon dioxide, chlorofluorocarbons, methane, and nitrous oxide are likely to raise the earth's average temperature 3-8°F in the next century (Charney, 1979). Such a warming would cause ocean water to expand, mountain glaciers to melt, and, possibly, polar glaciers to disintegrate. Although global sea level rose only four to six inches in the last century (Gornitz et al., 1982), the National Academy of Sciences (Revelle, 1983) and the Environmental Protection Agency (Hoffman et al., 1983; Hoffman, 1984) have estimated that it will rise one and one-half to five feet in the next century.

Local governments throughout the coastal zone of the United States are formulating strategies in response to erosion caused by current sea level trends.[2] The decisions they make could involve controversial choices between individual and community rights. These officials view the prospect of an accelerated sea level rise as a sword that could cut either way. It may generate the public awareness necessary to enact measures that would be required to address current problems; but it also could overwhelm their efforts or, if subsequently proven to be a false alarm, make their foresight look like folly. Coastal officials want to know more about sea level rise as soon as they can, but many fear that they will have to act before they know enough.

[2]Almost every coastal state has a coastal management agency affiliated with the federal government's Office of Coastal Zone Management. These agencies work with local governments such as Ocean City, Maryland; Atlantic City, New Jersey; and Terrbonne Parish, Louisiana to develop planning and engineering responses to erosion. Many of the participants are unaware of the extent to which erosion is caused by relative sea level rise, a factor that has often contributed to local decisions to use groins and other measures that are ineffective at addressing erosion caused by sea level rise.

Nowhere is the need to do something about the erosion caused by relative sea level rise better established or more urgent than in coastal Louisiana. For over 6,000 years, nature has allowed the Mississippi River Delta to keep up and even expand with a rising sea (see Gagliano et al., 1981; and Gagliano, 1984). Even the additional sea level rise from the greenhouse effect would not, by itself, prevent more than about half the delta from continuing to thrive. Yet human activities are preventing the delta from keeping pace with current sea level trends to the point that 1% of the wetlands are destroyed every year, and that rate may be accelerating.

In the last twenty years, scientists have established beyond any reasonable doubt the human causes of wetland loss in Louisiana: levees, dams and reservoirs, river control activities, and canals. No one denies that these activities have played an important role in the economic development of Louisiana and the nation. But it is now time to ask: Is there no way to modify these activities so that we can avoid losing one of the most important aquatic "farms" in the United States?

The scientists and local governments have done their job; there is a wealth of information and the public perceives that there is a problem. But the questions remain: how much more vulnerable will New Orleans be to a hurricane after the wetlands have vanished? Where will America get its seafood and how many fishermen will lose their jobs? How should building codes and flood insurance provisions be modified? How would these outcomes change if the Mississippi River was diverted or if ring levees replaced river levees? Would the public prefer minor variations of the status quo or a fundamental departure from current policies if it fully understood the consequences that await us and the options by which they might be avoided? How much would the projected rise in sea level accelerate the destruction of wetlands or change the best way to address the problem?

We hope that our efforts will stimulate the awareness necessary to address these issues, because time is running out. This paper addresses human causes of wetland loss in Louisiana, and proposes a policy study of the possible solutions. Coastal erosion in Louisiana is no longer an issue of interest only to scientists, engineers, and analysts. Our goal is to ensure that the public and all levels of government have the information to determine and possibly alter the fate of coastal Louisiana while there is still time to do so.

Sediment Transport and the Delta

The Mississippi River Delta formed over thousands of years as sediment was deposited along the lower portion of the river, and through accumulation of organic material in the associated wetlands. The river branched out into several distributaries, each of which carried fresh water and sediment to the Gulf. As ridges (natural levees) formed along these channels, the delta would gradually advance into the sea, with low-lying marshes occupying the areas between the channels. Much of the water and natural levee-building concentrated around a single main channel, which advanced farthest into the sea. Because this process lengthened the river's course, the river would eventually divert most of its flow to a shorter route to the sea, and the process of natural levee building would repeat itself. Previous main channels include Bayou Lafourche and a route extending east from New Orleans. Today, only the Old River Control Structure at Simmesport, Louisiana prevents the main flow of the Mississippi River from switching to the Atchafalaya River.

Thus, coastal Louisiana today consists of numerous thin ridges along present and former distributaries of the river, on which most development has occurred. In between are thousands of square miles of highly productive wetlands ranging from freshwater swamps to salt marshes, on which Louisiana's $400 million seafood industry and many wildlife resources depend (Davis, 1974).

Although the river has always carried life-sustaining sediment to the wetlands, natural destruction of marshes has taken place as well. When the main flow changes its course, most of the sediment is diverted to the new main channel and wetlands associated with the former main channel(s) receive less sediment. As the deltaic sediments subside and sea level rises, the outer wetlands along the former main distributary revert to open water. Furthermore, because salt water from the sea is no longer held back by the river flow, it diffuses upstream and kills cypress swamps and other wetlands that cannot tolerate salt. Until people interrupted the natural cycle, occasional river flooding provided sufficient sediment for most of the delta to keep up with subsidence and sea level rise. New growth fully offset the natural loss of older delta areas.

Most of us learned in school that the Mississippi Delta is thereby growing into the Gulf of Mexico. Unfortunately, this is no longer the case. The natural processes that created and sustained the wetlands are being thwarted by human beings, and the wetlands are now disappearing at a rate of 40-50 square

miles per year (Gould, 1970) (see Figure 1), implying that in the next 20-25 years, Louisiana will lose an area equal in size to the state of Rhode Island. The projected rise in sea level from the greenhouse effect will further accelerate the rate of wetland loss.

The Disappearing Delta

The forces of nature once supplied the Mississippi River Delta with sediment in a fashion that maximized the area of marsh creation, but we have modified the plumbing of the Mississippi in a way that comes close to maximizing the rate of marsh destruction. As sea level rises three feet per century relative to the land, the sediment that once allowed wetlands to keep pace with this rise is deposited off the edge of the continental shelf, because of flood and river flow regulation. Salt intrusion caused by a variety of activities is killing cypress swamps and some types of marshes. (By "river flow regulation," we include 1) river control structures whose primary purpose is to divert water; and 2) levees that seal off minor distributaries. The latter are designed with flood control in mind, but water diversion also occurs, a fact that is sometimes overlooked.)

A quick glance at a map of Louisiana tells the story about sediment supply (Gould, 1970) (Figures 2 and 3). Along the main channel of the Mississippi, the delta has advanced far into the Gulf. To facilitate economic development and provide flood protection, the Corps of Engineers has constructed river control structures and levees which have sealed off minor distributaries. These flow regulation activities now confine 70% of the river flow to the main channel as far downstream as the Birdfoot Delta. These structural measures maintain the flow down the main channel, and by decreasing sediment deposition, help maintain a deep navigation channel to the Gulf of Mexico. Although the artificially maintained river banks south of Venice do not protect property from floods, they have more than paid for themselves in reduced dredging costs,[3] disregarding their impacts on wetlands.[4]

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[3]For example, see, U.S. Army Corps of Engineers (1984). Page 2 states that a proposed levee system would reduce baseline dredging requirements from 54.2 to 12.7 million cubic yards per year.

[4]The ability to estimate wetland loss associated with levees is fairly new. The U.S. Army Corps of Engineers project, for example, does not estimate the wetland loss associated with sediment starvation induced by the levee system. However, Steve Mathies of the New Orleans District says that a planned levee extension along the Atchafalaya River will incorporate such an analysis.

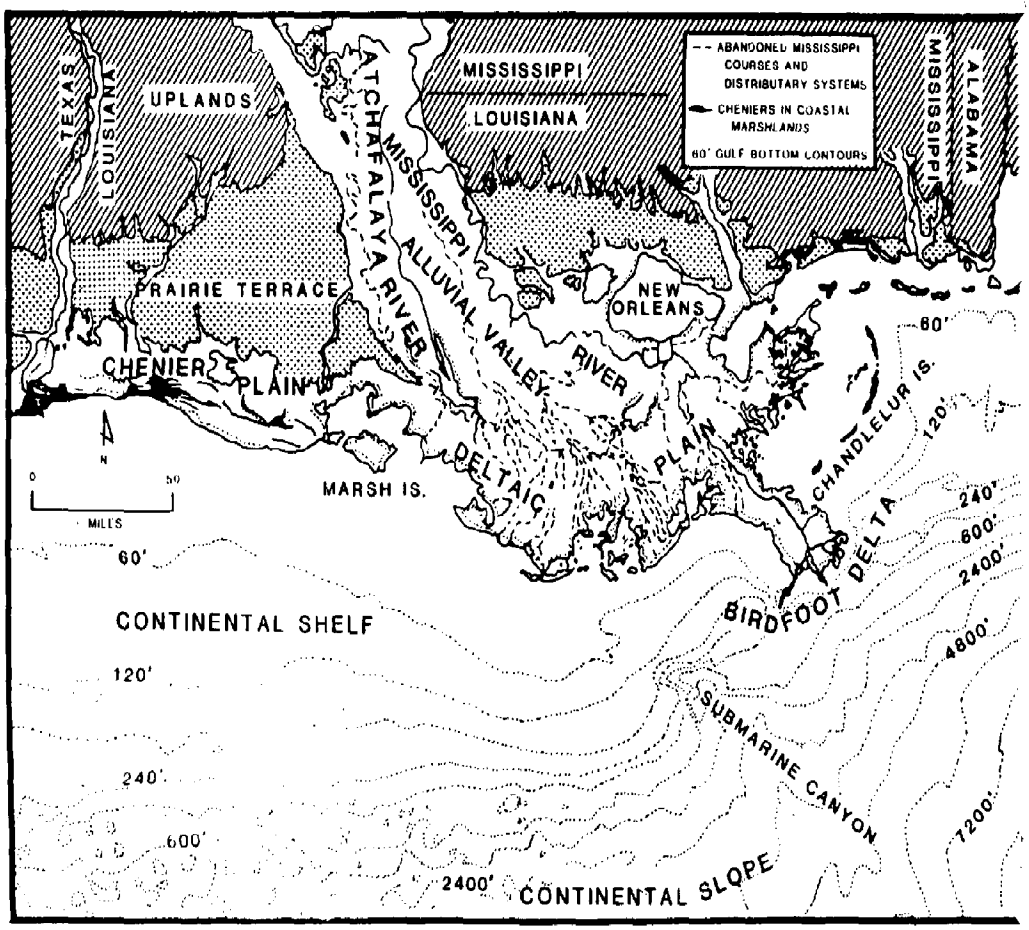

Figure 1

The Mississippi River Delta

ACTIVE DELTA 1956

Figure 2

Legend

Symbol	Habitat Type
	Marsh
	Forested Wetland
	Upland
	Dredge Deposit

Scale

2.5 0 2.5 5.0 7.5 10.0

Miles

SOURCE: U. S. FISH AND WILDLIFE SERVICE NATIONAL COASTAL ECOSYSTEMS TEAM

ACTIVE DELTA 1978

Figure 3

Legend

Symbol	Habitat Type
	Marsh
	Forested Wetland
	Upland
	Dredge Deposit

Scale

2.5 0 2.5 5.0 7.5 10.0

Miles

SOURCE: U. S. FISH AND WILDLIFE SERVICE NATIONAL COASTAL ECOSYSTEMS TEAM

Without river flow regulation, the Atchafalaya River would capture an increasing volume of the flow of the Mississippi and cause more wetlands growth around its mouth. The many smaller bayous that have been sealed off by levees would also carry water and sediment; wetland losses from sediment deprivation and salt intrusion would be much less. It is easy to understand why marsh creation would have been greater. Along most of the coast where sediment would normally be deposited, the Gulf is less than 20 feet deep, while it is over 400 feet deep outside the continental shelf where the sediment is now being deposited. Because the water is over twenty times as deep at the end of Birdfoot Delta, additional marsh creation requires over 20 times as much sediment. Thus, flow regulation has caused the delta-building process to be less than one-twentieth as efficient at creating marshland as it used to be.[5]

Besides sealing off minor distributaries, levees also contribute to wetlands loss by preventing them from flooding. Much of the sediment that would normally allow marshes to keep pace with relative sea level rise was supplied by annual flooding of the river. By preventing the river from overflowing its banks, the levees keep life-sustaining sediment, freshwater, and nutrients from reaching adjacent wetlands.

A final cause of wetland destruction concerns saltwater intrusion. Both natural and artificial canals for navigation within the wetlands permit saltwater to reach brackish and freshwater environments. Cypress trees and other vegetation frequently die, and the wetlands convert to open water. Flow regulation increases freshwater for some areas and decreases it for others, allowing saltwater to intrude farther into such areas as distributaries that have been sealed off and the mouth of the Atchafalaya River. By slowing the flow rate, sea level rise allows salt water to intrude farther inland everywhere.

Implications of the Greenhouse Effect

A rise in sea level from the greenhouse effect would accelerate the loss of wetlands that Louisiana is experiencing today. Marsh drowning and saltwater intrusion both would increase. The time required for Terrebonne Parish to

[5]This assertion is a result of elementary geometry. If the water is twenty times as deep, it takes twenty times as much sediment to reclaim land from the sea.

convert to open water, for example, would be reduced from 100 to 60-75 years, if no action is taken.[6] The local government there has developed a 25-year construction plan to help restore natural processes and curtail wetland loss. Given the long lead time necessary for gaining a public consensus on the public works that may have to be built or modified, decisions that local officials might like to delay until 2020 will probably be necessary within the next ten years.

One of the most important problems concerning the greenhouse effect is our inability to forecast future sea level rise accurately. Although much of the nation has the luxury of being able to wait 20 years until better forecasts are available, Louisiana does not. Thus it is very likely that we will have to develop a wetland protection strategy that addresses the possibility of a "greenhouse" rise in sea level before we know what its magnitude will actually be.

Nevertheless, the sooner we have better forecasts of sea level rise, the sooner Louisiana will be able to develop strategies that address an accurate understanding of what lies ahead. Several federal agencies fund research concerning the greenhouse effect and sea level rise, including the Department of Energy, the Environmental Protection Agency, the National Academy of Sciences, the National Science Foundation, the National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration. Although the outcomes of decisions involving billions of dollars in Louisiana alone will depend on whether we can accurately anticipate future sea level rise, the federal government only spends about $100,000 per year developing better forecasts. Recognizing the need for better information, Terrebonne Parish recently became the first local government in the nation to call for increased federal efforts to forecast sea level rise (Terrebonne Parish Council, 1984).

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[6]This is a conservative estimate. Given current trends of relative sea level rise (3 feet per century), Terrebonne could completely erode in 100 years. EPA's "low" scenario implies that sea level will rise 0.8 feet by 2050, by which time subsidence should be 2.2 feet for a relative rise of 3 feet by 2050. EPA's "mid-range high" scenario implies a rise in relative sea level of 3 feet by 2040. Thus, the greenhouse warming could accelerate the occurrence of a 3-foot rise from 2080 at current trends to between 2040-2050. We further note that EPA's "high" scenario would imply a relative rise of 3 feet by 2025, but that scenario is extremely unlikely.

Saving the Land

The most fundamental threat to any government is the possibility that its land will be taken away. In response to current trends, local governments and the State of Louisiana have initiated a level of effort unprecedented in the history of environmental protection. The Louisiana Legislature created a $35 million Coastal Protection Trust Fund to research, develop, and demonstrate methods to slow coastal erosion. Local governments have also appropriated millions of dollars, and have been joined by private landowners such as Texaco and Tenneco LaTerre. Terrebonne Parish has initiated a public awareness campaign that includes billboards, pamphlets, slide slows, and its secondary school curriculum (Edmonson and Jones, 1984).

The federal government, however, has played a much smaller role in trying to develop a solution to the problem of relative sea level rise and land loss in Louisiana. This is unfortunate because a wide variety of federal activities are inextricably intertwined with both the problem and any possible solution. The Corps of Engineers is involved with river control, levee construction, freshwater diversion, dredging, and coastal land loss studies. The Federal Emergency Management Agency operates the National Flood Insurance Program, which already pays more flood claims to two parishes in Louisiana than anywhere else. The Environmental Protection Agency, the Fish and Wildlife Service, and the National Park Service all have vital mandates to maintain the important ecosystems of coastal Louisiana, which has one-half the nation's coastal wetlands and produces one-quarter of the nation's seafood harvest.

The history of environmental protection in the United States suggests that although the state and local efforts are a start, they will not be sufficient without significant intergovernmental cooperation and a federal mandate to correct the problem. Solutions to environmental problems, even when economically justified, are almost always too controversial and involve too many jurisdictions outside of local control for a state government to implement on its own. This is even more the case in Louisiana, where federal policies involving navigation and flood mitigation are largely the root of the problem. Only the federal government can undertake the basic research or the reevaluation of its own practices that will be necessary to adequately address coastal erosion and wetland loss in Louisiana.

The major reason for optimism is that the river carries enough sediment to sustain a large portion of the wetlands. Our challenge is to devise a strategy

that can take advantage of the forces of nature, without sacrificing the tremendous economic infrastructure that was unfortunately developed without an understanding of the consequences of subsidence and rising seas. Terrebonne Parish has developed such a plan but requires more accurate forecasts of sea level rise and the actions of other government agencies before final budget estimates can be solidified.

We cannot rule out the possibility that coastal Louisiana must eventually choose between becoming like Holland or like Venice. (Already people discuss the possibility of a large dike along the marsh to harness the productive estuary; the possibility of several island cities in the Gulf of Mexico would not be altogether inconceivable for a culture that relied on water transportation for centuries.) If we allow events to overtake us, and merely respond to erosion as it occurs, these will be our only options. Only if we reexamine the activities that are causing land loss, only if we plan today, is there even the most remote chance that coastal Louisiana will remain the growing delta that it has been since the beginning of recorded history.

A Proposed Study of Solutions to Land Loss

Many government activities would benefit from a comprehensive study of the impacts and responses to relative sea level rise in coastal Louisiana. Such a study could provide a clearer understanding of the implications of what is known, and thereby suggest which coastal protection, wetland management, and hazard mitigation options warrant additional consideration. Our objectives include the following:

1) Provide the state of Louisiana with an independent overview of the costs and benefits from each of the wide variety of policy options at its disposal.

2) Provide participating parishes with an assessment of the impacts of wetland protection alternatives on their environment, and identify the interrelationships between the actions of particular parishes.

3) Provide Terrebonne Parish with data, analysis, and recommendations on optimizing the trade-off between flood protection and the vitality of its wetlands.

4) Provide EPA's Office of Policy Analysis with estimates of the environmental benefits of planning for sea level rise in Louisiana, and the value of better forecasts of sea level rise.

TERREBONNE PARISH HABITATS-1955

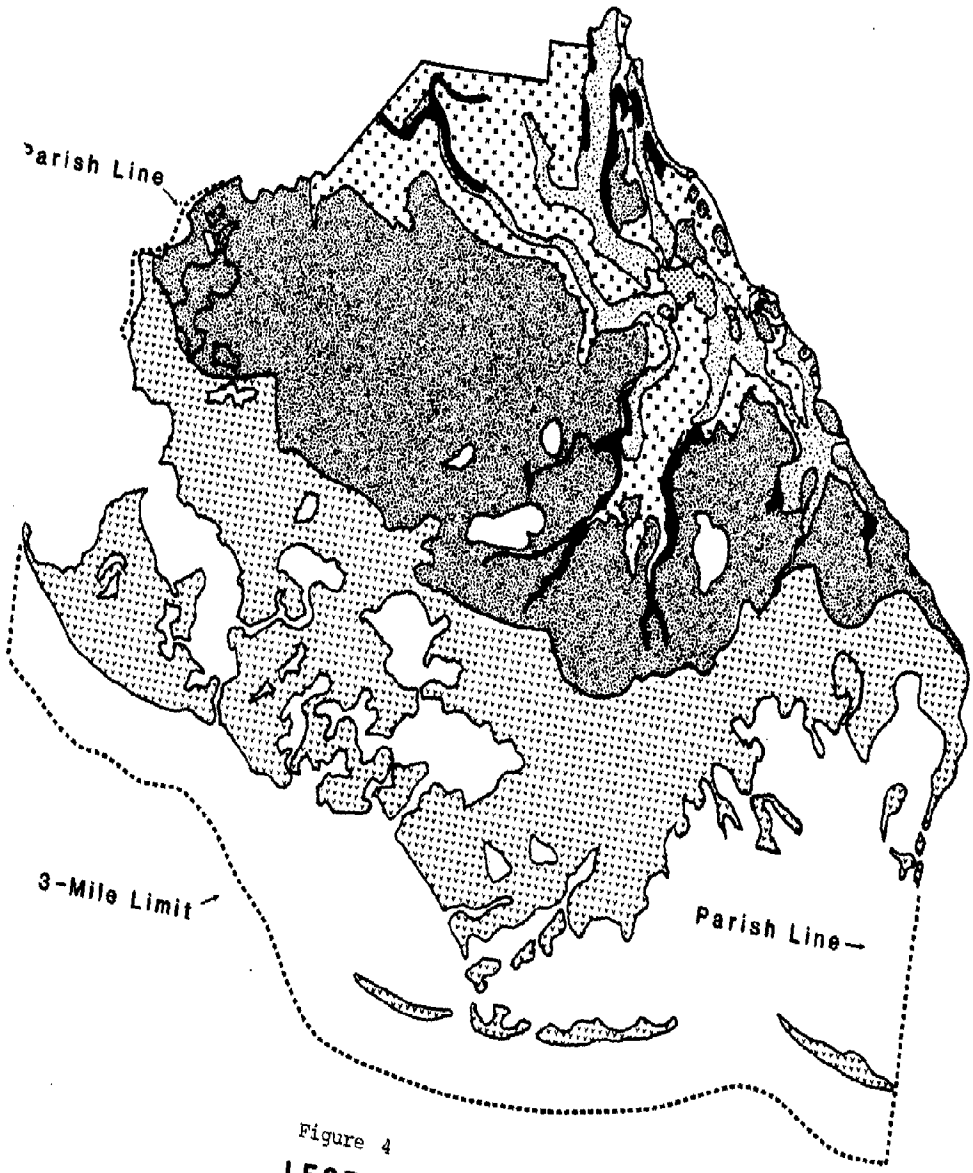

Figure 4

LEGEND

- Developed
- Agriculture
- Swamp
- Forest
- Fresh Marsh
- Non-Fresh Marsh

TERREBONNE PARISH HABITATS - 1978

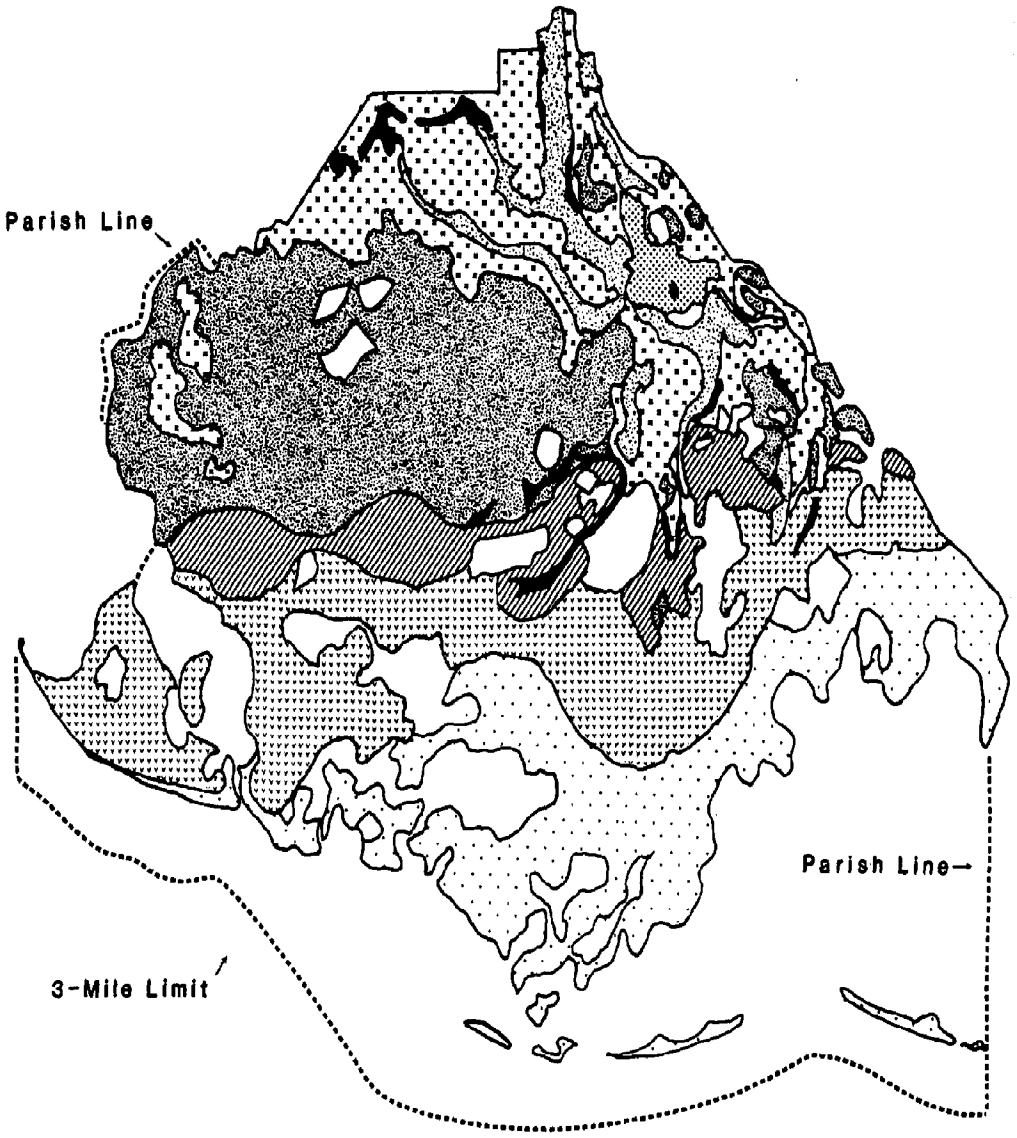

Figure 5

LEGEND

- Developed
- Agriculture
- Swamp
- Forest
- Fresh Marsh
- Intermediate Marsh
- Brackish Marsh
- Saline Marsh

5) Provide the Federal Insurance Administration and other offices within the Federal Emergency Management Agency with estimates of future flood damages, insurance premiums and payments, and federal disaster assistance under alternative wetland protection policies. Determine how frequently the insurance rate maps must be redrawn. Develop data necessary to assess whether rates should reflect the average risk over the life of a property, or current risk only.

6) Provide the Army Corps of Engineers with estimates of wetland impacts of alternative strategies of flood control, river control, and channelization under various sea level rise scenarios, and the impact of wetland protection strategies on the Corps' navigation, dredging, levee, and EIS activities.

7) Provide EPA's Office of Federal Activities and Region VI with estimates of the wetland loss that will result under alternative policies for various sea level rise scenarios.

8) Provide EPA's Office of Drinking Water with estimates of water quality for alternative policies.

9) Provide the Department of Interior's Fish and Wildlife Service and the National Park Service with useful information for management of wetlands under their control and for compliance with Coordination Act requirements. Provide the Mineral Management Service with projections of the value to coastal parishes of making offshore sand more readily available.

10) Provide legislators and people who allocate research budgets with estimates of the value of improving forecasts of future sea level rise and the resulting impacts.

11) Provide the research community with a ranking of research priorities.

12) Provide the citizens of Louisiana with an easily read document that explains the choices facing the state.

Research has been completed that sheds light on these issues, and this information could be used to project the impacts of additional sea level rise from the greenhouse effect. A wide variety of solutions has also been proposed. But the various pieces of the puzzle must be put together in a form appropriate for decision making.

Table 1 outlines the proposed study. The study should begin by projecting shoreline change expected under current management practices for current trends and two global sea level rise scenarios. It would rely on existing mapping studies, estimates of sediment transport, wetland drowning, and salt intrusion.

Next, a panel of leading coastal hydrologists, geologists, and engineers would specify a wide variety of technically feasible methods to slow or halt

net wetland loss. The possibility of the virtual destruction of coastal Louisiana as we know it is so real and so severe that drastic measures should not be ruled out in a comprehensive policy study merely because they appear politically infeasible today. Thus, the proposed study should cast as wide a net as possible in considering options, including

- Do nothing to stop erosion immediately, but build a large levee past which it could not proceed;
- Alternative river diversion and rediversion;
- More dredging in lieu of levees and jetties at South Pass and Southwest Pass;
- Alternative flood protection/levee strategies, including supplementing river levees with ring levees in well developed areas;
- Stopgap measures such as barrier island restoration, dune building, marsh building, and minor water diversions that prevent saltwater intrusion.

The costs and impacts of each of the proposed options would then be assessed. Flood damages would play an important part; river diversion, ring levee construction, and river levee destruction could all substantially change the flood damages in lightly developed areas. But the wetland destruction that would otherwise occur may leave New Orleans and other highly developed areas ripe for a hurricane disaster that would be much worse. Allowing the river to flow out of more distributaries would increase the Corps of Engineers' dredging requirements but might save costs for subsequent water diversion and hurricane protection projects.

We have no illusions about the level and quality of resources that must be invested to solve the coastal erosion problem in Louisiana. A comprehensive policy study is a small but necessary step in addressing a problem that will be with us for decades. The impacts of relative sea level rise are so diverse that no one government agency can be reasonably expected to address the entire problem. But all of these impacts must be laid out and estimated in a single document. The importance of Louisiana's wetlands demands nothing less than a clear picture of where we intend to go and how we intend to get there.

Table 1
STUDY OUTLINE

I. Use existing data to project shoreline changes under current levee, dredging, and water regulation policies, assuming current sea level trends (3 feet by 2085), a 5-foot rise, and a 7-foot rise by 2085.

II. Panel Specifies Alternative Coastal Management Options

- A. Current policies
- B. Atchafalaya natural diversion
- C. Atchafalaya delta management
- D. Diversion into former or new distributaries
- E. Sediment supplementation via jet-spray or hydraulic dredging
- F. Supplement or replace river levees with ring levees around major population centers
- G. Barrier island restoration
- H. Large hurricane protection levee along the Gulf Coast and wetland management inland of that levee
- I. Combinations

III. Estimate the impact on shoreline location and wetland acreage by type, for each of the management alternatives, using available research.

- A. Impacts for alternative implementation dates
- B. Saltwater intrusion along main channel of the Mississippi River and elsewhere.
- C. Flood risks to life and property from river and hurricane protection.
- D. Impacts on seafood production, loss of land, pelt production, highway maintenance, unemployment, other.
- E. Calculate the value of better forecasts of sea level rise.

IV. Design a study plan to provide better estimates or reference existing studies under the Louisiana Coastal Protection Trust Fund that would help secure better understanding of the impacts.

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THE COASTAL BARRIER RESOURCES ACT: PRESENT STUDIES

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Coastal studies are presently being conducted by the U.S. Department of the Interior to meet the requirements of the Coastal Barrier Resources Act which specifies the submission of a report to Congress in October 1985. The first important legislation that formed the basis of our present approach was the Omnibus Budget Reconciliation Act of 1981 (ORBA), passed in August 1981. This Act directed the Secretary of the Interior to conduct a study within one year that would result in proposed designations of undeveloped coastal barriers. As a result of this Act's passage, the Secretary established a Coastal Barriers Task Force--an interdepartmental group of people who had expertise in coastal matters. This group had representatives from the U.S. Fish and Wildlife Service, the National Park Service, the U.S. Geological Survey, the Federal Emergency Management Agency, the Solicitor's Office of the Department, the Congressional Liaison Office, among others. On August 16, 1982, the Secretary submitted a report to Congress recommending designation of 188 units as undeveloped coastal barriers, which included approximately 750 miles of the 2,700 miles of the Atlantic Ocean and Gulf of Mexico coasts. The principal effect of such designation was that, effective October, 1983, new development on these units was not eligible for federal flood insurance. In addition, the Secretary recommended that the Act be amended to include barriers that were designated as "otherwise protected."

On October 18, 1982, the Coastal Barrier Resources Act (CRBA) was signed into law as P.L. 97-348. This Act superseded the ORBA provisions concerning coastal barriers; it established and identified a 186-unit undeveloped Coastal Barrier Resources System along the Atlantic Ocean and Gulf of Mexico coasts. The units included were basically those recommended by the Task Force. Effective on October 18, 1982, the areas designated became ineligible for most kinds of federal assistance for such things as building bridges to the barriers,

sewage treatment plants, and roads; the federal flood insurance prohibitions were delayed until October 1983. In recognition of certain overriding national interests, the Act includes some areas excepted from ineligibility, such as defense, channel maintenance, highway maintenance, energy development, and research.

Included in the requirements of CRBA is the preparation of a report to Congress with "recommendations for the conservation of the fish, wildlife, and other natural resources of the System based on an evaluation and comparison of all management alternatives and combinations thereof," and "recommendations for additions to, and deletions from," the System. This study provision reflects the concern that the removal of federal financial assistance alone may not be adequate, in and of itself, to protect the identified System units. This report is currently being prepared by the Coastal Barriers Study Group, a group similar to the Coastal Barriers Task Force, with major field work conducted by four NPS field representatives. Regarding recommendations for additions to or deletions from the System, three bureaus within the Department of the Interior --the National Park Service, the Fish and Wildlife Service, and the Geological Survey--are working together to identify potential sites at these locations:

1) On the Atlantic Ocean and Gulf of Mexico coasts: protected areas, and areas that may be additions to or deletions from the Coastal Barrier Resources System; and

2) On the Great Lakes, the Pacific Ocean coasts, and the U.S. Trust Territorial areas: additional coastal barriers.

We have almost completed the accumulation of data for identifying additional undeveloped coastal barrier areas, and have tentatively identified on U.S. Geological Survey topographic quadrangles areas in California, Oregon, Washington, the Great Lakes, and the Caribbean. Aerial photography flights have been completed for most of the areas. The Trust Territories and Alaska remain to be studied, but only existing mapping and aerial photography will be considered as preliminary data indicate that an adequate job of identification can be done using this information.

The other part of this task--that of identifying the "otherwise protected areas" (local, state, and federal parks; federal and state wildlife areas; private conservation organizations' lands)--has just about been completed for the Atlantic Ocean and Gulf of Mexico coasts. The affected states have been

working with the Fish and Wildlife Service and the National Park Service to identify all protected areas by providing maps and documentation of the levels of protection. This exercise may lead to a recommendation that CBRA be amended to include these areas. It is the Study Group's position that these areas should be included within CRBA's protection as the exemptions under Section 6 of the Act allow continued federal assistance for protected areas as long as conservation and recreation are the management objectives. Inclusion of these areas within the System under the Act would prevent federal assistance only should the status of such areas change in the future to allow development. This amendment, if accepted by the Secretary, recommended to and passed by the Congress, would greatly enlarge the size of the present System and would increase the consistency of federal policy on coastal barriers. A similar study for the other coasts will also be completed.

We are examining proposals from state governments and other interested parties for additions to and deletions from the Coastal Barrier Resources System. One option we are considering is recommending that the definition of a coastal barrier in the Act be changed to include areas of consolidated sediment in high energy areas like the Florida Keys, larger bays like the Chesapeake, and important biological habitats in intertidal zones that do not have a landward aquatic habitat. Other considerations involve the possibility of redefining the "level of development," enlarging units based on state requests, and adding developed areas destroyed by storms or hurricanes. In line with the Act's mandate, we are cooperating with state and local governments and the private sector in defining criteria for any modifications to the existing criteria.

In directing us to consider additional management alternatives that foster conservation of the Coastal Barrier Resources System, Congress has provided us with the very exciting possibility that a wise federal policy could lead to further protection without further federal involvement! In response to this challenge the Study Group has focused on two major categories of governmental actions, in addition to financial assistance, that affect the coast: tax policy and permits/zoning. These issues are being analyzed at the state and local as well as the federal level.

The study process itself has been broken down into a series of components. The majority of state and local alternatives are being reviewed by the four NPS field representatives appointed by the Director specifically for this purpose.

They are responsible for assessing all state and local issues except the impact of tax policy as a possible management alternative. Federal alternatives are being considered by the Study Group in WASO, and include federal tax policy and the impact of federal permits on coastal barrier conservation.

To be more specific, the four NPS field representatives are collecting data on the current use and management of coastal resources on the Atlantic and Gulf coasts in order to 1) identify and evaluate resource management issues; 2) compare and evaluate existing state and local laws, regulations, and/or other mechanisms that encourage, facilitate, or adversely affect protection of the coastal barriers; and 3) review and assess the impacts and opportunities for private sector conservation initiatives, such as private land trusts and donations. The assessment of the feasibility of new management alternatives will be a part of the effort of both this group and the Study Group in WASO. These alternatives will include surplus property land exchanges and mechanisms for institutional cooperation (regional coastal commissions).

The Secretary will submit a report to Congress in October 1985 with the study's findings and recommendations. There are still many opportunities for the state and local governments, conservation groups, private citizens, scientific groups, and all others to submit their ideas and recommendations to the Department. We are trying to keep everyone informed through the Federal Register and other means. Remember, this is a cooperative effort.

LONG RANGE MANAGEMENT PLANS FOR BARRIER ISLANDS

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Introduction

Like the Gaul of Julius Caesar, coastal barriers may be divided into three parts. The total extent of U.S. coastal barriers along the Atlantic and Gulf shorelines is estimated to be approximately 1,685 miles in length with a land area of about 1.6 million acres (Table 1). For present purposes we may classify this total resource into subgroups according to the state of development and legal status. The first subgroup includes coastal barriers protected through public ownership or as holdings of the Nature Conservancy or other conservation organizations. This subgroup accounts for about 36% of the total barrier shoreline and slightly more than half of the total acreage. The second subgroup includes barriers that are undeveloped but not owned by a public or conservation organization. This subgroup is now synonymous with the "coastal barrier resource system" (CBRS) as established under the Coastal Barrier Resources Act of 1982. It comprises about 24% of the total barrier shorelines and 29% of its acreage. These barriers are "protected" to the extent that federal flood insurance and grants for such development infrastructure as roads, bridges, and erosion protection are precluded under the 1982 Act.

Barriers not included in the preceding subgroups are assigned to a third category most crucial for management purposes, namely "developed and unprotected." This subgroup accounts for about 40% of total shoreline length (1,058 miles) but only 17% of barrier acreage. This subgroup was the subject of the Conference on Managing Developed Coastal Barriers held in Virginia Beach, January 15-18, 1985. Since the other subgroups of barriers enjoy one or another form of protection, the developed and unprotected barriers clearly pose the most significant long-term management problems.

Table 1

Geographical Extent of Atlantic and Gulf Coastal Barrier Features

	Shore Length (in miles)				Land Area (in acres)	
	All Barriers		148 Major Barrier Islands			
	Miles	Percent	Miles	Percent	Acres	Percent
Total	2,685		1,610		1,645,000	
Undeveloped	644	24.0	334	20.7	480,000	29.0
Otherwise protected	954	36.0	624	38.7	885,000	53.7
Developed/unprotected	1,050	40.0	549	34.0	280,000	17.0

(Ringold and Clark, 1980)

(Godschalk, 1984)

Geographic Variation Among Developed Coastal Barriers

Management options for developed coastal barriers must reflect extreme geographic diversity that exists among their features. A paper for the Virginia Beach Conference classified coastal barriers according to various parameters: e.g., population size and density, date of settlement, economic function, land values, and political structure. For present purposes we may simply note that developed barriers range from full-scale "cities on the beach" (e.g., Miami Beach, Florida; Galveston, Texas; Atlantic City, New Jersey) to resort communities experiencing rapid and high density growth (e.g., Ocean City, Maryland; Clearwater, Florida) to more isolated resort communities with carefully planned land use patterns (Hilton Head, South Carolina; Captiva Island, Florida) to miscellaneous barriers having a mixture of developed and undeveloped areas (e.g., Topsail Beach, North Carolina; Amelia Island, Florida).

Developed barriers may also be distinguished according to the status of planning control. Jekyll Island, Georgia, is owned and totally planned by the State of Georgia. Some barriers are divided among multiple jurisdictions, both

municipal and county, while others are within a single political unit of local government. Some are governed by municipalities that are limited to the barriers such as Galveston, while others are part of much larger urban governments such as Rockaway Beach in New York City. Counties govern unincorporated areas. These and other factors complicate the problem of recommending long-term management policies for developed coastal barriers.

Assembly of appropriate data would facilitate the preparation of long-term management plans for barriers by states and their subunits of authority. Such plans should embrace at least the following elements of public policy concern:

- Ultimate population/development levels;
- Infilling policy;
- Erosion;
- Emergency warning and evacuation;
- Water supply;
- Wastewater management;
- Public open space and beach access;
- Cultural and historic preservation; and
- Natural area preservation.

Inevitably, federal policies and programs influence the realization of planning goals set forth above. The "federal consistence" provision of the Coastal Zone Management Act of 1972 may be operative to the extent that long-term barrier management plans are incorporated into overall state CZM plans. But several specific areas of federal influence should be targeted for particular attention.

Federal Subsidies for Infrastructure

Distinction between developed and undeveloped barriers in many places is arbitrary. The Department of Interior had to make many judgment calls in drawing boundaries around units designated for the Coastal Barrier Resource System (CRBS). The areas omitted from the system for political or planning reasons nevertheless are substantially undeveloped at this time but remain eligible for federal infrastructure assistance on flood insurance. It makes little sense to deny federal incentives for development in one part of a

barrier while allowing other areas, nominally outside the CBRS, to develop even more intensely to meet the existing demand. Indeed, the arguments made on behalf of the Coastal Barrier Resources Act largely recited conditions of overcrowding, hurricane hazard, and other problems afflicting developed barriers. It would undermine the intent of Congress if federal aid to areas outside the CBRS induced additional development and intensified these problems.

Accordingly, a distinction must be made for developed barriers, between federal aid that simply replaces and updates infrastructures serving existing development and aid that facilitates expansion of development into new areas or to a higher level of density. The latter would be inconsistent with the spirit if not the letter of the Coastal Barrier Resources Act.

I am suggesting that, for purposes of federal assistance, each developed coastal barrier should be viewed as subject to a "growth cap" at its present level of development. Minor infilling, of course, may occur, if it can be accommodated by existing infrastructure. But where federal assistance would significantly expand population and investment risk, it should be curtailed. This is presumably the intent of Executive Order No. 11988 regarding federal investment in flood hazard areas. This does not mean that further development may not occur; it means that state, local, and private sources will have to foot the bill for expansion of necessary services.

Flood Insurance

In a study of six coastal and barrier communities, the General Accounting Office (1982) found that new development was occurring in the Coastal High Hazard areas of each with the benefit of flood insurance. There has been considerable improvement of the administration of flood insurance for coastal V Zones through the consideration of wave height in hazard mapping studies and the requirement of engineer certification of first flood elevations. Nevertheless, the very definition of "coastal high hazard areas" suggests the folly of providing any flood insurance in this zone. Furthermore, where beach recession is occurring due to sea level rise and other causes, the coastal hazard area may be entirely under water within a matter of a few years (Kaufman and Pilkey, 1983).

With regard to A Zones and other areas of coastal barriers landward of the V Zone, flood insurance for new development must be carefully monitored to ensure that true actuarial rates are charged. Frequent updating of rates and

maps are necessary as shoreline recession and other physical changes occur. In view of the dynamic nature of coastal barriers, the NFIP should consider establishing a special zone for such features which would involve a surcharge above normal coastal A Zone rates.

Land Acquisition

The optimal long-term management strategy for coastal barriers is to acquire them for public purposes. According to the Conservation Foundation (1982, p. 311), the Federal Land and Water Conservation Fund (LAWCON) between 1965 and 1978 allocated $51 million to state and local governments for open space acquisition on barriers. It allocated another $128 million to federal agencies, chiefly the National Park Service and the Fish and Wildlife Service, for this purpose. These amounts are surprisingly modest for a 13-year period which spanned the "era of environmental awareness." Certainly, the extremely high values of shorefront property preclude extensive acquisition. Yet undeveloped parcels within "developed coastal barriers" are local targets for public acquisition. The National Park Service has lengthy experience in the use of easements and leasebacks to cut costs in a long-term acquisition program. Considering that LAWCON derives much of its funds from off-shore oil and gas revenues, it is appropriate that a portion of the fund be earmarked for coastal barrier acquisition.

Furthermore, Congress should increase the federal share in LAWCON from 50% to 80% of project costs in the case of coastal barrier projects. This would be equivalent to the federal share in coastal zone management grants and would reflect the limited state and local resources available for barrier acquisition activities. A larger federal share for barriers than for other open space acquisition is justified by the greater national interest in preventing further development of barriers and avoiding increased disaster relief outlays.

Postdisaster Mitigation

In 1980, ten federal agencies at the direction of the Office of Management and Budget signed an interagency agreement to cooperate in the identification of opportunities for mitigating future flood losses. The agreement provides that an interagency and intergovernmental team will convene under the direction of the FEMA regional office immediately after a Presidential flood disaster declaration. An initial report recommending mitigation actions within 15 days after the disaster must be submitted to the appropriate federal, state, and local authorities.

This procedure affords a unique tool for long-term coastal barrier management. As hurricanes and northeasters occur, all levels of government should strenuously seek to alleviate future hazards. Measures available include acquisition and relocation, redesign or elimination of certain public infrastructure (such as bridges or roads), the adoption of tighter building codes and land use regulations, and floodproofing for remaining structures. Warning and evacuation capabilities should be examined as well. Since adoption of the agreement, only two major hurricanes, Frederic (1980) and Alicia (1983), have significantly damaged coastal barriers. Mitigation procedures were novel in 1980; the aftermath of Alicia should be instructive as to whether postdisaster recommendation are in fact followed.

Essential to this process is advance planning and identification of "hot spots" that require immediate attention in the event of a disaster. According to Frank Petrone, Director, FEMA Region II, preparation of the 15-day mitigation report in his region strongly reflects ongoing contact between federal, state, and local planners and emergency managers. To start from scratch in the wake of a major disaster is most difficult.

Conclusion

This brief paper has indicated certain avenues for long-term management of coastal barriers. The CBRS is only a first step to limiting federal incentives to further barrier development. It addresses only the easiest case. The harder cases are those where development now exists or is in progress. CBRS will worsen settlement and hazard trends for such areas unless policies and programs are promptly modified, as outlined above, to limit federal investment in still developing areas.

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COASTAL HIGH HAZARD AREA PROBLEMS IN MASSACHUSETTS

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Introduction

High rates of erosion as well as rapid and/or long-term inundation are characteristic of coastal high hazard areas in Massachusetts. The risks associated with these natural hazards may be substantial in areas where development has occurred. In Massachusetts, these high hazard coastal areas are generally associated with barrier beaches and coastal banks. Such sedimentary landforms are found along all the Massachusetts coast and are continually being modified by physical processes including storms (northeasters and hurricanes) and rising sea level.

The development now encroaching upon these coastal high hazard areas is a relatively recent phenomenon. An awareness of the land use history associated with barrier beaches and coastal banks offers an important perspective on the resource management problems that exist today.

Historic Background

The earliest European settlers of the Massachusetts coast were sustained by the abundant resources of the land and sea. These settlers were also wary of situating their homes and structures too close to the coast. As early as 1635 they had observed serious tidal flooding along the coast during storms.

An important event promoting the subsequent development of the coastal region was the development of a railroad and, eventually, the highway network. By the late 1800s and early 1900s shorefront resort development increased, a trend accelerated by the rising popularity of the automobile. Unlike the early coast-wise residents, summer dwellers and vacationers unfamiliar with the natural processes of the coast built in areas that would have been considered unsuitable by the early settlers. By the 1950s the edges of cliffs and dunes had become valuable real estate and more and more of these areas had been developed. Today, the seasonal housing stock in these areas is being rapidly

converted to year-round use. The results are problems that previous generations had not encountered.

The response of these new shoreline dwellers to the loss or potential loss of property due to flooding and erosion was often the development of various coastal engineering structures. Each of these structures is designed to act either as a barrier to trap sediment being transported along shore, or as a wall to protect cliffs, dunes, or buildings from destructive wave action. Until the 1960s, engineering structures were perceived as the optimum solution to coastal hazards. With increased recognition of the natural processes governing coastal change came public pressure to preserve the features which provide the natural protection of the coast. In Massachusetts, various regulatory, acquisition, and planning programs have been established to address land use management problems associated with coastal high hazard areas. Despite significant progress, important problems still remain. This paper identifies some of the problems that remain not only in Massachusetts but in many other states and recommends possible solutions.

Coastal High Hazard Problems

Identification of Hazard Zones

One serious difficulty associated with many mapping programs in coastal high hazard areas is a failure to account for the potential of relatively rapid changes in shoreline position. Barrier beaches and coastal banks are two examples where changes in the location, form, and elevation of the landforms can be catastrophic. In Massachusetts, some of these landforms in open coast areas are eroding at an annual average rate of one to three feet per year. In extreme cases, annual rates of retreat may exceed ten feet per year. Obviously, maps that portray high hazard boundaries such as velocity zones as static features are seriously flawed.

Maps for coastal high hazard areas must reflect the dynamic nature of the coastline. For example, Massachusetts has initiated a comprehensive historic shoreline position mapping program to identify the direction and rates of shoreline change. These digitized data will describe three historic and one present-day shoreline for much of the state's 1,500 miles of tidal shoreline. Only shorelines that have been heavily urbanized and stabilized and the upper reaches of estuaries and embayments that have existed for long periods of time have been excluded.

The digitized shoreline change data provide an opportunity to utilize rates and trends of shoreline erosion or accretion for more effective coastal zone management. This information may be used for new or strengthened local erosion setback bylaws, Executive Orders regarding the use of state funds, and modifications in existing regulatory programs. Finally, it will be an important educational tool for increasing the public's general awareness of the dynamic nature of the shoreline.

Use of Fill in a Flood Zone

Filling in coastal floodplains can often exacerbate flooding problems by increasing the velocity of floodwaters on adjacent properties. Filling can also change the direction and depth of flow, thereby inducing or intensifying erosion.

Wave action in the A Zone is generally less severe. In the A Zone of coastal high hazard areas like barrier beaches, however, wave action and high velocity flow can eventually be a problem as the landform is modified by overwash, submergence, and new tidal inlet formation. These physical processes make fill undesirable in A Zones even if proper slopes are provided for the fill and protective measures such as riprap or vegetation are applied to seaward slopes. Building codes should be modified to require all new or substantially reconstructed buildings in A Zones in coastal high hazard areas to be elevated and firmly anchored on pilings.

Subsurface Wastewater Disposal Systems

Development in coastal high hazard areas may include the disposal of residential wastewater in subsurface disposal systems. These septic systems include subsurface concrete structures and pipes. In coastal high hazard areas these facilities can present potentially serious public health problems if they or their contents are exposed by erosion or flooding. In addition, the concrete subsurface structures that are exposed by erosion may also lead to additional scouring of adjacent areas if floodwaters are diverted. (A recent regulatory decision in Massachusetts [DEQE Wetlands File 19-188] denied construction of a single-family residence on a barrier beach based on the high probability that the system would eventually be exposed by erosion.) Subsurface septic systems located in coastal banks also contribute to increased erosion of these areas through accelerated bank slumping caused by groundwater seepage. In coastal high hazard areas, board of health regulations should be

modified to prohibit the placement of new septic systems in the velocity zone or in rapidly eroding coastal banks.

Flood Insurance

The high risks of flooding and erosion on barrier beaches and coastal banks are directly reflected in the significant costs associated with repairing and rebuilding storm damaged structures in these areas. A study of developed barrier beaches in Massachusetts provides an example of the potential magnitude of these costs. There are approximately 2,100 structures on intensively developed barrier beaches in 29 Massachusetts coastal communities. These communities account for over half of the flood insurance policies written in the state and half of the $1.1 billion (1983) in flood insurance coverage for high hazard areas.

The disproportionate flood insurance coverage clearly indicates the relative risk associated with development on barrier beaches. It is imprudent to continue to subsidize insurance for new development on barrier beaches as the subsidies promote a costly cycle of destruction and rebuilding. Action is needed now to at least contain the costs associated with development in high hazard areas. This should include no new flood insurance coverage for 1) new structures; 2) substantial improvements to existing structures or; 3) structures that have been destroyed or substantially damaged. In addition, a complete phaseout of the national program for direct federal flood insurance at subsidized rates must be accomplished. Over the past five years, the national program has cost the federal taxpayer approximately $140 million per year. Enforcement of flood insurance program regulations and federal Executive Orders on wetlands and floodplains needs to be vigorously pursued.

Acquisition Program

Public acquisition of coastal high hazard areas is one of the most effective techniques to reduce future storm damage losses while providing increased open space, recreation, and public access opportunities. Unfortunately, local and state acquisition of these areas is sometimes precluded by lack of funds. The Federal Emergency Management Agency (FEMA) offers two programs for acquiring flood-damaged structures. The 1362 program allows FEMA to purchase property from willing sellers when the insured buildings have been damaged more than 50% in a single storm or at least 25% in three storms over a five-year period. The local or state government is then given the land to manage for open space purposes. The Constructive Total Loss (CTL) Program authorizes FEMA to pay up

to the full face value of the flood insurance policy in force where local regulations do not permit rebuilding and when the structure is in an extremely hazardous location.

Even when funds are limited, governments can acquire coastal high hazard areas at less than fair market value by exercising foreclosures on tax delinquent properties. Communities can adopt a local subdivision bylaw that requires developers of large parcels to place a restriction on a certain percentage of that land for use only as recreation or open space. A landowner may also be willing to sell land to the community at a price lower than the property's fair market value in return for a tax deduction equivalent to the difference.

Coastal Barrier Resources Act

The Congress, through the Coastal Zone Management Act, has found that the protection of high hazard areas serves the national interest and that states should be "encouraged and assisted to exercise effectively their responsibilities in the coastal zone through the protection of natural resources ... to help minimize the loss of life and property caused by improper development in flood-prone, storm surge, geological hazard and erosion-prone areas."

The Coastal Barrier Resources Act (CRBA) represents a step toward implementing this policy by prohibiting and/or discouraging further growth and development in coastal high hazard areas. The Act should be strengthened by expanding the prohibition of federal expenditures already in CBRA to other high hazard coastal resource areas. This would include floodplains, erosion-prone areas and coastal barriers, whether developed or undeveloped, along all coastlines of the United States. Other forms of federal subsidies such as casualty loss tax deduction for property loss in high hazard areas should also be eliminated through CBRA.

Public Awareness and Opinion

Effective management of high risk flood areas requires identification and implementation techniques often based on scientific, engineering, and economic analyses. These analyses can provide a compelling justification for instituting or modifying public policy. Yet implementation of such a policy may falter or fail unless the perception and attitude of the affected population are adequately considered. Consequently, improving land management standards and other flood loss reduction measures requires more than merely developing

methods and guidelines. Sound floodplain management policy also addresses the concerns, expectations, and awareness of landowners in high risk flood areas.

In Massachusetts public attitudes concerning coastal high hazard areas have been assessed in several opinion surveys. These surveys identified that a large percentage of landowners on developed coastal barriers are unaware of local evacuation plans; few of them have experienced a serious storm. Another survey indicated a majority of citizens across the state strongly support the acquisition of remaining undeveloped coastal hazard area lands for conservation and recreation use. The sampling results offer an opportunity to develop policies and target funding more effectively.

Storm Preparedness

Storm preparedness includes addressing the problem of evacuating large numbers of people from hazard-prone areas when a major storm approaches. Storm evacuation plans for affected communities are intended to accomplish this. These plans, however, may not be sufficiently comprehensive especially in coastal areas where population growth is rapidly increasing.

Comprehensive storm evacuation plans should be fully integrated with similar plans of adjacent communities, counties and sometimes nearby states. This can be particularly important with respect to the transportation network and the provision of emergency supplies and shelter.

A comprehensive plan should also incorporate the National Weather Service use of probabilities in hurricane forecasting. These probabilities are intended primarily for decision makers in government and private industry who must begin protective actions prior to 24 hours before forecasted landfall. For example, residents in coastal areas with very long evacuation times will have to begin evacuation when probabilities of a hurricane landfall are as low as 12 to 20%.

Comprehensive plans must also recognize that the potential for damage and loss of life from a hurricane varies greatly depending on the intensity of the storm. On the Atlantic seaboard, for example, hurricanes can rapidly increase in size and speed, moving hundreds of miles in less than 24 hours. Unfortunately, even within 24 hours, forecasts of a hurricane landfall can be made only with a maximum probability of 50%.

Conclusion

Despite the significant risks to property and life, the pressure to develop coastal high hazard areas is unlikely to abate. Prudent public policy

for these areas, however, should seek to ultimately minimize and avoid further loss and damage. Otherwise, the potential for extensive and recurrent storm damage will increase substantially.

Immediate steps can be taken by public agencies to improve coastal hazard area management through planning, funding, legislative, and regulatory changes. These changes, some of which are suggested in this paper, do not necessarily require the investment of additional public funds. Effective measures can be implemented by redirecting or eliminating the use of public funds and resources for hazard-prone areas. Other techniques, such as land acquisition, will involve substantial public expenditures although these expenditures can be significantly less in the long term than if these hazard-prone areas are allowed to be developed. These and other measures can be part of a coastal hazard area management program to reduce or avoid storm damage and loss.

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PREDISASTER PLANNING FOR POSTDISASTER RECONSTRUCTION

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New Jersey Division of Water Resources

Through its Bureau of Flood Plain Management, the New Jersey Division of Water Resources acts as the state coordinating agency for the National Flood Insurance Program (NFIP). A primary goal of the Bureau's program is the reduction of flood damage potential throughout New Jersey and not just within the coastal zone. The Bureau pursues a three-stage program aimed at reducing flood damage potential. The three steps or stages of this program are basically the same regardless of the source of the flooding, which in the coastal zone would be the result of storm surge combined with wave action.

The first step is to identify hazard areas. This is accomplished by undertaking floodplain delineation or flood insurance studies, wave height and vulnerability analyses. The second step requires adoption or modification of municipal flood damage prevention ordinances and monitoring new construction and substantial improvements to existing structures to insure enforcement of these ordinances. The third and final step requires development of hazard mitigation plans to reduce the damage potential to existing structures to the maximum degree possible.

Coastal storm or flood predisaster planning, or more properly flood hazard mitigation, of the type described as step three, has only recently been recognized as a separate work element in New Jersey. This recognition is primarily the result of New Jersey involvement in the Coastal Storm Planning and Preparedness Program through which FEMA has funded vulnerability analyses of three of our barrier islands. The vulnerability analyses of the Atlantic County barrier islands, namely Absecon and Brigantine Islands and Ocean City, Cape May County, has indicated that most of the damage from an intense storm generating a 100-year surge would not be a result of the hazards identified by either a Flood Insurance Study or Wave Height Analysis.

Wave runup on seawalls and timber bulkheads and waves overtopping these structures together with the scour and erosion caused by overwashing waves

appear to be the primary source of potential damage. In areas where stillwater surge depth exceeds 3.5 feet, flotation of unanchored or inadequately anchored structures will be a primary cause of damage, and battering by floating debris will increase damage throughout the hazard areas.

Our vulnerability analyses have further indicated that advanced warning time could be quite short. The National Weather Service attempts to provide hurricane warnings that leave 12 hours of daylight before the arrival of hurricane force winds and peak storm surge. These 12 hours unfortunately cannot be fully utilized to evacuate residents, since time is required to mobilize citizens, and escape routes become impassible due to flooding two to three hours before the peak surge occurs. These analyses have indicated that the area studied is highly vulnerable to loss of human life and property damage and is relatively unprepared to withstand a major coastal storm or intense hurricane. Since the findings of these studies can be generally applied to most of the coastal areas of New Jersey, hazard mitigation has been included this year as a task assigned to the State Assistance Program of the NFIP and has been included in the Comprehensive Cooperation Agreement for Emergency Management Services between FEMA and the State of New Jersey.

During the current fiscal year, members of my staff will be required to meet with and investigate the feasibility of developing hazard mitigation work plans for twenty-five New Jersey municipalities. Though this work has been delayed by the storms and severe flooding experienced this spring, damage caused by these events still should stimulate interest in this program and provide motivation for its implementation.

The specific methods of mitigation being considered under this program are:

1) An update of municipal Emergency Operations Plans (EOPs) is needed. Our studies, furthermore, recommend rudimentary situation plans for individual structures--such as condominiums, retirement communities, and nursing homes--located in vulnerable areas.

2) Though our Community Assistance and Program Evaluation activities have indicated that NFIP floodplain management standards are generally being enforced in New Jersey, more specific standards are needed in some instances. A committee of construction officials has been established to review and develop required detailed standards. State and FEMA representatives are also members of this committee.

3) During the recent flooding advance warning failed to filter down to the citizens. It appears that a standard operating procedure must be developed and adopted by local governments to alert residents of vulnerable areas.

4) Though preliminary investigation has indicated that only limited use of contents removal plans is feasible on barrier islands due to the limited amount of time available for evacuation, such plans appear to be feasible in other coastal municipalities and within inland municipalities that experience riverine flooding.

5) Many of the older structures located within areas prone to flooding are either unanchored (gravity unanchored) or inadequately anchored. Anchorage surveys to determine which structures (particularly single-story timber-frame buildings) require retrofitting to properly anchor them can ultimately reduce damage related to flotation, lateral movement, and collision of floaters.

6) Field reconnaissance within areas recently studied has identified poorly maintained or deteriorated seawalls and timber bulkheads in both public and private ownership. While the total replacement of these structures may be undesirable and the cost excessive, repair or reinforcement of some of them is feasible. The false sense of security created by seawalls and timber bulkheads has resulted in many structures being constructed close behind these barriers, where they are vulnerable to damage from wave runup. Establishment of adequate setbacks by local governments before the next storm is being encouraged. The need for setbacks can be determined as part of local inspection programs which also identify structures requiring maintenance.

7) Traditional flood fighting techniques are under-utilized as a way of reducing damages in New Jersey, primarily due to short warning times and a lack of plans that employ them. Planning at the present time for their use and stockpiling of the material required to utilize them could expand their use.

8) Finally, though the purchase of flood insurance is encouraged in New Jersey and is the primary way in which damages are recovered, it really should not be considered as a mitigation technique.

Unfortunately, the success of our prestorm mitigation program cannot be assessed at this time. We do feel that the techniques listed and discussed, if seriously considered, thoroughly investigated, and fully implemented, can save lives and considerably reduce storm damage, and thereby reduce the effort that will have to be expended during the recovery phase.

Significant damage is undoubtedly going to occur in certain areas where vulnerability is the greatest. Total destruction, in fact, is almost inevitable should overwashing and breaching occur in some places. Long-term hazard

mitigation and recovery planning is, therefore, needed to develop strategies and ultimately to adopt policies that can be applied to these areas.

The New Jersey Division of Coastal Resources, under the final phase of the Coastal Storm Planning and Preparedness program, is investigating mitigation strategies. They have recently established steering committees within each of the five municipalities being studied on the Atlantic County barrier islands and in Ocean City, New Jersey. They plan to meet with these committees during the summer and prepare a report containing recommendations by the end of September, 1984.

PREDISASTER PLANNING FOR POSTDISASTER RECONSTRUCTION

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Background

I will briefly describe the approach the Division of Coastal Resources is presently taking in coastal storm planning and preparedness and then focus on three municipalities, Brigantine in Atlantic County and Avalon and Upper Township in Cape May County.

The Division is working with municipalities individually to incorporate coastal storm hazard mitigation into their master plans, zoning, and other ordinances. In part, New Jersey has taken this approach due to a lack of regulatory authority to guide most development in these areas. All of New Jersey's barrier islands are densely developed, but many are redeveloping at an ever greater density.

A northeaster hit the New Jersey coast on March 28 and 29, 1984, and remained through two successive high tides. Besides its occurrence on average tides of the month, the factor that saved the New Jersey coast from a possible new storm of record was the fact that after two destructive high tides, the wind dropped and shifted to the NNW before a third high tide. The storm was termed only a 10-year event, based on surge or tidal flood elevations of 8.4 feet MLW, but resulted in damages estimated by the state at $24 million for sand and dune replacement and an additional $6-10 million for debris removal. Damage surveys have not yet been finalized. Four coastal counties were declared disaster areas by President Reagan. The storm has increased the awareness of the public and municipal officials of the storm hazards they face and increased their interest in and support of the Division's efforts.

Avalon, New Jersey

The Division of Coastal Resources began working with the Borough of Avalon in the late 1970s to build dunes in the community, providing technical advice, and sand fencing. This was followed by a grant for prestorm planning. The

grant provided for a geologist, Stewart Farrell from Stockton State College, and a planner, John Sinton, to study the island's geological processes and storm vulnerability and devise short- and long-term hazard reduction strategies--including changes in building codes, dune nourishment, and zoning changes. Proposed changes included establishing setbacks from dunes and changing residential zones to conservation zones. The report is now being prepared for publication. It has not yet been implemented by Avalon, although they are agreeable to the recommended changes.

Avalon's dune protection and restoration program has been quite successful. There was significant dune erosion in the March, 1984, storm, less than or similar to that throughout the state, but no structural damage. Only a two to three block area with no dunes in the nodal zone of the island was overwashed. Estimates for damages to public facilities were $44,000 for dune repair, $14,000 for debris removal, and $18,000 for repairing a parking lot. Farrell and Sinton recommended that this parking lot be fronted with a protective dune due to its vulnerability, and it has been recommended by the Hazard Mitigation Team that disaster aid funds be so conditioned.

Brigantine, New Jersey

At present, the Division is working with six municipalities, including Brigantine, Atlantic City, and Ocean City, under a FEMA funded program. The Division has reviewed a variety of hazard mitigation strategies in use throughout the country and presented them to municipal steering committees with the goal of incorporating such techniques at the municipal level. Evacuation concerns are being addressed separately. I will use Brigantine as an example.

Brigantine is a developed barrier island in Atlantic County, which is accreting at the southern end due to stabilization of Absecon Inlet by a large jetty (3,730 feet long) built in the 1950s and incrementally extended in the early and mid-1960s. Wide dune fields have grown in one portion of the island. However, the northern end of the city is experiencing erosion and has narrower beaches, little dune protection, and therefore is bulkheaded. The erosion rate in this section is on the order of three to five feet per year. In the early 1900s a now abandoned hotel was 1,000 feet from the beach. We are most concerned about the north end of town in the narrowing section of the island. Many areas were overwashed during the March, 1984, northeaster. The damage survey reports for public facilities eligible for federal disaster aid funds

were surveyed at approximately $1 million, about $800,000 of which was for dune fencing and restoration.

The Brigantine hazard mitigation steering committee is composed of the mayor, two commissioners, the city administrator, engineer and emergency manager, and the county planner.

At our first meeting, the vulnerability analysis prepared by the Bureau of Floodplain Management was presented. The vulnerability map and report were used in conjunction with the shoreline change map, and photographs of New Jersey's last major destructive storm (March, 1962) in discussing and identifying hazards. The vulnerability map indicates the presence of high hazard areas, wave runup zones, flotation zones, and structures with evacuation problems.

We superimposed the city zoning map on the vulnerability map for use by the committee in considering zoning problems and changes needed. This pointed out the high risk areas presently zoned for high density residential use.

Zoning and master plan changes are a major focus of the effort. Among these changes are widening of the oceanfront conservation zones and establishment of setbacks. The present conservation zones consist of most beach and dune areas. Extension of this zone to allow dune migration or creation is essential to protect property. In addition, areas are being identified where dunes can be augmented and dune cuts eliminated or reoriented to the southeast. Trading of low density uses for high density is also being considered, as is establishment of seasonal recreational uses rather than year-round residential use.

Specific consideration is being given to identifying target poststorm acquisition areas and areas where destroyed infrastructure should not be rebuilt. Anchoring of homes in flotation zones and elevation of low homes are also being pursued; the construction official will be recommending needed changes to the uniform construction code. The local steering committee will be reviewing the hazard mitigation techniques and vulnerability maps prior to our second meeting next month when specific applications will be discussed.

One possible result of this effort would be the expansion of the conservation zone, establishment of setbacks, abandonment of a segment of road, and rezoning. Several more workshops are planned throughout the summer to discuss and evaluate specific proposals. The Division will prepare a report containing recommendations this fall. Ultimately, the municipality will decide what

mitigation measures to adopt, allowing it to better face and recover from the next major storm.

Upper Township, New Jersey

Another hazard mitigation planning effort is beginning in Upper Township, Cape May County. This municipality consists of mainland and a barrier island segment. The municipality and the Division of Coastal Resources are presently negotiating a contract for the township to study the use of Transfer of Development Rights (TDR) as a hazard mitigation technique. TDR involves the establishment of conservation zones with attendant development rights and the establishment of receiving or transfer zones where development rights can be purchased to exceed the zoned density. In the context of storm hazard mitigation, high-hazard, high-erosion areas would be designated preservation zones and safer areas as receiving zones.

The barrier island portion of Upper Township is heavily developed. The Whale Beach area is about 200' wide and less than 10' (MSL) in elevation; most is in the V zone. The high water line has moved inland at the rate of approximately five feet per year since it was first mapped by the USCGS in 1842. A more recent erosion rate of $2.8m^3/m/yr$ from 1963-1972 was established in 1978.

The March, 1962, storm devastated the island, requiring the building of 6.5 miles of emergency dunes costing over $1 million. Six shore protection projects, both groins and beachfill, were undertaken at Whale Beach between 1964 and 1983 at a cost of nearly $1.7 million. A $3 million beachfill project is proposed for 1985. Whale Beach was overwashed in the March, 1984, storm; Ocean Avenue covered by approximately four feet of sand; and the few dunes present lost. Damages were estimated at $400,000 to replace the dunes alone. There is presently very little to no beach at high tide.

The excessive costs to protect Whale Beach, the relatively low number of structures located on that section of the island (about 80 single family homes and 20 condominium units), and the extreme high risk to people and property in the area have led the state and municipality to look for alternative solutions. The proposed study will evaluate the feasibility of TDR. The Whale Beach area and perhaps high hazard portions of Strathmere could be designated conservation/recreation zones and mainland portions of Upper Township would become receiving zones.

The study will explore TDR in terms of market considerations, equity for landowners in the preservation district, evaluation of transfer zones and availability of infrastructure, and economic benefits--cost savings and avoidances. The approach is attractive as it would ideally eliminate development in the high hazard area, greatly reduce federal, state, and local spending, and monetarily compensate property owners for not developing or redeveloping their property. This effort has been supported by the Interagency Hazard Mitigation Team assembled in response to the Presidential Disaster Declaration of March, 1984. The Team's 15-day report recommends that an acquisition/relocation project be implemented for the area, changing the use from single family residential to open-space/recreational. TDR is one suggested means of financing this change.

Summary

The Division of Coastal Resources is pursuing predisaster planning on an individual basis with municipalities and has found interest and support from those towns, along with a desire to utilize the state's technical expertise.

ASSESSING COMMUNITY FLOOD MANAGEMENT CAPABILITY

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Background

The management of coastal high hazard areas generally brings to mind the Gulf states and southeastern coastal regions. The Connecticut shoreline has not experienced a multitude of hurricane events, but nonetheless has been and remains vulnerable to such occurrences. A long period has elapsed since the last major storm struck Connecticut's coast. Unfortunately, from a state flood management point of view, this has resulted in a general feeling of apathy and disinterest to hurricane preparedness among the shoreline municipal officials. In a local newspaper article about the State's flood management program they claimed, "The sea is not furious here. Cottages nestled as close to the water line as possible in Old Lyme and Old Saybrook are testimony to owner's faith in the stability of Long Island Sound's waters."

An interesting contrast is found in the following description of those same waters written on September 23, 1938.

> Millions of dollars in property damage and heavy loss of life, despite examples of heroism and fortitude wrote finis to the 1938 season at the various Connecticut shore resorts strung along Long Island Sound. Surf which did not wait for high tide to top sea walls, rushing waters which twisted and tore cottages from their foundations, floated furniture into ditches and boats onto highways caused monetary loss which chaotic highway and communication conditions Thursday made it impossible to estimate. A long list of persons unreported or known to be missing held an ominous threat for the expansion of a long casualty list.

The shoreline has not suffered a major coastal storm in approximately thirty years but during that period has undergone intensive development. These factors led two years ago to an inventory of coastal flood damage potential along Connecticut's shoreline. The results showed that 40,000 structures are located in flood hazard areas, 4,000 of them in the coastal V Zone. A major coastal storm hitting Connecticut could potentially cause millions and millions of dollars in damages and could severely disrupt the state's economy. These

findings led to the development of a municipal assistance program designed to document and upgrade local ability to deal with flood events.

The Municipal Assistance Program consisted of several elements. First, after completing the inventory of flood-prone structures, "municipal profiles" were developed for each of Connecticut's 25 coastal towns. They included the names of local officials who would be key players in flood preparedness and response activities; a survey of the population and structures occurring within flood zones; the town's history of flooding; flood studies that had been completed; a list of flood control structures and projects' flood warning systems; the status of Emergency Operations Plans; an analysis of public ownership in flood zones; National Flood Insurance policy and claims data; and a survey of watercourses, impoundments, wetlands, dams, bridges, marinas, utilities, and water supply information.

Second, local zoning regulations governing floodplains were reviewed.

Next, existing emergency operations plans were reviewed and carefully evaluated, looking specifically for flood preparedness and flood mitigation measures.

Finally, additional flood insurance needs were identified; local road, bridge, and culvert design standards and stormwater management plans were examined; and the feasibility of acquiring flood-prone areas was explored.

Results

Are Connecticut's communities prepared for a major coastal storm? In working with the coastal towns, we found a great diversity in levels of preparedness. Those communities that seem best prepared are either those that experience frequent "nuisance" flooding or those that have the highest property values, and even these towns have welcomed our assistance.

The City of Milford has 600 buildings (including a number of apartments and condominiums) on the direct shoreline, many of which flood practically every time high tide rolls in. Milford heeded our suggestion that they write a flood annex to their emergency operations plan, and now has an extensive and very specific warning and evacuation plan.

Westport, one of our "gold coast" towns, has an extremely well prepared and well-equipped emergency response team. Their police and fire departments have access to amphibious vehicles, maintain a list of every handicapped and elderly resident who may need assistance in evacuation, and stage regularly scheduled drills. While they appear to be very well prepared in emergency

response, they are seriously considering some of our other suggestions. After reviewing our assessment, the Public Works Director wrote to his First Selectman:

> The recommendation that the Town develop a Comprehensive Drainage Plan is one that should be given much consideration. The Town has never developed a comprehensive plan for handling all storm drainage. This could be costly, but also could save the Town money by having developers provide drainage projects that fit a Town wide plan. Our small drainage projects are often a band-aid approach; a comprehensive plan would tie everything together.

Stamford, the home of many corporate world headquarters, became the first municipality in the state to install an automated flood warning system. The results of our inventory played a role in their securement of financing for this effort. Stamford furthermore requires that an evacuation plan be submitted with any proposal for an office building or multifamily housing unit to be constructed within a flood zone, and has used our recommendations as guidelines in reviewing such plans.

At the other end of the spectrum are the town officials who rely on the common sense and "go-with-the-flow" approach to flood management. One town selectman, when asked about his Emergency Operations Plan, was "quite" sure that his Civil Defense Director had some sort of "plan" stashed somewhere. He then concluded that since his CD Director worked a long distance from town, he likely would be unavailable during an emergency anyway.

Most towns fall somewhere in the middle of this range. They do maintain local emergency operations plans which are updated every two years (as required by the State Office of Civil Preparedness), but these plans address nuclear considerations and not natural disasters.

Many local officials simply do not perceive coastal flooding as an issue that demands much attention or planning and, therefore, do not address it. Coastal flooding occurs infrequently in Connecticut. The federal and state governments have historically done a good job of funding disaster assistance and recovery, and the events are forgotten within a surprisingly short period of time. While these towns have not developed planning that addresses coastal flooding, there was not a single local official who was not extremely confident that his or her town could prevent loss of life in most any situation. So, in summary, while the towns are prepared to undertake life saving actions, with

very few exceptions they are unprepared to implement any measures to reduce or minimize property losses.

Deficiencies

What are the most serious deficiencies? Inadequate coastal flood warning has to top the list. While most local officials are confident that, in hurricane situations, the National Weather Service would provide more than adequate warning, they feel strongly that the more frequently occurring "Northeasters" will never be predicted. Even minor coastal floods have proven that either the warning simply is not there, or if a warning is available, it will likely not reflect the extent of flooding which will ultimately occur.

Last March, I visited the Mayor and Civil Preparedness Director of Milford after that city sustained over $1 million in private property damages from a "minor" coastal winter storm. When I asked what kind of warning time they received, they replied, " We're still waiting!" When the Mayor called a local radio station to encourage public cooperation with evacuations the station personnel doubted the validity of the information, as most of Connecticut was unaware that a serious storm was underway. While Connecticut is presently installing a statewide automated flood warning system, the system will not adequately address coastal flood warning, at least in the first few years.

Another area of concern is that of floodplain zoning. While zoning regulations in all coastal towns were found to be adequate and consistent with National Flood Insurance Program (NFIP) standards, enforcement was very often lacking. Some towns admitted they had problems requiring a new structure to be elevated to base flood elevation when surrounding existing buildings are much lower. Other towns seem to do a fairly good job of either ignoring the regulations or misinterpreting them. One of the coastal towns indicated to us that the only way to correct this problem would be to have either the state or federal government provide better "watchdog" service, and require quarterly or even monthly reports (vs. annual reports) on building permits granted in flood zones. They expressed doubt that the annual reports they submit to FEMA are ever even reviewed.

Public awareness, or rather lack thereof, of storm damage potential was a major problem, and this resulted in inadequate flood insurance coverage. The Municipal Assistance Program included a public awareness section, in which questionnaires regarding flood preparedness were distributed to a representa-

tive sample of coastal homeowners. Fifty percent of the respondents had purchased their coastal property within the last ten years and had never witnessed a major coastal storm. It appears that many of these individuals believe that the "abnormally" high tides and routine street flooding they have experienced represent the extent of the effects of a coastal storm. Even the folks who had lived through the 1938 and 1950s storms appear not to have been in the major damage centers, and, surprisingly, from their responses, seem no better prepared than the newcomers.

As a result, flood insurance coverage hit a low of 17% of the structures subject to the 100-year flood in one town, with the average coverage being 58%. When we distributed our questionnaires, we had homeowners write back who had not even heard of the National Flood Insurance Program; and our office was instrumental in the actual sale of approximately one hundred policies. Other property owners expressed disinterest in the NFIP because the maximum coverage limits only approached a fraction of the true value of their real estate. These people must be made to understand that the chances of a flood completely destroying their property are small, and that, in most cases, the flood insurance will cover the losses sustained.

This problem must be addressed through a more aggressive and continuing public awareness program. While the Connecticut program involved questionnaire distribution and display exhibits, we were able to reach only a small percentage of the population who may be affected. This year we plan to work directly with the beach associations along Connecticut's coast, arranging informational meetings and distributing information through them. In addition, we are considering providing "flood audits" to interested homeowners. The flood audits would be similar to energy audits performed in New England; the home would be inspected and specific recommendations made to the property owner that would minimize future flood losses.

Conclusion

The Municipal Assistance Program has proved to be valuable in a number of ways. The towns are working with our recommendations and are taking steps to improve their local flood management programs. The communities, for the most part, seem eager to do the best job they can but have had neither the personnel nor the expertise to develop comprehensive programs. At the state level, we have taken care of much of the legwork and have spelled out specific measures for local governments to take--providing a good deal of initiative for local

action. In addition, this program has gone a long way in improving state/municipal liaison.

Staffing and budget limitations will certainly preclude the implementation of some aspects of this program and will, therefore, force us to seek "creative financing." One possible source that we are optimistic about in Connecticut (and may be applicable in a number of states) is the Integrated Emergency Management System. The preliminary analysis of hazards in Connecticut clearly identified flooding as the number one hazard. It is hoped that this finding will result in the channeling of additional resources towards flood preparedness planning.

Finally, this program has been successful in convincing the towns that the state has documented and is well aware of the coastal flood hazard potential. Even more importantly, by providing specific measures the locals can take to reduce flood losses, the state has assured that the towns cannot claim ignorance of flood management techniques when the flood occurs. This is a very important consideration given the shift of responsibility for flood preparedness and recovery from the federal to the state and local governments.

PROBLEMS AND APPROACHES IN MAPPING VELOCITY ALONG THE U.S. COASTLINE

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Introduction

In the coastal zone, storm effects are varied and complex. Not only do the high velocity water associated with surge and waves challenge the structural integrity of buildings, but also the erodibility of the shore itself can be a cause of structural degradation or failure. The hazard potential of a site is further complicated when coastal protective devices are present (e.g., seawalls, groins, and breakwaters.)

To assess the absolute, or total, hazard requires that the interactions water↔sediment↔structure↔water be understood and quantified. Specification of the water motion (e.g., surge elevations and currents, wave heights and runup) on a nonerodible shoreline in the absence of human-made structures can be accomplished with a reasonable degree of accuracy. When the movement of the sediment and the modification of the flow by structures are included, such a specification becomes much more inexact. That is, the interactions can neither be described nor modeled in minute detail. Approximations are required.

A few examples illustrate the nature of these interactions. When a shoreline is attacked by waves, waves running up the front face of the dunes excavate material and transport it offshore. The consequent shoaling and flattening of the beach profile seaward of the dune reduce the height of the incoming waves and the rate of dune erosion. This type of feedback mechanism is common. A groin, whose purpose is to stabilize the shoreline (at least locally) can, because of its blocking action, induce a rip current. This narrow jet of water may transport sediment seaward and scour a channel parallel to the groin. Upland property could be destabilized and larger waves allowed to impact the groin. When coastal areas are filled in and bulkheaded for development (e.g., backshore lagoons and marshes) surge waters can no longer disperse their energy at low velocity over a wide area. Rather, the channelization funnels and

intensifies the surge currents. Scour and possible undermining of structures result.

How these and other interactions evolve over the course of a storm is only partly understood. The easiest study approach is to combine poststorm observations (beach profiles, location and degree of damage) with gross storm characteristics (peak surge level, significant wave height) to develop predictive relationships among the governing physical parameters. Even this "easy" approach has not realized its full potential.

In conducting flood insurance studies, the Federal Emergency Management Agency (FEMA) has attempted to strike a balance between ease of implementation and level of technical sophistication. The goal has been to provide a reasonable description of the hazard and to do so in a uniform, evenhanded manner along the entire U.S. coastline. At the same time it has been recognized that science does not have all the tools necessary to accurately and economically predict the full range of storm hazards. Of necessity, FEMA's technical procedures have evolved gradually over the past decade as the program has become more established and the scientific community has been stimulated to study coastal phenomena in greater detail. Limitations in the past have related to the practical implementation of such a broadly based program and to gaps in our knowledge of the physical processes governing the coastal zone.

Although these two considerations still pertain today, technical procedures have become more comprehensive and more defensible. The storm surge hydrodynamic model has advanced in sophistication; wave heights and wave runup have been incorporated in the "base flood elevation;" beach and dune erosion are being considered to some extent. The flood insurance program has also responded to local conditions. One example is the prediction of wave runup in the northeast U.S.; previously only the stillwater (surge) elevations were computed, and these levels consistently fell below the observed storm damage. Now with the inclusion of wave runup, the predicted upland penetration of high velocity water more closely mirrors historical observations. Erosion has always presented a problem for program implementation. This is because of its multifaceted nature and our scientific ignorance about how moving water and sediment interact. Recently some quantitative approaches have been introduced to partially address this deficiency (Tayfun et al., 1979; Balsillie, 1982; Vellinga, 1983).

Erosion--Approaches and Constraints

Not all aspects of surge and wave-induced erosion can realistically be accommodated in a flood insurance study. Erosion due to currents is to be differentiated from erosion due to direct wave action; scour at the base of a structure is different from scour at the base of a dune; the dramatic short-term erosion experienced during a single storm may contrast with a long-term trend of accretion for a particular segment of the shoreline. FEMA has taken some first tentative steps to account for the phenomenon. However, because FEMA's mandate is to establish flood elevations, all the nuances of the erosion phenomenon are beyond the scope of the flood insurance studies. An eroded ground profile is the starting point for the computation of wave crest elevations; the direct impact of the erosion itself on a structure is not the focus of attention.

Consideration of erosion at all represents a significant leap forward. Since FEMA's objective has been to establish minimum national criteria, it is incumbent on the individual states and communities to provide the detailed analyses and engineering criteria necessary for the siting and design of buildings in their respective localities.

Some of the kinds of erosion are described below:

1) Wave-induced buildup of pore pressure internally in soils may lead to liquefaction, i.e. the soil behaving like a fluid.

2) Currents associated with the surge can cause scour around the foundation of buildings and breaching of low-lying sections of barrier islands. In backshore areas the storage of surge water during a storm can eventually lead to the formation of strong currents directed toward the backside of the barrier island when onshore winds cease and/or reverse direction (Leatherman, 1983; Miller, 1983; Miller and Bachman, 1984). Channels and other rigid human-made structures may exacerbate these flows.

   The primary objective of coastal flood studies is to predict water elevations, not currents, although the two are mutually dependent. Currents may be examined during the model calibration process (i.e. evaluation of the capability of a hydrodynamic surge model to reproduce observed elevations), but no hazard assessment is made based on the magnitude of these currents. In addition, in areas inland from the open coast, the water motion is usually resolved at a scale of about one mile; the effect of physical features (either natural or human-made) with dimensions less than this may not be revealed by the modeling.

3) Scour at the base of a seawall (or other protective structure), or removal of supporting backfill by overtopping waves, can undermine the structure and allow higher waves and progressive erosion to threaten upland buildings.

4) Deposition of sand or debris under an elevated building, as might occur because of overwash, would restrict water flow underneath the building and concentrate wave energy on the structure.

5) An inlet prone to migration or erosion may be destablized during a storm. The large volume of high velocity water that is conveyed could erode the banks of the inlet. Additionally, accumulation of littoral drift on the updrift side of the inlet would favor erosion of the downdrift shore and a net migration of the inlet. Erosion or inlet migration of modest proportions could endanger nearshore development.

6) Shorelines are ephemeral. They are subject to change on short and long time scales. There are reversible seasonal changes; reversible and irreversible long-term trends (e.g. end points of a barrier island eroding, or retreating; the middle section of the island accreting, or prograding such as on Kiawah Island, South Carolina); and episodic changes due to individual storms. Summer beach profiles are obviously more appropriate for a determination of velocity zones due to hurricanes; winter beach profiles are more appropriate for northeasters.

Data on the long-term rate of change of U.S. shorelines, including the Great Lakes, have been assembled (May et al., 1982; Dolan et al., 1983). This data set, which draws upon various individual and organizational sources for 1,689 coastal sites, is designed for presentation as a series of U.S. Geological Survey maps at a 1:2,000,000 scale. The original rate-of-change data on 3-minute grid cells, and statistical summaries, are provided in a Computerized Erosion Information System (CEIS) at the University of Virginia. (More detailed local information is available from other sources, e.g. Benton, 1983).

The Atlantic and Gulf coasts are experiencing long-term shoreline recession rates of 0.8 and 1.8 meters/year. The Pacific Coast has a recession rate of only .005 meter/year. These are averages. Not all coasts are eroding; some are accreting (e.g. the rocky shores of Maine, and parts of South Carolina).

Arguments have been made that risk assessment should acknowledge the fact that not all barrier islands are created equal (Hayes et al., 1981). Many of the barrier islands of South Carolina have been categorized as "regressive", i.e. developed through the seaward accretion of beach ridges/land-based sediments, which are deposited atop more seaward sediments (Nummedal, 1983). In contrast, "transgressive" (landward moving) barriers have formed seaward of the mainland on the continental shelf during a period of lower water and have migrated shoreward as the water level rose (e.g. the Outer Banks of North Carolina).

A stable or growing barrier island is one for which the vertical rate of sedimentation (material supplied by rivers, for instance) exceeds the rate of sea level rise. In the case of an eroding barrier the balance has swung the other way. In other words, a shoreline may actually build seaward even though sea level is rising. From this observation one can argue that a setback line for development must incorporate local dynamics. The shore adjacent to an inlet may be unstable, but toward the central portion of the island long-term stability could pertain.

Long-term erosion or accretion is a response to storm surge and waves, aeolian (wind transport) processes, rising sea level, and littoral transport mechanisms (rivers, wave-induced longshore currents, inlet tidal flows). Delineation of these trends and fluctuation is important when

establishing setback lines for development. However, the task is often difficult because long-term trends can be masked by short-term fluctuations and patterns of erosion/accretion can migrate alongshore. In flood insurance studies analyses are performed with a topography that is contemporary (as best as can be estimated with available maps) or is the expected shape of the landform immediately following the 100-year storm event. Realistically, long-term shoreline changes can only be accommodated by adjusting study results periodically.

7) The scour/undermining of dunes is a dramatic short-term event. Because it occurs coincident with the surge and waves generated by a storm, the inland propagation of the surge and the maximum attainable wave height are functions of the rate of erosion of the dune field. Therefore, specification of the "base flood elevation" must include this interaction. Various approaches have been adopted. The method most widely used at this time is historical reference--examining pre- and post-storm beach profiles to identify shoreline adjustments to severe storms. An example is the beach profile data gathered in Alabama after Hurricane Frederic. This method is obviously limited by the availability and quality of historical data. A variation on this technique is to assume that a reasonable erosion profile is obtained by drawing a line from the toe of the dune to the point on the leeside of the dune where the first slope break occurs. A more general approach, based on field observations and laboratory experiments, has been applied in North Carolina (Tayfun et al., 1979; Tetra Tech, 1983; Hodges et al., 1984) following the work of Edelman (1968, 1970). The method assumes that dune material is deposited directly offshore, and, consequently, the volume of sediment eroded from the dune equals the volume of deposition. Beach slopes are reduced (flattened) by a set factor. Recent work by Vellinga (1983, 1984) offers the prospect that the shape of the eroded profile (slopes) can be adjusted on a site-specific basis as a function of the sediment size.

The drawback of these methodologies is that they are not explicitly designed for the case of surge overtopping, i.e. cases in which the storm surge level is above the crest of the dune. Practical modifications have been made to model this case (Hodges et al., 1984), although the results are only indicative of the erosion pattern to be expected. The transition to onshore sand transport (washover) is not accounted for. Investigations parallel to those in North Carolina have been undertaken in Florida (Balsillie, 1982; 1983).

Scour of the beach and dunes is a process that cannot be ignored in flood insurance studies. Scour was a major damage factor--second only to wind--during Hurricane Alicia, a moderate storm that struck the Galveston-Houston area in 1983 (Miller, 1983). Once it was recognized that storm waves were capable of inflicting substantial damage, the establishment of V Zones was undertaken. There have been and continue to be problems in identifying and delineating this special hazard; however, as the work has proceeded the gap between problems and solutions has gradually narrowed. The incorporation of beach and dune erosion can be expected to follow a similar path. At the moment a uniform approach is not forthcoming. The effort should be made to sift through and synthesize the various data and methods. What is required is a comparison and consolidation of the several pieces of work that exist today--the scientific studies and the procedures that some states have already implemented. The increased

interest in erosion mandates that more sophisticated thinking be brought to bear on the problem.

All of the erosion categories described above are worthy of further attention and study. However, the diversity and subtleties of the erosion phenomena defy complete analysis. Of the seven (nonexclusive) categories identified, only category seven can be implemented with some degree of confidence. Nevertheless, FEMA should work with and encourage coastal states in their efforts to quantify the erosion potential in all its aspects and to establish appropriate setback or land use criteria.

Coastal Structures--Protection versus Hazard

When protective structures are placed in the coastal zones (e.g., seawalls, groins, breakwaters, bulkheads, beach fill) some disturbance of the balance among waves, currents, and sediment is inevitable. The natural forces will tend to realign themselves to accommodate the presence of the structure. Although ambivalent feelings are often expressed about the benefits to be gained with the use of such structures, it can probably be stated that the adverse effects generally outweigh the benefits. However, there are several exceptions. When an absolute need, or some other justification (usually economic) exists, then a structure may be considered. A nuclear power plant, with its cooling requirements, has to be sited where large quantities of water are available; an established development may have to be "retrofitted" with a floodwall because current protection proves inadequate; a resort area that anchors a community economically may require periodic renourishment of its beaches or maintenance of its shorefront facilities; a port or harbor needs jetties to stabilize an inlet for navigation or a breakwater to intercept and reduce wave action.

In assessing the protection afforded by coastal structures there are several considerations (and potential unknowns):

1) Was the structure designed for a 10-year storm? a 100-year storm?

2) Is the design adequate for the specified design period? Were construction procedures adequate?

3) Is this a major structure or does it protect only a narrow stretch of the shoreline (e.g., one residence)? What is the diversity and density of structures along the shore?

4) To what degree does the structure destabilize the beach or ground around it?

During Hurricane Alicia the failure of oceanfront bulkheads and grade slabs on Galveston Island was fairly common (Miller, 1983). These bulkheads were obviously not designed for a severe storm. In contrast, on the same island sits the Galveston seawall, a formidable structure built to withstand severe stresses. Large, publicly funded projects, like the Galveston seawall, have a built-in risk factor that is usually predictable. Small and/or privately funded projects are less likely to have design and construction criteria that can be easily accessed and evaluated. Therefore, it becomes problematic how to assess the vulnerability of individual structures to a 100-year storm.

The problem is compounded when the structure varies in design and type from point to point along the shore. For example, one homeowner may elect to protect his property with a stone revetment; his neighbor may rely upon a timber bulkhead. Each protective device has different dimensions and survivability. In both cases, however, the 100-year storm will probably exceed the structures' design thresholds. In fact, parts of the structures could become projectiles during a storm, endangering the residences they were presumed to protect. During design this presumption can promote a false sense of security and lead to insufficient setback of the residence.

Ideally, each protective structure along the shore should be individually certified by an engineer. In practice this is not entirely feasible in flood insurance mapping where a broader brush stroke is applied. If, for instance, a group of protective structures is shown or assumed to remain intact during an extreme storm and their top elevations do not vary appreciably one from the other, then they may be treated as a single structure for the purposes of computing wave heights.

The creation or renourishment of a beach is a nonstructural protective device. The elevation of the beach berm will control the maximum heights of the wave that propagates inland. Losses and reworking of the placed fill mean that the shoreline and the beach profile vary over time. Fill projects are often characterized by relatively rapid loss or migration of material (both offshore and alongshore), especially in the initial stages of the project. If these losses have been accommodated in the design and/or periodic renourishment is scheduled, then it may be possible to define a "stable" berm elevation. However, the art of beach design and the prediction of maintenance requirements is still rather primitive. More comprehensive measurement programs are needed to be able to identify those conditions for which an efficient design is

possible. If a beach has demonstrated stability over a number of years, then that beach configuration can be the starting point for the V Zone determination.

The destabilizing influence of solid structures on contiguous sediments has been alluded to earlier. Immobile, nonyielding structures can concentrate flows and intensify local scour. The beach profile tends to deepen at the base of a seawall. This in turn could precipitate structural failure during a storm. A seawall that is not properly tied back into the shore at its end points may be flanked by wave action and undermined. In California, winter storms require that periodic reconstruction of destroyed seawalls and bulkheads be undertaken. Along these same lines, it appears that in some cases a family of groins will induce a steepening of the offshore beach profile, permitting larger waves to approach the shore and promoting offshore transport of beach sediment. Because solid structures inhibit the natural transfer of material between the beach and the offshore area, a disequilibrium can occur whereby additional erosion of adjacent, unprotected shorelines is required to re-establish the sediment balance in the nearshore area. Thus, the presence of a seawall can enhance the local rates of erosion (Walton and Sensabaugh, 1976). In North Carolina there is a policy to disallow any shore hardening and a special setback to account for the immobility of structures.

Are there situations in which coastal structures provide a level of protection that would otherwise be absent? Certainly a well-engineered structure will protect the property behind it. Seawalls will break the incoming waves, as will an offshore breakwater or a shore-attached breakwater. FEMA's wave height method accounts for wave transmission over thin, human-made barriers (seawalls, floodwalls) but not over or around more massive structures such as breakwaters. Wave runup on sloping revetment structures may or may not be considered depending on the level of detail brought to the study. A groin, because it is oriented perpendicular to the shoreline, does not supply appreciable protection against waves arriving perpendicular to the shore. With respect to its sediment gathering capability, a groin has a differential effect on the shoreline, causing accretion in one area but erosion elsewhere. There are special cases in which groins can have a long-term beneficial effect. Sediment that is being lost from the tip of an island due to longshore drift may be retained by the placement of a single groin. Since the sediment was not feeding downdrift beaches, no detrimental effect ensues. Considerations like

this are somewhat academic, since it is a "snapshot" (not a history) of the beach and shoreline that is incorporated in the V Zone calculations.

Summary

The impacts of erosion and structures on the determination of V Zones have just begun to be explored and quantified. This is partly due to program constraints (the inclusion of wave heights alone was, and is, a formidable undertaking) and partly due to the state of the science. Variations on the water-structure-sediment interaction theme defy current analysis. Some have been discussed here, others may be important. It is imperative that there be internal consistency in the methods to compute V Zones. With respect to erosion, in particular, the establishment of a uniform procedure(s) is needed. As the study guidelines are routinely updated, they should be made more explicit concerning the options available to the study contractor, conditions that require special attention, and procedures to be followed.

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EROSION RATES AND HAZARD MAPPING IN COASTAL RESOURCE MANAGEMENT

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Introduction

Developing a clear delineation of natural hazards is an essential element in coastal resource management. Knowing the magnitude, frequency, and impacts of various natural hazards is a necessity in properly managing development along the coast. It is therefore important that data gathering and analysis on hazards be an integral part of a management system to insure that the necessary information is available and that it meets the legal and political needs of the management program.

In the North Carolina coastal management program, properly managing development in natural hazard areas has long been a principal goal. The state's Coastal Resources Commission, in adopting its standards for development along North Carolina's 320 miles of ocean beaches, set three specific objectives for its oceanfront development:

1) Minimizing the loss of life and property;

2) Reducing the encroachment of permanent structures onto the active beach system; and

3) Reducing the public costs of improper development, particularly the costs of disaster relief, infrastructure repair and replacement, flood insurance losses, and income tax losses through casualty loss deductions.

Operating primarily through the regulatory and planning provisions of the Coastal Area Management Act, the state actively manages the location and design of new coastal development to meet these three objectives.

In order to successfully implement such a management program, accurate information on natural hazards is necessary. In determining how large an oceanfront setback to adopt and how stringent building design and construction

standards should be, the Commission had to secure accurate hazard delineation data.

To be used in such a management program, hazards data have to meet three standards. First, they must be realistic. If they are not accurate, the management system that is based on them will be ineffective. It is critical to test hazards data not only against academic models, but also against past experience and other studies. Second, the data must be available for use. If they are too costly to secure or too time-consuming to generate or use, they cannot be used practically in a management scheme. Third, the data must be legally defensible. This standard does not require perfection, but it does require reasonable accuracy. The level of detail and accuracy required varies with the uses to which the data are put, but this factor must be carefully considered when selecting a method for hazard delineation. These three factors again emphasize the importance of developing hazards data and a management system concurrently and in close coordination. Knowledge of how the data will be used and what standard of accuracy and detail is required is essential in determining what information to collect and analyze. Similarly, knowledge of what data are or can be made available and their limitations is critical in the design of management systems.

Hazard Delineation for the North Carolina Oceanfront

In designing North Carolina's coastal management program, three natural hazards received particular attention--long-term erosion, inlet formation and migration, and flooding. Such hazards as fire or high winds in coastal storms were deemed to be adequately addressed by other programs.

Erosion Studies

Erosion along North Carolina's oceanfront has two dimensions--the long-term fluctuation of the shoreline over many years and the dramatic short-term fluctuation of the shoreline in major storms. Attempts have been made to address both in the state's management program.

Long-term Erosion. It has long been known intuitively that many segments of the state's ocean shoreline are receding. Structures first built along the ocean 50 years ago have been moved landward several times. Highways built in the 1940s have washed to sea, with segments being replaced in more landward locations. Subdivisions platted in the 1950s now have ocean front cottages on what were once second and third tier lots. While understanding of the impacts

of sea level rise is relatively recent, this experience has confirmed the fact that much of the state's coastline is indeed eroding over the long run.

After reviewing over 93 studies delineating erosion rates for the state's beaches, it was concluded that none met the required standards of being adequately realistic, available, and defensible for use in the state's management program. Those that seemed reasonably accurate were only available for small segments of the coast. Those with statewide coverage were either too general for use with regulations or were early efforts with untested scientific reliability.

Because of the critical need for accurate long-term erosion rate information and its central part in the emerging management program, the state decided to invest in a new study that would generate the needed data. This study, completed in 1980 and updated in 1981, is the most detailed, accurate, and comprehensive oceanfront erosion rate study conducted in the state and is now used as a key part of the management system.

These erosion rates, which depict past erosion and do not purport to project future erosion per se, were produced using a method developed largely by Dr. Robert Dolan (Dolan, Hayden, and Heywood, 1978). Low altitude aerial photography, dating from 1935 to 1980, was compared to ascertain shoreline movement. This time period reflects both the period for which high quality, accurate photography suitable for analysis is available as well as being the 40-50 year time frame that much of the state's management program is designed to address.

In summary, the methodology involves: 1) enlarging 7-1/2 minute quad sheets to produce standard 1:5,000 base maps; 2) establishing a base line on this map parallel to the shoreline, with transects at 100-meter intervals for comparative shoreline measurements; 3) overlaying aerial photographs on the base map with a reflecting projector or zoom transfer scope; and 4) tracing and digitizing the projected shoreline to allow computerized analysis of the vegetation and high water line movement.

While the accuracy of this raw data is acceptable (Dolan, Hayden, May, and May, 1980), further data manipulation was undertaken to improve its usefulness for management purposes (Benton, 1983). In order to eliminate the impacts of possible operator error in individual measurements and to filter out short-term localized erosion phenomena, smoothing of the raw data via a running mean was undertaken. For each 100-meter transect, an average erosion rate was generated

using the 15 stations on either side of it. This produces, at 100-meter intervals, an erosion rate for the 3,100 meter segment of shoreline centered on that transect. This procedure provides increased statistical reliability for the data. Where fewer than 31 stations were available, as near inlets, linear regression was used to smooth the raw data.

In addition to smoothing via a running mean, blocking of areas with similar erosion rates was done to make the data administratively useful. Segments with similar erosion rates, using a minimum length of one-half mile, was assigned a common erosion rate factor to be used in determining permit jurisdiction and minimum oceanfront setbacks. The data was then displayed on 1"=400' aerial photographs for use by the permitting staff and on 1"=2 mi. maps for public information and general planning purposes.

While constant updating of these data is required and developing methods must be evaluated constantly (Leatherman, 1983), the hazard data developed in this manner have proven to be realistic, available, and defensible. The results produced are generally compatible with older studies, including data from longer-term analysis using 19th Century U.S. Coast and Geodetic Survey charts. Also, since 1980, the state has expressed a willingness to modify the data for individual sites if more accurate and reliable localized data can be produced, and, to date, only one such request has been made, and the submitted data in that instance were found to be unreliable. The method has been challenged and upheld in administrative appeals, and none of these has continued to judicial review.

Short-term Erosion. In contrast to this active and successful use of long-term erosion data, the state has been less successful in developing useful short-term erosion data. While it is certain that the shoreline is subject to dramatic short-term changes in storms, often measuring several hundred feet in major storms, there have been only a few studies documenting the change in North Carolina. The models predicting shoreline recession in storms are still evolving and to date have not successfully resolved the question of predicting the impact of dune overtopping on recession rates, a factor that likely will be common when a 100-year storm strikes North Carolina.

Still, since short-term recession is such a critical factor for coastal management, efforts have been made to incorporate this aspect of coastal hazards into the state's management program. A study was conducted in 1979 to generate the best possible estimate of projected erosion in a 100-year storm

(Tayfun, Rogers, and Langfelder, 1979). The method used was a semiempirical model that balances areas of upland erosion and offshore deposition in a major storm. Three hundred and eighteen beach profiles were used to generate the recession estimates, which were then mapped on a 1"=400' scale. While these data were not deemed precise enough for use in regulations establishing minimum ocean setbacks, the figures were used to delineate the hazard zones that set permit jurisdiction. Within these hazard zones minimum building standards are applied. For this more limited purpose--building standards rather than setbacks--the data were deemed sufficiently realistic and defensible, since more accurate data are not available.

Inlet Studies

The inlets connecting the Atlantic Ocean to North Carolina's extensive estuarine system of rivers and sounds appear to be stable and permanent. A number of the inlets have been bridged and development along their shores has increased, lending credence to this popular perception.

However, analysis of the inlets' creation, closing, and migration show these to be among the state's most dynamic and hazardous areas. With the exception of the few with jetties or those that are naturally stable, the state's inlets are constantly shifting. Some move continuously in one direction, while others fluctuate back and forth. All are subject to swift change that can destroy any improperly located development.

Delineation of a hazard zone for existing inlets was carried out via statistical analysis of past inlet movement (Priddy and Carraway, 1978). Surveys and aerial photographs of past inlet location were mapped and analyzed to predict future inlet migration within varying confidence levels. This mapping also took into account such natural features as an unusually narrow barrier island or overwash area, and existing human alterations such as jetties and channels. The confidence intervals were then used to locate a minimum inlet setback and a broader hazard zone within which density and construction standards are applied. These inlet hazard area delineations, first applied in 1978 and updated in 1981, have been successfully used in the management program.

Establishing hazard zones where there is a high potential for new inlets has not yet been accomplished. While new inlet formation occurs only rarely on the barrier islands that are large enough for substantial development, it is recognized to be a serious and real hazard. Formation of an inlet during a

major storm would obliterate development in its path and sever vital transportation and utility links. However, the state has not yet been able to generate data with sufficient reliability to justify use in the management program.

Flood Studies

To avoid unnecessary expense and duplication, the state generally uses flood insurance rate maps published by the Federal Emergency Management Agency (FEMA) to delineate flood hazard areas. Any area shown as a high hazard flood area (the open velocity zones) on such maps is automatically brought within state coastal permit jurisdiction. Use of the V Zones has the advantage of using a familiar map that is readily available and generally recognized to be accurate.

However, FEMA's recent remapping of the coastal flood areas to incorporate wave heights has caused several difficulties in North Carolina. While the state had requested and supported this move to produce maps that more realistically portray flood hazards, the results depicted in the draft maps prepared under contract for FEMA were disappointing. The first draft maps submitted to the state for review showed generally small V Zones when wave heights were added. In fact, in one case the V Zone depicted on the map was entirely seaward of the current mean high water line.

Ensuing discussions with FEMA over the course of 1981-83 revealed that several disturbing assumptions were made in preparing the updated maps. First, the maps totally ignored long-term erosion, even though the state had detailed, reliable, and readily available data on past erosion rates. While this presents few difficulties in stable areas with high elevations, it leads to a major understatement of risk in high erosion areas. Locating a 60-foot wide V Zone in an area with a 15-foot/year erosion rate without taking account of erosion is folly, unless new rate maps are going to be issued semiannually.

Second, the models failed to take account of storm-induced erosion. As with long-term erosion, flooding and wave action in past storms clearly indicate that this is a seriously fallacious assumption.

Third, the models assume that sand dunes are stable physical features in storms. Basing a V Zone on the seaward 15-foot elevation contour of a 16-foot oceanfront dune, and assuming this will be stable in a 100-year storm, ignores

reality and seriously understates risk.

Fourth, there are some indications that storm surge levels were underestimated. Finally, outdated base maps may have been used, further exacerbating the above problems in high erosion areas.

Fortunately, some of these concerns appear close to resolution after two years of discussion with FEMA. The models have been revised to take account of at least some estimation of storm-induced erosion. However, FEMA has concluded that policy and legal constraints require them to ignore long-term erosion as a factor in mapping and that this can only be addressed through periodic map updates.

In addition to these technical concerns, the lack of coordination with the state has been troublesome. As an example, FEMA has recently explained the two- to three-year delay in finalizing the maps to local governments (who in some cases are anxiously awaiting the maps in order to move from the emergency to the regular program) as being due to state requests to include erosion effects. Since this problem has been identified by numerous reviewers on a national level over the past years and since FEMA does have a responsibility to promulgate reasonably accurate maps, such intergovernmental complaints are misleading and contribute little to effective coordination.

Management System for Oceanfront Development

Regulatory Provisions

Using the studies described above, the state has established a program to manage development in the most hazardous areas along the oceanfront (Owens, 1981).

The regulatory program applies in three delineated high hazard areas that are officially designated in administrative rules adopted by the state Coastal Resources Commission. The "ocean erodible area" starts at mean low water and extends inland a distance equal to 60 times the long-term average annual erosion rate plus the projected 100-year storm recession (this distance being measured from the vegetation line). The "inlet hazard area" includes areas of potential inlet migration adjacent to existing inlets, and the "high hazard flood area" includes all numbered V Zones on published flood insurance rate maps.

With these three areas, permits are required for any development or land-disturbing activity. The principal locational requirement in the permit standards is the minimum oceanfront setback. The setback rule establishes four

tiers for development. First, no development may be located seaward of the vegetation line. Second, in the zone extending from the vegetation line landward, a distance 30 times the annual erosion rate (a 60-foot minimum), no permanent substantial structures are allowed although parking lots, tennis courts and the like can be located there. Third, small structures (those with fewer than four units and/or less than 5,000 sq. ft. of floor area) can be located between 30 times and 60 times the annual erosion rate landward of the vegetation line. Larger structures must be at least 60 times the annual erosion rate behind the vegetation line. Figure 1 illustrates these requirements. Development must also be landward of the inlet setback, the landward toe of small frontal dunes, and the crest of larger primary dunes.

Beyond this setback, any development in the delineated hazard areas must meet minimum construction standards. For the most part these standards are based on those required by FEMA for floodplain zoning ordinances and the state's minimum building codes. Some standards, such as minimum piling size and penetration, have been increased. New moves by FEMA to establish graduated insurance rates based on the quality and survivability of structures will help reinforce these standards. Community risk rating would also contribute to the coordination of state and FEMA programs.

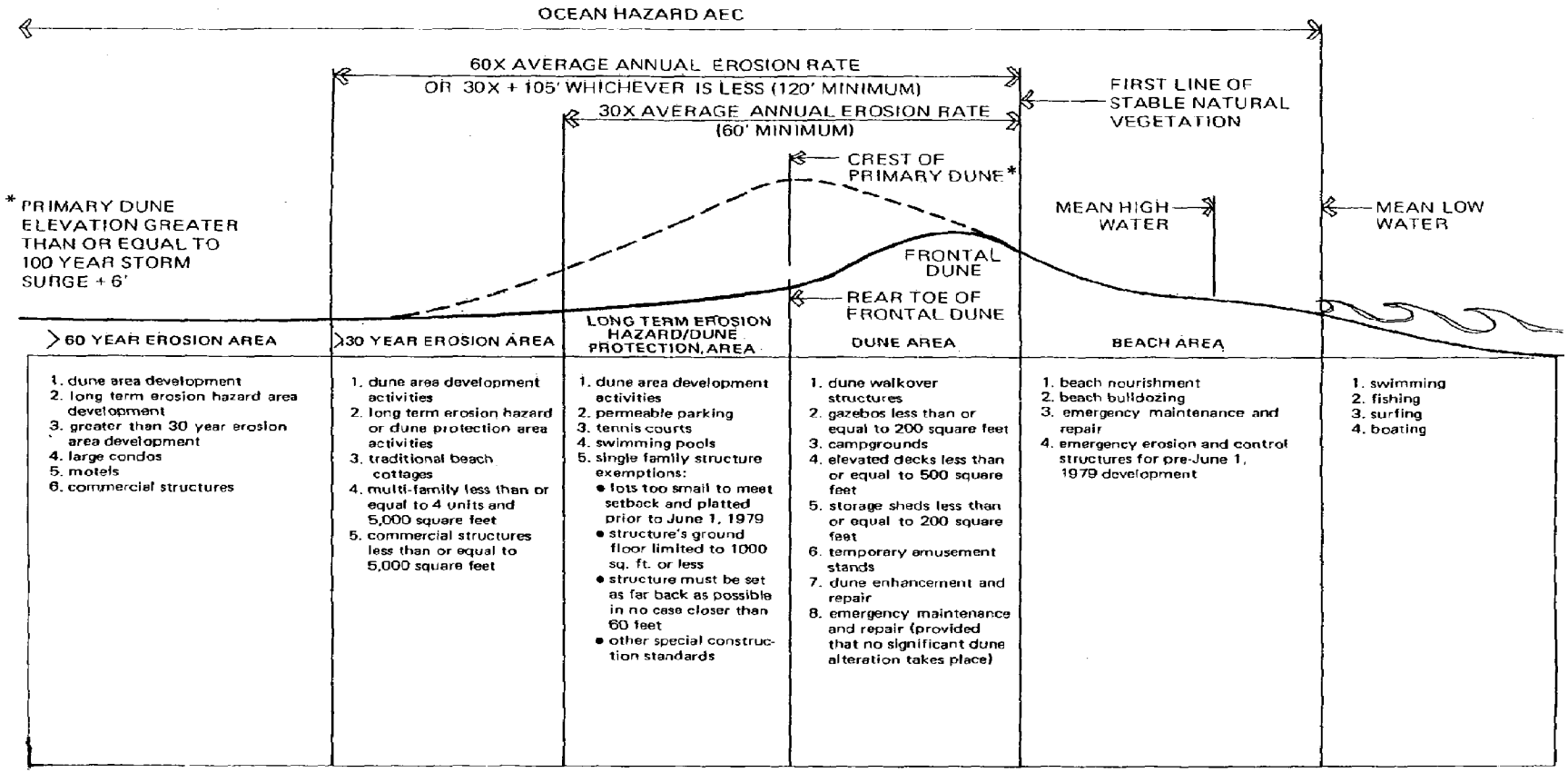
Other state development standards include density limits in the inlet hazard area (only single family detached units are allowed), limits on any growth-inducing public investments in hazard areas, and limits on oceanfront erosion control structures. Significant new policy initiatives now being proposed in this last area would preclude any permanent shoreline stabilization and any projects that would block public use of the beach or increase erosion on neighboring properties (Outer Banks Erosion Task Force, 1984).

Nonregulatory Provisions

The state also actively employs nonregulatory techniques for managing oceanfront development. Coastal local governments are required to prepare comprehensive land use plans that are consistent with state standards. As of 1983, the plans must include a poststorm planning element that addresses steps to be taken prior to coastal storms to minimize damage, specifies evacuation and recovery operations, and sets forth poststorm rebuilding policies. In addition, the state has actively used land acquisition to further its management objectives (Owens, 1983). This includes a beach access acquisition program with an explicit priority for acquiring lots unsuitable for development,

Figure 1

PERMITABLE DEVELOPMENT ACTIVITIES WITHIN OCEAN HAZARD AEC AREAS



tax credits for the donation of hazardous areas, estuarine sanctuaries and other programs.

The state has strongly encouraged FEMA to more aggressively use relocation as a means of reducing certain future flood insurance losses, but to date this effort has been unsuccessful. The state is still pursuing adequate funding for Section 1362 acquisitions and coverage of prudent relocation under flood insurance policies.

Conclusions

The state of North Carolina has made substantial progress in the past five years in identifying hazard areas along its oceanfront and assessing the magnitude of risks there. Accurate oceanfront erosion rates have been determined in a cost effective manner. Additional research is needed to quantify projected short-term erosion during major storms, and careful attention must be given to new flood insurance rate maps to assure that they do not significantly understate very real and serious hazards.

Similarly, the state's management systems, at both the state and local level, have dramatically improved over the past five years. There remains a strong need for continued federal funding of these efforts to assure that these gains will not be lost and that progress in reasonable resource management will continue.

Continued and improved coordination is badly needed. Academic efforts to study and delineate hazards must be closely related to management needs. Federal programs affecting development in hazardous areas--especially flood insurance, emergency management, land acquisition, public investment, and coastal management programs--must be coordinated to avoid counterproductive efforts. Through such renewed cooperation, better delineation of hazard areas and better management of inevitable coastal development is possible.

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MAKING MAPS USEFUL FOR LOCAL GOVERNMENTS

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The possible approaches to making maps more useful would be unlimited if one had unlimited funds. Since this is not the case, we, as state floodplain managers, must be innovative in helping local officials to use the maps. Many local officials are not aware of the true hazards associated with high risk areas such as coastal V Zones. Most have not been fortunate enough to have heard Neil Frank's message and perhaps do not understand the seriousness of the threat.

Before I tackled this issue, the problem had to be clearly defined, which seems like an easy enough task. Yet, as I have discovered during my six months as Georgia's Floodplain Coordinator, when you are dealing with the NFIP, nothing is simple. So I distributed a questionnaire to 15 coastal communities in Georgia to gain insight into the day-to-day struggles facing the officials. The questionnaire covered topics such as: problems encountered with the maps; whether officials felt the maps were useful; and what suggestions officials could offer to improve the maps. Ten of the 15 local governments responded to the questionnaire, and the others were contacted by phone.

In response to the question concerning problems encountered with the maps, there was a broad range of responses. Some of the cited deficiencies were quite legitimate. They ranged from a lack of benchmark locations for surveying, to inadequate base maps, to the generality and difficulty of referencing the maps. There seemed to be a common feeling of frustration among the officials having to enforce these maps.

Most of the officials I dealt with were generally knowledgeable about the maps. I discovered that if there was confusion, it was primarily with the insurance aspects of the program and not with actual flood mapping. Most officials were aware of what a V Zone defined and why the storm surge/wave height had recently been added to the maps. They did not agree with the wave height elevations or think that they were a necessary addition, but they did

understand fairly well the concept behind wave height mapping. Most officials thought that the maps were technically sound and reliable. Their concern was not that the data was correct, but rather that it was too general and therefore open to differing interpretations from homeowners, developers, or local officials.

One of the most common complaints was that the base maps, which included roads, streets, legends, contour intervals, topography, and scale, were inadequate. Many officials find it incredibly difficult to reference any specific site on the maps and determine, without a doubt, what the site elevation is and in which zone it lies. This is further complicated in McIntosh County, because there are few benchmarks there to determine first floor elevations.

Another dilemma is posed to some Georgia communities because of height restrictions on buildings located on barrier islands. For example, off the southern coast of Georgia, on St. Simon's Island, which is currently experiencing a condo boom, the county had restrictions in effect limiting building heights to four stories before the adoption of the flood maps. The velocity zone elevations of those maps have resulted in requests for variances to build five-story buildings with parking below the first floor. Thus, the well intended flood program has left local officials with the problem of deciding between local and federal regulations.

Regarding the insurance applications of the maps, many local officials, being planners and engineers, are ignorant of FIA requirements. When design standards are reviewed, many FIA requirements are not considered. A prime example of this occurred in Chatham County, where misunderstanding of the requirements for an elevation certificate caused chaos for several weeks. Engineers there refused to sign the elevation certificate for several structures because they had not been built according to FIA standards. These particular structures were built with garages below the first floor level--which is allowed if the walls are breakaway or have openings every several feet to allow the free flow of water. Since these stipulations were ignored, the first floor elevation for these structures was determined to be garage level, even though that level might have been used for storage purposes only. Needless to say, the Chatham County developers were more than slightly annoyed when they were told this. This problem was not a direct result of the flood maps but does reflect the confusion that can occur when not everyone is properly informed of the maps' use and the pertinent regulations.

The suggestions local governments offered for improving the flood maps centered on 1) improving the base maps; 2) providing training and education for those individuals who enforce V Zone regulations; and 3) conducting more detailed mapping.

Inadequate base maps are usually a result of the map being out of date so that other maps must be used for reference.

Training and education does seem to be widely needed. Improved interaction between state and local officials, federal and local officials, and FIA and local officials was specifically requested. Local officials also desperately need information on current construction standards and floodproofing techniques for commercial structures in A and V Zones. Increasing the awareness and understanding of officials as well as private citizens concerning the prediction of, forces involved with, and damages resulting from a hurricane should help discourage development in V Zones. If it does not discourage development, at least it will increase awareness for evacuation purposes.

The third suggestion made by the officials was to make the flood maps more detailed, so that officials would have a scale they could work with and be confident with. The method used for mapping does not seem to be the problem. Instead it seems to be the unsatisfactory way in which the data is presented on the maps. A larger scale map would definitely help. Most officials are able to enforce the wave height regulations but not without resistance from locals.

From my standpoint, the major difficulty for local officials in dealing with the maps results from the maps' representing a predicted or theoretical flood potential rather than a perceived flood potential. This makes it difficult to impose wave height regulations on individuals who have lived in the area for a number of years and have never experienced anything more than average seasonal rainfall. This problem is, of course, not specific to the coast, but has been magnified there because of the recent imposition of increased wave height elevations. Because Georgia has not experienced a storm with hurricane force winds in several years, locals generally do not believe that a storm sufficient to produce the wave heights shown on the FEMA flood maps could, in fact, occur.

In conclusion, there are several possible steps that could be taken to guide local officials:

First, more training and education should be provided. Workshops that review Federal Insurance Administration regulations are definitely needed. The

flood maps have limited usefulness without some understanding of the corresponding regulations. The maps should not be presented to local officials without also providing a clear understanding of the objectives and goals to be met in using those maps. A coastal construction workshop to better acquaint local officials with construction designs and standards required by the FIA and NFIP would also be of tremendous assistance.

Second, the relevant published research information--including handbooks, brochures, and manuals--should be distributed generously to officials. Again, the officials are able to benefit from the program only if they are knowledgeable about its maps and regulations.

Third, hurricane awareness should be promoted and adequate evacuation measures taught.

Fourth, local officials should be requested to record the type of construction, floodproofing methods, and standards used on various projects for reference, so that successful and not-so-successful techniques can be determined.

Fifth, and most importantly, local officials should be provided with realistic planning guidelines in areas of high risk. The maps should be used as a tool to identify and recognize the areas that are most vulnerable.

Sixth, areas such as inlets, beach frontages, and hazardous erosion zones should be emphasized to the officials as extreme high risk areas, so that management in these areas is more effective.

I am certain there are many other possible ways to help local officials with the flood maps, but I think we can all agree that the number one priority is simply to educate them so that they can understand the maps and, perhaps more importantly, the NFIP. There will be little accomplished if we decide to improve the flood maps and ignore this basic lack of understanding.

PART THREE

STRATEGIES FOR MANAGING HIGH RISK AREAS:

Mapping

THE FUTURE OF FEMA'S FLOODPLAIN MAPPING PROGRAM

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Introduction

The future direction of FEMA's flood mapping program can be thought of as being divided into three major areas: 1) the direction the program will take between now and the end of FY 1987; 2) the direction the program will take in FY 1988 and subsequent years; and 3) related goals we intend to accomplish along the way. Before I begin, let me tell you of a telephone call I received Friday as I was leaving the office. Jim Holton, Director of Public Affairs, called. "John," he said, " we would like to feature your office in our next issue of the Emergency Management newsletter." "Great," I said, "I will look forward to getting my copy." "OK," he said, "but that is not why I'm calling. Just what is it you guys do up there?"

Like Jim, many of you might not know what the Office of Risk Assessment does. Figures 1 and 2 illustrate the Office's position within the Federal Insurance Administration, and Figure 3 lists its goals and activities.

The most important thing I can tell you of my office is that it, along with the Office of Loss Reduction, was reintegrated as a unit of the Federal Insurance Administration on November 20, 1983. This was an important reorganization in that it now permits a more direct approach to resolving inconsistencies in insurance, mapping, and regulations that might have come into being during the past few years when units responsible for these functions operated more or less autonomously.

Near Term Direction (NFIP)

Flood Insurance Study Program

FY 1984 to FY 1987

The National Flood Insurance Act of 1968 established a 1983 deadline for the completion of all initial flood insurance rate studies. However, that Act

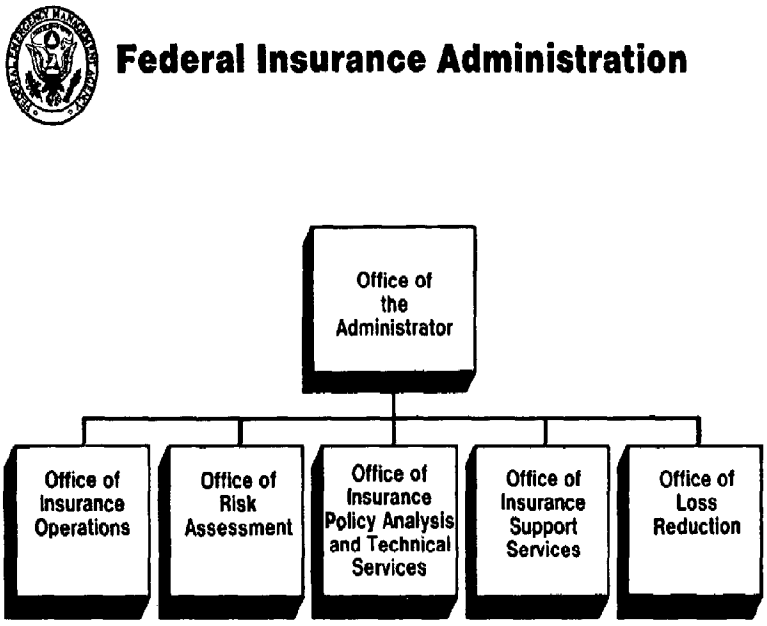

Figure 1

The Federal Insurance Administration

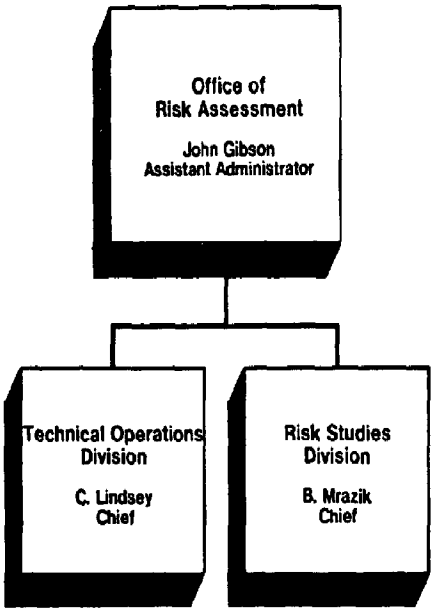

Figure 2

The Office of Risk Assessment

MISSION STATEMENT:

THE OFFICE OF RISK ASSESSMENT DEVELOPS POLICIES, PROCEDURES AND METHODOLOGIES AND CONDUCTS FLOOD HAZARD IDENTIFICATION AND RISK ASSESSMENT STUDIES WHICH PROVIDE DATA NECESSARY FOR THE IMPLEMENTATION OF AN ACTUARIALLY SOUND NATIONWIDE FLOOD INSURANCE PROGRAM AND THE REDUCTION OF FLOOD LOSSES THROUGH LOCAL FLOOD PLAIN MANAGEMENT PROGRAMS. THE FUNCTIONS OF ITS TWO MAJOR DIVISIONS ARE:

TECHNICAL OPERATIONS DIVISION

- **INITIATE NEW STUDIES AND RESTUDIES**
- **PROCESS REQUESTS FOR LETTERS OF MAP AMENDMENT/MAP REVISION**
- **PRINT AND DISTRIBUTE MAPS AND REPORTS**
- **TRACK FLOOD STUDY FUNDS**
- **RESPONSIBLE FOR SPECIAL CONVERSIONS**

RISK STUDIES DIVISION

- **MANAGE FLOOD RISK STUDY AND MAPPING PROGRAM**
- **DEVELOP TECHNICAL POLICIES, GUIDELINES AND PROCEDURES**
- **PROVIDE A NATIONAL FOCAL POINT FOR DEVELOPMENT OF FLOOD HAZARD AND RISK DATA**
- **PERFORM TECHNICAL REVIEW OF FLOOD INSURANCE STUDIES**
- **RESOLVE TECHNICAL ISSUES OF APPEALS**

Figure 3

Office of Risk Assessment Functions

assumed that there were only about 5,000 flood-prone communities in the nation. Today, we know that there are almost 22,000 flood-prone communities in the United States. We have prepared Flood Hazard Boundary Maps for about 19,100 of these communities. As of the start of FY 1984, about 17,500 of these communities participated in the NFIP. The status of these communities is shown in Figure 4.

The near term direction of the flood study program will focus on providing full program status--that is, conversion to the regular program--to the 7,826 communities presently in the emergency program.

Although well over the original estimate of 5,000 community studies have been completed, the question remains: how many emergency program communities warrant a flood risk study, and what level of effort should be expended to develop risk data for them?

In 1983, the U.S. General Accounting Office released a report, "The Federal Emergency Management Agency Can Reduce Mapping Costs," in response to the desire by Congress to consider options for expediting the conversion of

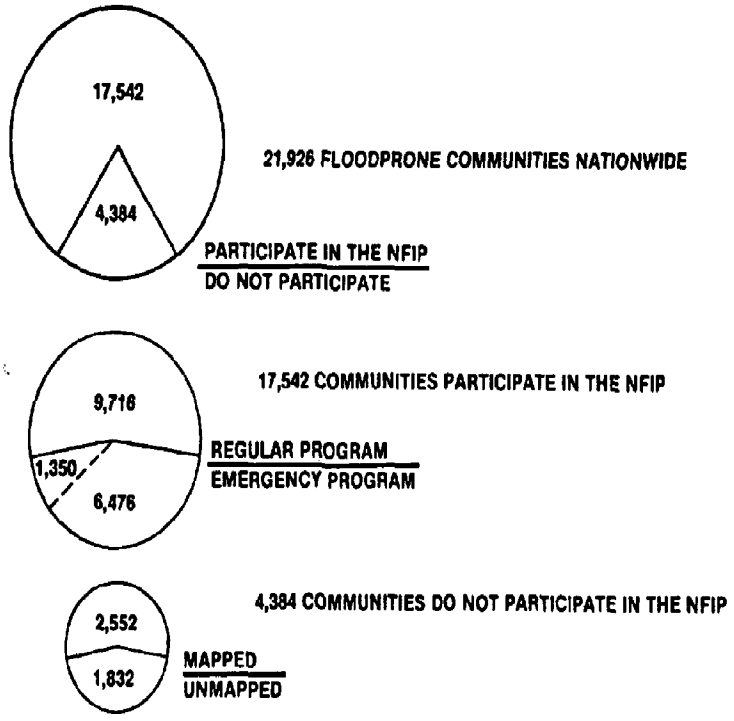

Figure 4

Status of the NFIP as of the Start of FY 1984

remaining unstudied communities to the Regular Program. The GAO recommended that FEMA undertake a systematic approach to determine the level of study needed, including the following actions:

- Rank communities on the basis of development potential;
- Incorporate other mapping approaches in the decision-making process; and
- Weigh the benefit of additional detailed study against study costs in making decisions.

In November, 1983, Congress passed P.L. 98-181, which amended Section 1360(a)(2) of the National Flood Insurance Act of 1968, to extend the flood insurance study program to September 30, 1985, and added a new subsection requiring the Director of FEMA to submit to Congress a plan for converting all communities to the Regular Program of the NFIP by September 30, 1987. Congress also extended the Emergency Program and the initial studies completion date to September 30, 1985.

FEMA has responded to this legislation and the GAO report by initiating a number of actions which will determine the future directions of the flood insurance study program. In FY 1983, FEMA initiated a study to evaluate the floodplain development potential in the remaining unstudied communities. This contract was awarded to Donnelley Marketing Information Services, a company of the Dunn and Bradstreet Corporation. Donnelley is a leading firm in small area demography. The final results of this study were received in May 1984, and include an assessment of existing floodplain property at risk and projected future property at risk for the period 1984-1998. About $13.8 billion in new development is expected to occur in the unstudied floodplains during this period (Figure 5). The Donnelley study indicates that only 3,712 communities would experience significant new development in their unstudied special flood hazard areas--the 100-year floodplain--during this period. The rest of the communities would experience steady or declining development in their 100-year floodplains. The unstudied communities were then ranked based on the value of property at risk in the 100-year floodplain.

In FY 1984, FEMA entered into an Interagency Agreement with the U.S. Geological Survey to review all remaining unstudied communities that had been recommended for detailed study by the FEMA Regional Offices. The purpose of that review is to assess the applicability of less costly and less time consuming methods for assessing the hydrologic and hydraulic conditions within those communities and to recommend various types and levels of study based on those findings. The location of the 2,400 communities being screened by the U.S. Geological Survey is shown by state on the map of the United States in Figure 6. The U.S. Geological Survey will complete most of its screening efforts this summer.

FEMA is currently in the process of preparing the report to Congress required by the 1983 amendments to the National Flood Insurance Act. This report will detail the number of communities to be converted to the Regular Program by the various methods (i.e. full detail study, limited detail study, existing data study, minimally flood-prone conversion or non-flood-prone conversion), the funding required, and the time required. The decision whether a community warrants a flood insurance study and, if so, what level study should be performed, will be based on a benefit/cost analysis. This analysis considers the costs associated with the various types of study in relation to the future benefits of reduced flood losses that can be expected as a result of

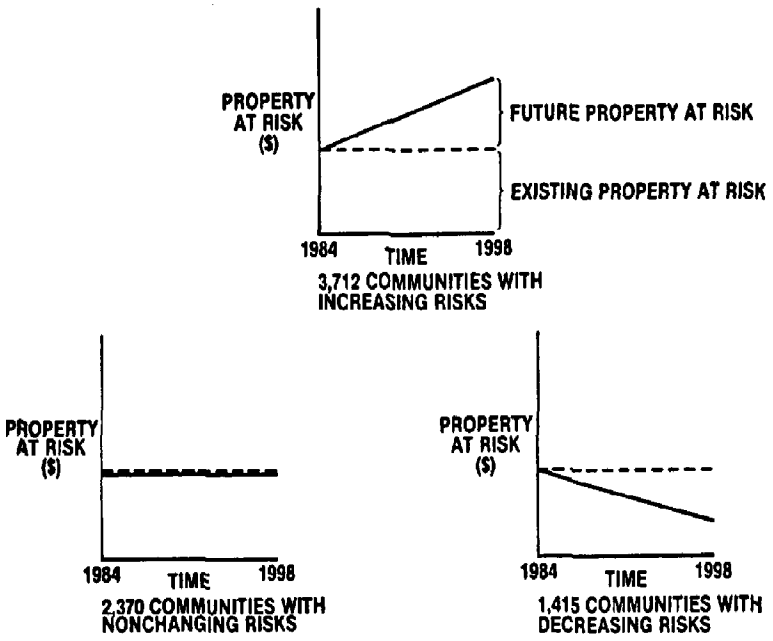

Figure 5

Results of the Demographic Survey of 7,497 Communities

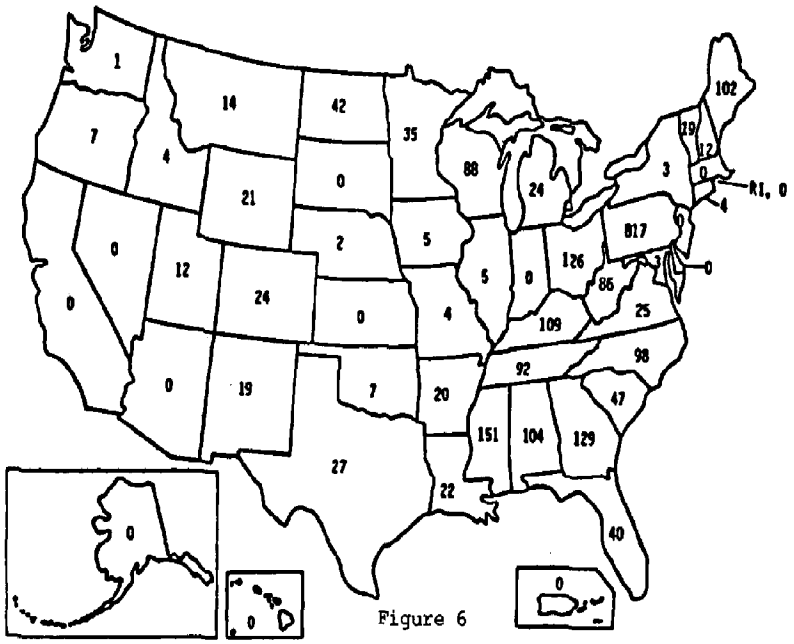

Figure 6

Number of Study Areas to Be Evaluated by USGS for Less Detailed Study Methods

improved floodplain management based on the data provided by the study. We have determined that the benefit of a flood insurance study, in these terms, is about 2.5 cents per one dollar of future development that would have been otherwise unwisely sited in the 100-year floodplain. By comparing this benefit with the average study cost of the different types of flood insurance studies and Donnelley's estimates of the value of future development, we have been able to determine the most cost-effective means of converting the 6,476 unstudied communities to the Regular Program.

Results of our analysis show that some 820 full detail studies and 770 limited detail studies can be supported by future floodplain development. We also find justification for studying about 190 additional communities using the existing data study process. The remaining unstudied participating communities, approximately 4,700, will not receive a study and will be converted to the Regular Program as either minimally flood-prone (with approximate flood hazard mapping) or non-flood-prone (without a map). These study initiations and special conversions will all occur between FY 1984 and FY 1987 (Figure 7).

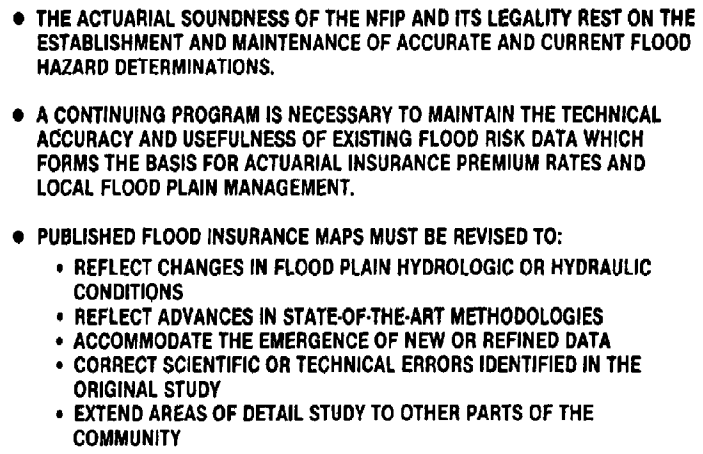

Figure 7

NFIP Need for Flood Studies Maintenance Activity

- MORE THAN 19,000 FLOOD INSURANCE MAPS HAVE BEEN PUBLISHED SINCE THE INCEPTION OF THE NFIP. HISTORICALLY, MORE THAN $100 MILLION OR ABOUT 20% OF TOTAL APPROPRIATIONS HAVE BEEN SPENT TO KEEP THESE MAPS ACCURATE AND UP TO DATE.
- PUBLISHED FLOOD INSURANCE MAPS AND STUDIES MAY BE UPDATED BY FOUR MEANS:
  - FLOOD INSURANCE RESTUDIES — PERFORMED WHEN CHANGE IS EXTENSIVE
  - FLOOD INSURANCE STUDY REVISIONS
  - LETTERS OF MAP REVISION (LOMRs)
  - LETTERS OF MAP AMENDMENT (LOMAs)

  — PERFORMED WHEN AN APPELLANT PROVIDES DATA
- WITH THE START OF FY 1988 THE STUDIES PROGRAM WILL BEGIN TO OPERATE AT THE FULL MAINTENANCE LEVEL.
- ANNUAL APPROPRIATIONS OF ABOUT $36 MILLION WILL BE REQUIRED TO SUSTAIN THE ESTIMATED LEVEL OF MAINTENANCE TO BE ACCOMPLISHED IN FY 1988 AND SUBSEQUENT YEARS. THESE FUNDS WILL SUPPORT THE FOLLOWING ACTIVITIES:
  - 215 FLOOD INSURANCE RESTUDIES
  - 400 FLOOD INSURANCE STUDY REVISIONS
  - 1,520 LOMRs/LOMAs

Figure 8

NFIP Projected Flood Studies Maintenance Activity

FY 1988 and Beyond

Our plan to Congress will recommend that, after netting out studies started during FY 1984 and FY 1985, funding be provided to initiate the remaining cost-effective studies in FY 1986 and FY 1987 and authorization to conduct these new studies be extended to cover those two years. The new studies initiated during FY 1984 will be those recommended to us by our regional offices. Most of the FY 1985 funding for new studies will be used to initiate those limited detail studies recommended by the U.S. Geological Survey.

All minimally and non-flood-prone communities will be converted to the Regular Program during FY 1984-1987, with an average of about 1,200 communities scheduled for conversion each year during this period. Our plan to Congress will also recommend that the Emergency Program be extended to September 30, 1990, to allow all communities that had studies initiated in FY 1986 and FY 1987 to be converted with effective Flood Insurance Rate Maps.

Long-Term Direction of the NFIP

Flood Insurance Study Program

FY 1988 and After

FEMA intends to begin a full maintenance-level program of flood insurance restudies and map revisions beginning in FY 1988. The philosophy of applying benefit cost relationships in study decision making will continue in the restudy program.

In FY 1986, FEMA will establish a formal restudy decision-making process that will take into consideration both insurance and floodplain management benefits to be derived from restudies relative to their cost. FEMA will also be encouraging cost sharing, either by direct contribution of funding or by actual performance of various study elements by state or local governments, as a means of increasing restudy priority. FEMA will also respond to appeals by individuals or communities to revise maps when such appeals are supported with technical data supplied by those groups.

My best estimate of the level of activity that will occur as the flood study program operates in the maintenance mode is that we will be revising about 5% of all the effective flood insurance studies with base flood elevations each year (Figures 7 and 8). We project that one-third of these updates will be accomplished by the restudy process and the other two-thirds through the map revision/amendment process. This would translate into initiating about 215 restudies per year, performing about 400 map revisions, and issuing about 1,520 letters of map revision or amendment. Congress would have to provide funding of about $36 million per year to support this level of activity. We will have a more realistic picture of FY 1988 and beyond after we have completed the formal study we will be undertaking next year.

Actions Related to the Flood Insurance Study Program

In January we had ambitious plans for having the map initiatives program far enough along by now that I could talk to you about likely alternative map products and whether we would continue to print separate Flood Insurance Rate Map and Flood Boundary Floodway Map panels. Unfortunately, we underestimated the time it would take to get input from agents, lenders, appraisers, others in the insurance industries, and public officials. Our original timetable was premised on piggybacking the map initiatives survey onto already scheduled workshops. After conducting two insurance workshops in this manner in February, we realized that the project was too important to squeeze it into an

- **Changes common to all new samples:**
  - Zones compressed – maximum of 5 (AE, VE, A, V, and O) in coastal communities and 3 in riverine communities (AE, A, and O)
  - Differences between sample and current format in explanatory box.
  - *Map repository address and zone identification dates eliminated.*
- **Changes in new FIRM Index Panels:**
  - Floodprone street index
  - SFHA delineated shown
  - Map information shown beyond corporate limits
- **Changes in new FIRM Panels:**
  - Alpha-numeric street locator grid
  - Rectilinearized SFHA
  - Small scale single panel FIRM for entire community
- **New FIRM/FBFM Panels:**
  - New initiative to show all information on one map
  - Shows insurance information (SFHA, Zones, BFEs) and floodplain management information (floodway, cross-sections, river miles)

Figure 9

Map Initiatives Project

Final Map Sample Selection

already ambitious agenda. We want it to be given the attention it deserves. The last workshop was conducted on June 7, 1984, and the tabulation of the questionnaires is to be completed by June 30. The sample maps and questionnaire relate to changes shown in Figure 9.

We have received from the Association's Mapping and Standards Committee Chair about 220 completed questionnaires with a preliminary evaluation of the results. Likewise, we have received a preliminary analysis of the 180 responses submitted during three agent/lender workshops and 14 completed questionnaires from four of our regional offices. Preliminary findings based on these partial samples are shown in Figure 10. I am pleased with the reaction received from all survey respondents. The response has been overwhelmingly enthusiastic, and it looks as though we will have more than 800 opinions from all sections of the country upon which to base our future decisions.

I have given you the bad news--the survey was not completed as originally scheduled. The good news is that we can make up the slippage in the schedule. All cost-effective recommendations for alternate formats are scheduled to be

	AGENTS/LENDERS	ASFPM	FEMA REGIONS
NO. OF RESPONDENTS	180	219	14 in 4 Regions
PRELIMINARY FINDING			
ELIMINATE TWO MAPS (FIRM/FBFM)	80%	88%	100%
PREFER RECTILINEAR FIRM	86%	9%	0%
PREFER CURVILINEAR FIRM	14%	91%	100%
PREFER LESS DETAIL ON FIRM	YES	NO	NO
PREFER MORE DETAIL ON FIRM	NO	YES	YES
PREFER SFHA ON FIRM INDEX	YES	—	YES
PREFER STREET INDEX & GRID	YES	—	NO
PREFER CROSS HATCHED FLOODWAY	YES	—	YES
INCLUDE AREA BEYOND CORP. LIMITS	YES	YES	YES
PREFER MAP SAMPLE NO.	F2	R3	R3

MAP F2 = NEW FORMAT—SINGLE PANEL, SMALL SCALE FIRM WITH RECTILINEAR SFHA COMPRESSED ZONES, FLOODPRONE STREET GRID AND STREET LOCATOR GRID

MAP R3 = NEW FORMAT—MULTIPLE PANEL, LARGE SCALE COMBINED FIRM/FBFM WITH COMPRESSED ZONES, CONTOUR LINES, LANDMARK BUILDINGS, SPOT ELEVATIONS AND INFORMATION SHOWN BEYOND THE CORPORATE LIMITS

Figure 10

Map Initiatives Project Preliminary Findings

implemented at the start of FY 1985 as new maps are issued or as existing maps are revised.

Some of the innovative mapping initiatives we are pursuing are a feasibility study of providing users with microimages of our maps rather than paper copies; a feasibility study of the LIDAR laser ranging system to produce topographic maps; and the use of geographic information systems to produce digitized maps and to fully automate the production and distribution of flood insurance maps. A summary of the future directions of the NFIP Flood Studies Program is given in Figure 11.

NATIONAL FLOOD INSURANCE PROGRAM

- **EMPHASIS FY 1984—1987**

  COMPLETE THE INITIAL STUDIES PROGRAM

  - INITIATE ALL COST-EFFECTIVE STUDIES BY SEPTEMBER 30, 1987 AND COMPLETE THEM BY SEPTEMBER 30, 1990
  - INITIATE AND COMPLETE ALL SPECIAL CONVERSIONS BY SEPTEMBER 30, 1987

- **EMPHASIS FY 1988 AND BEYOND**

  - BEGIN FULL MAINTENANCE LEVEL ACTIVITY IN FY 1988 AND OPERATE IN THIS MODE DURING SUBSEQUENT YEARS
  - FY 1988-90 COMPLETE PIPELINE OF STUDIES STARTED IN FY 1986-87

- **RELATED ACTIVITIES**

  - IMPLEMENT MAP INITIATIVES PROJECT RECOMMENDATIONS
  - ISSUE COMPREHENSIVE APPEALS PROCESS MANUAL
  - COMPLETE COUNTY-WIDE MAPPING FEASIBILITY STUDY
  - COMPLETE HURRICANE CLIMATOLOGY STUDY
  - COMPLETE STORM SURGE MODEL REVISIONS
  - COMPLETE ALLUVIAL FAN METHODOLOGY UPDATE
  - COMPLETE LIDAR LASER RANGING SYSTEM FEASIBILITY STUDY
  - COMPLETE ALASKA COAST TSUNAMI STUDY
  - COMPLETE MICRO IMAGING FEASIBILITY STUDY

Figure 11

Future Directions of the Flood Studies Program

APPLICATION OF INNOVATIONS IN MAPPING TECHNOLOGY TO FLOOD INSURANCE STUDIES

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Introduction

Technology presently exists for fully automating nearly all of the flood insurance study and mapping process. Yet in present application, many floodplain mapping processes for flood insurance studies and other purposes remain largely manual operations. This brief paper examines the elements of a fully automated floodplain mapping system, some of the reasons why greater automation is not yet applied, and a possible transition plan for phasing into a fully automated process.

Automated Floodplain Mapping System: An Idealized Concept

Topographic Data Collection

Figure 1 illustrates the components of an idealized floodplain mapping system which are summarized in Table 1 and can be compared to conventional flood insurance study approaches. Under the conventional approach, topographic data is collected by field surveys or a combination of field surveys and photogrammetric methods. Additional topographic data may be obtained by manually taking data points off available contour maps. This data is then hand encoded and keypunched for input to hydraulic or hydrologic computer models.

The development of profiling laser ranging systems such as the LIDAR (Light Detection and Ranging) system under study by the Corps of Engineers and the APTS system (Aerial Profiling of Terrain System) under development by the United States Geological Survey (USGS), provides opportunity for the rapid collection of ground elevation data, in digital map format, which can be directly input to computer based Geographic Information Systems (GIS). Scanning laser mapping systems have also been proposed that would allow for the generation of an entire topographic map in digital format.

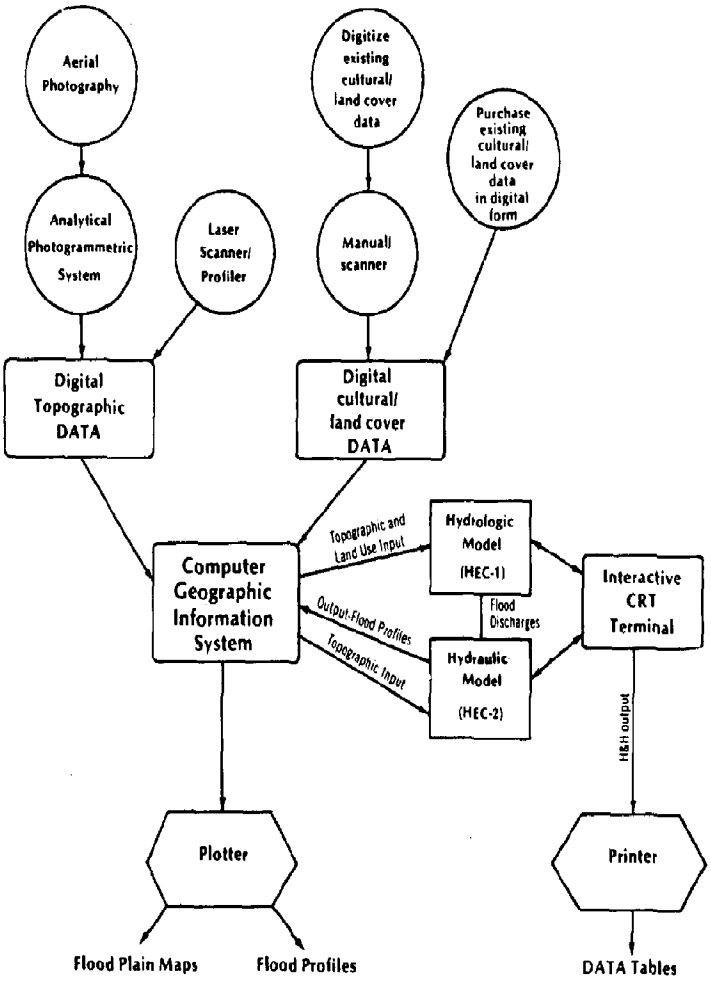

Figure 1

Conceptual Diagram of Fully Automated

Flood Insurance Study System

1. Collection and utilization of topographic data in digital format using laser profiling (e.g., LIDAR), laser mapping systems, or Analytical Photogrammetric Systems (APS).
2. Collection and utilization of land cover and cultural data in digital format by manual or scanning digitization of existing mapping or by purchase of such data generated from satellite or photographic imagery.
3. Utilization of Geographic Information Systems (GIS) to develop direct input of digital topographic and land cover data into hydrologic and hydraulic models.
4. Utilization of GIS to generate flood plain maps and profiles from hydraulic model outputs and to store and revise maps and profiles.

Table 1

Elements of a Fully Automated

Flood Insurance Study System

Analytical Photogrammetric Systems (APS) rely on conventional aerial photography with human interpretation but provide for computer-assisted set up and maintenance of the stereo model. In application, APS records x, y and z coordinate data in digital format. Attributes can be assigned to digitized point, line, and polygon features at the same time. The resulting digital data base can also be used to create a GIS.

Planimetric and Land Cover Data

In addition to topographic data, flood insurance studies utilize other map-based information, including land cover and soils data required to determine runoff coefficients in some hydrologic models. Cultural data and other planimetric information such as roads are usually obtained from existing map sources to formulate a base for the floodplain mapping. A fully automated floodplain mapping system would utilize land cover, soils, and cultural data in digital format.

Land cover data can be digitized manually from aerial photography using the APS system. Landsat systems, including the Thematic Mapper and Multi-Spectral Scanner can also be used to provide digital land cover data at a somewhat lower resolution. Another alternative is the manual digitization of land cover data from existing maps such as USGS quadrangles.

Planimetric data can be digitized from aerial photography utilizing APS, but more frequently it is digitized from existing mapping sources. Planimetric line data can also be digitized automatically through the use of various map scanning devices such as the SysScan system.

Interfacing with Hydrologic Models

Under the conventional approach, topographic and land cover information are manually encoded, keypunched ,and utilized as input data to various hydrologic and hydraulic models to generate flood discharge-frequency and elevation-frequency data. This is an iterative process whereby the engineer interprets the output, primarily in printout format, and then adjusts various input parameters to correct, calibrate, or "fine tune" the model. This can be an expensive and time consuming process because adjustment to the input data, such as adding an additional cross section, or subdividing a watershed, requires additional manual operations.

Using state-of-the-art digital mapping technology, much of this process can be automated, including the interfacing between digital topographic and land cover data, and hydrologic and hydraulic models, as well as the computer generation of flood profiles and maps. At the heart of this process is the computer-based GIS. GIS technology permits the storage and manipulation of map data by geographic coordinates such as latitude and longitude. Many "overlays" of attributes such as elevation, land covers, and soils can be assigned to a particular point, line, or polygon defined by various coordinates.

In application to floodplain mapping, digital topographic, cultural, and land cover data would be fed into the GIS as separate overlays and registered to the same coordinate system. Watershed and sub-basin boundaries would also be digitized if hydrologic modeling is to be utilized to obtain flood frequency estimates. The GIS can then be used to directly generate input data required for the hydrologic and hydraulic modeling. For example, graphic display terminals could permit engineers to select the location and alignment of stream cross sections, which the GIS would evaluate and encode for input to the hydraulic model. As a second example, GIS overlaying of watershed and sub-basin boundaries on land cover and soils map information could be used to automatically compute runoff curve numbers for sub-basins as input to the SCS TR-20 program.

Real time interfacing of hydrologic and hydraulic models with a GIS in conjunction with graphic display terminals can permit the engineer to see

almost immediately the impact of a data input decision or calibration adjustment on the final flood profile or floodplain or floodway boundary. Such a system could greatly reduce the iterative processing time required to calibrate and tune such models to achieve an acceptable result.

Generation, Storage and Revision of Flood Mapping

Under the conventional mapping approach, when a satisfactory hydraulic result is achieved, computed flood elevations are usually read manually from the computer printout and plotted to form flood elevation profiles which are incorporated into the flood insurance study text. Elevations from the flood profiles are also used in conjunction with a topographic base map to plot the floodplain limits in a fully manual process. Floodplain limits are then overlaid on a planimetric base map to produce a Flood Insurance Rate Map using the standard manual cartographic processes. Under a fully automated system, a GIS can be used to drive plotters and generate hard copy floodplain maps and profiles using the digital topographic and planimetric data in conjunction with digital output from the hydraulic model.

Perhaps the greatest advantage of the GIS is the potential to readily revise and update floodplain maps. Because all input data as well as the floodplain maps themselves can be stored in digital map format, changes such as in watershed land use or floodplain topography can be digitized to update the various overlays and input for revised hydrologic and hydraulic analyses. Output from the revised analyses is then used by the GIS to generate new floodplain maps and store the revised map in digital form.

Current Limitations

Topographic Data Collection Systems

Although the state-of-the-art in computer mapping technology has advanced to the point where fully automating the flood insurance study process is possible, there are a number of constraints which preclude this being a cost-effective alternative in the near term (Table 2).

For topographic data collection, LIDAR is a representative example of airborne laser profiling systems. LIDAR is the acronym for Light Detection and Ranging and works on a principle similar to RADAR or SONAR. LIDAR systems measure distances by measuring the time difference between laser pulse generation and return of the pulse after reflection by the target. Mounted on aircraft, LIDAR can be used to collect elevation data by measuring the distance

1. Vertical elevation accuracy of current laser systems.
2. Field surveys required for hydraulic structures and underwater sections.
3. Availability and cost of hardware within the private sector.
4. Existing digital data bases at a usable scale (e.g., 1:24000) are very limited.
5. Creation of digital data bases by manual digitization or even scanning digitization with manual assignment of attributes is costly and time consuming.
6. Large study areas are required to achieve cost break-even.
7. Digital map data from different sources is not in a standardized format.

Table 2

Factors Currently Limiting Full Utilization of

Automated Insurance Study Systems

between the aircraft and the land surface. This measurement is very accurate, within centimeters over miles. However, the overall accuracy of airborne LIDAR data is a function of how accurately the aircraft position can be determined. This accuracy does not yet approach that of aerial photogrammetric or land-based surveys, although this limitation will probably disappear in the near future. Recent and future advances in satellite navigation systems such as the NAVSTAR Global Positioning System will provide a capability for precisely locating ground station control for airborne laser systems. Inertial navigation systems aboard the aircraft will also maintain accurate aircraft position data to increase the overall accuracy of airborne laser systems.

A second factor limiting the usefulness of airborne laser mapping systems is the continuing need to obtain field surveys of hydraulic structures such as bridges and underwater channel cross sections. Thus, the costs of field survey efforts are not completely eliminated by this approach, so that they add to the cost of the total survey effort.

A third key limiting factor is that the availability of hardware and software systems as well as operational experience is extremely limited within the private sector. This is the result of the large investment which most conventional surveying and mapping firms have been unwilling to make at this time. As a consequence, although airborne laser systems offer the advantages of speed and direct collection of data in digital format, they may only be cost effective in situations where large mapping jobs are required in more remote areas. These constraints do not presently conform to current flood insurance study efforts in which the collection of topographic data is usually limited to small reaches of floodplain in developed and developing areas.

For the near future, the APS offers the greatest promise for reducing surveying costs for floodplain mapping studies. Although the basic data extraction techniques remain the same as for conventional aerial photogrammetry (i.e., manual interpretation of a stereo image), stereo model development and aerotriangulation procedures are performed by computer with the APS system. These automated functions may offer up to a 40% time savings over the traditional photogrammetric methods. Another advantage of APS is that topography, cultural line work, and land-use polygons can be digitized and stored to create a spatial data base for later computer manipulation by GIS. The primary factor limiting the use of APS in floodplain mapping is its limited availability in the private sector. This will probably be a short-term limitation.

Geographic Information Systems

Computer generation of floodplain maps from digital data likewise has a number of limitations that currently preclude its cost-effective use as a standard production method. The main advantages of GIS cartography are that once spatial data have been entered into the data base in the form of a series of overlays, computer cartographic software allows the overlays to be analyzed, combined, revised, changed in scale, and manipulated in other ways that would be extremely time-consuming by hand. The major drawback of GIS cartography at present is the lack of available map data in digital format and, therefore, the costs of establishing digital data bases.

Existing digital map data at a usable scale (e.g., 1:24,000 or larger) is still quite limited. The USGS has recently established a program to digitize its quadrangle maps at the rate of 300 per year. Eventually this type of "off the shelf" digital map data will greatly reduce the cost of creating a GIS for floodplain mapping purposes. However, immediate implementation of computerized

mapping for the National Flood Insurance Program (NFIP) would require an extremely heavy investment in digitizing existing base map data.

Although the encoding of map information through scanning can greatly reduce manual digitization efforts, computer analysis of scanned data beyond overlay and reproduction is extremely limited. More complex computer analysis generally requires manual digitization to assign attributes to particular points, lines, and polygons in the data base. This remains a costly and time consuming process.

Another limiting factor in computer generated mapping is the availability of hardware and software systems within the engineering community. At present, the requirement for production of maps in digital form by study contractors would limit the number of contractors capable of performing such studies. One option would be to convert studies to digital format at the Technical Evaluation Contractor (TEC) stage, but this would be an expensive digitizing effort.

Finally, the development of uniform digital cartographic standards and guidelines within the federal sector should probably precede any major effort by FEMA to produce floodplain mapping in digital format. In an effort to initiate such action, the Office of Management and Budget has created a Federal Interagency Coordinating Committee on Digital Cartography, in which FEMA is represented. This group is headed by the USGS and is engaged in identifying the status of digital cartography in the federal sector. After this assessment is complete, the committee will move toward the establishment of uniform standards, which is expected to take several years to complete.

Plans to Incorporate New Mapping Technology

Table 3 provides a proposed schedule for phasing new mapping technology into flood insurance study production. Since essentially all initial flood insurance studies will be underway or completed by FY 1987, this technology will be applied primarily in the maintenance level restudy program. Because the National Flood Insurance Program will not be a major producer of new mapping in the maintenance level program, FEMA's efforts will follow the trend set by the primary federal mapping agencies (USGS and the Defense Mapping Agency) rather than attempt to operate on the fringes of new technology which could be considerably more expensive. Therefore, the actual incorporation of new technology will occur only after a clear benefit-to-cost relationship has been

FISCAL YEARS	TASKS
84-87	PHASE I: PROOF-OF-CONCEPT
84	LIDAR demo
85	LIDAR & APS demos, GIS feasibility
86	LIDAR & APS applications
87	Conduct GIS Pilot & revise Technical Evaluation Contractor (TEC) Guidelines
88-90	PHASE II: TEC OPERATIONS
88	Award high technology TEC contracts
89	Begin TEC production of maps in GIS format for new studies
90	Begin digitizing older studies & converting to GIS format. Prepare Study Contractor Guidelines requiring study submittal in GIS format
91-93	PHASE III: STUDY CONTRACTOR OPERATIONS
91	Award high technology Study Contractor contracts
92	Begin receiving restudies in GIS format
93	Begin fully automated system

Table 3

Proposed Timetable for Phasing New Mapping Technology into Flood Insurance Studies

established. FEMA proposed a three phase transition plan: Proof-of-Concept, TEC Operations, and Study Contractor Operations.

Phase I--Proof-of-Concept

During the four-year Proof-of-Concept phase, demonstrations will be used to prove the effectiveness of new technology for flood study purposes. In particular, LIDAR and APS systems will be tested. GIS's will also be created and used to pilot test the production of floodplain mapping.

During the first year (FY 84) one LIDAR demonstration will be performed. FEMA and the U.S. Army Corps of Engineers have entered into an agreement to test airborne LIDAR as part of an ongoing Flood Insurance Study (FIS) for Hays County, Texas. The LIDAR data is expected to be collected during September 1984. FEMA hopes to have thoroughly examined the results of this demonstration and have developed conclusions and recommendations by late FY 85. FEMA is also exploring the possibility of testing LIDAR in some other locations during FY 85. Based on these tests, guidelines for LIDAR use in FIS's will be prepared and operational applications may begin as early as FY 86.

Phase II--TEC Operations

During the next three-year phase, TEC operations will be geared for the production of studies in GIS format. During FY 88, studies for which many revision requests are being received will be digitized and used to demonstrate efficiencies of computer-assisted revisions and to fully establish operational systems.

During FY 89, full production of flood study mapping in digital form will begin for new studies being processed through the TEC contractors. Also in FY 89 a conversion priority for communities with older maps in hardcopy will be established. The priority a community receives will be based on the number of revision requests expected, demographic trends, and other data. Digitizing existing studies based on this listing will be initiated in FY 90.

Preparation of study contractor guidelines requiring submittal of studies and mapping in GIS format will also be developed in FY 90.

The first APS demonstration will be conducted during FY 85, to be followed by further applications in FY 86. Use of the APS will result in the creation of a data base for a GIS. Presently, flood maps are not tied to a horizontal coordinate system that would facilitate the creation and use of a GIS. As part of a GIS feasibility investigation, FEMA will examine the need and requirements for horizontal control in floodplain mapping in FY 85 and incorporate such requirements in study contractor guidelines in FY 86. Testing the use of the GIS to produce studies will occur during FY 87 and will include processing at least one complete pilot FIS in digital format by a TEC.

During Phase I there will be a need to revise the TEC Guidelines and Specifications to require GIS techniques and provide guidance on procedures. This effort should be completed by FY 87. The TEC A&E selection criteria for new FY 88 contracts would include a requirement for the ability to produce flood studies and maps in digital format. This will set the base for Phase III.

Phase III--Study Contractor Operations

During Phase III, lasting three years, study contractor operations will be shifted to increase automation. Beginning in FY 91, study contractors with high technology capabilities will receive preferential treatment during contractor selection and by FY 93 only firms with acceptable technology levels will receive contracts.

The effort of digitizing older studies will continue through, and perhaps beyond, Phase III. The time frame for accomplishing this task will depend on resource commitment and advances in scanner technology that will minimize the resources required.

Summary and Conclusion

Technology currently exists to fully automate the flood insurance study process. Great strides are being made in digital topographic data collection and in the collection and processing of other map data in digital form. Advances in computer hardware and software capable of processing map data in digital form allow for the creation of Geographic Information Systems with the potential to create, revise, store, and transmit map information in far less time than conventional cartographic approaches.

Such systems are not presently used in the standard production of flood-plain mapping because of current limitations that inhibit their cost-effectiveness. These limitations include vertical accuracy constraints of airborne mapping and profiling systems; limited availability and cost of hardware and software systems within the private sector; limited availability of existing digital map data bases at usable levels of resolution; the high cost of the digitization process required to create digital data bases; and the lack of standardized digital mapping specifications among agencies producing digital map data. All of these limitations will be reduced in the future with the improvement and mass production of the hardware and software systems involved.

FEMA, as a second-level map producer, will follow the lead of the primary mapping agencies in the conversion to fully automated cartographic processes. It is estimated that this process will take approximately 10 years beginning with feasibility studies and demonstration efforts followed by conversion of TEC operations and finally by conversion of study contractor operations.

Transitions will be made at points where benefit and cost considerations justify doing so and in a prioritized fashion. The rate of total conversion of all community maps to digital format will depend on funding levels designated for this purpose.

FEMA USE OF AERIAL IMAGERY: A LAYMAN'S VIEW

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Background

Since October of 1983, I have been managing a project involving the analysis of aerial imagery applications to FEMA programs. Its purpose is to identify proven, affordable remote sensing tools that can improve FEMA programs. Research and development was neither intended nor performed. The project's scope includes only those applications that have been used successfully by others. The activities to be reviewed included mapping for flood insurance purposes; monitoring community implementation of the National Flood Insurance Program (NFIP); activities associated with presidentially declared disasters; and those associated with "other hazards"--unique hazards as defined for the purposes of this conference--managing dam breaks, mudflows, lake-rise flooding, liquefaction and others.

The "Layman"

FEMA did not choose a practitioner of remote sensing, e.g., a photogrammetrist, to perform this analysis. There seemed to be some concern about the objectivity of such practitioners based on previous experiences. FEMA wanted reports that were credible (not products of an advocate), understandable (not written in the jargon of a practitioner) and persuasive in their objectivity. I was selected because of my extensive experience in the fields of floodplain management and disaster mitigation, project management, policy analysis and program evaluation. As a geographer, I had some familiarity with air photo interpretation, but my experience in remote sensing was, in general, quite limited. I was assisted throughout the project by a technical advisor, Mr. Monte Mingus of the FEMA Region VIII staff, who has had several years' practice in air photo interpretation. In studying mapping applications, we were assisted by Mr. Daniel Cotter of FEMA's Risk Studies Division, a highly competent engineer and experienced practitioner of remote sensing, to whom credit for much of the success of our project belongs.

Method

Our approach was straightforward. We reviewed the literature, interviewed the practitioners, visited their facilities, and evaluated what we read and heard. For many applications, our task was easy, since much of what FEMA does is also done by other government agencies, most of which are far advanced in their reliance on aerial imagery. Several of the applications we reviewed are tried and tested and have long since been well-established as routine procedure. As an example, in our literature search we found a document entitled "Fifty Years of Aerial Surveys of Floodplains," (Miles, 1979).

In the case of floodplain mapping, we focused our interviews on Flood Insurance Study contractors and their aerial survey subcontractors. We asked what they were doing and how; the relative costs of air vs. ground surveys; their comparative strengths and weaknesses; the effects of the Contractor Guidelines' constraints on reliance on air surveys; and what benefits might be derived by changing current FEMA procedures. For some applications we performed field tests, for others where we were not equipped for testing, we recommended that such tests be performed.

Findings and Recommendations

The two applications of interest to participants in this workshop involve unique hazards and mapping. Unfortunately, from the standpoint of making comments relevant to this conference's overall theme, unique hazards have yet to be reviewed. Three recommendations have been made on mapping: 1) modify the Flood Insurance Study Contractor Guidelines to expand reliance on air vs. ground surveys as a cost-saving technique; 2) test LIDAR or other state-of-the-art remote sensing tools for elevation data gathering and test computerization of study-related data handling, again as cost-saving techniques; and 3) inventory air survey based techniques for performing "limited detail" studies to select workable, low-cost methods. Brian Mrazik and the Risk Studies Division of FEMA are addressing our second recommendation. That division is also arranging to have the Corps of Engineers perform a comprehensive review of potential improvements to the FIS Contractor's Guidelines (recommendation 1) and to have the U.S. Geological Survey inventory limited-detail study techniques (recommendation 3).

Our findings on the use of air photos in priority setting are not as positive. There appear to be little measurement data suitable for priority setting available through air photo interpretation that is superior to existing

sources in strength as an indicator of rank, reliability, or accessibility. Our findings on the use of air photos in monitoring efforts allowed for only a subjective assessment to be made because of difficulties in establishing cost effectiveness. We stated in the report that the benefits appear to offset the costs, but continued evaluation since then has yet to result in an objective assessment. We are continuing our review. We have not yet reviewed activities associated with Presidentially-declared disasters.

Conclusion

As a nonpractitioner (I've graduated to slightly beyond the layman level after nine months involvement in the project), I can provide an "objective" viewpoint. There are practicable, understandable, and affordable ways to improve floodplain management, especially mapping, by adding or increasing one's current reliance on remote sensing tools. However, as with most technology, its use has limitations and needs to be pursued with an open, but critical mind.

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INNOVATIONS IN LAND DATA SYSTEMS

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Introduction

Land information used in the regulation and management of high risk flood hazard areas is inadequate. One cannot fail to reach this conclusion after studying the material provided to participants in this conference and looking at the recent history of flood zone administration. Existing mapping and land information systems are often of low or unknown quality and accuracy, contain inappropriate data, are not easily accessible, and are not in a form or location that allows integration with other data sources.

While this paper will deal primarily with the technical aspects of the land information situation, it should be understood that a significant component of the problem is political, economic, institutional in nature and has little to do with technical innovations. Our ability to organize institutions to collect, integrate, and disseminate land data and information lags far behind our development of technological devices.

In the United States we still tend to think in terms of ad hoc data collection and single-purpose mapping. We do not approach the land information problem in a systematic manner. This condition is slowly changing and there is reason to believe that progress will be made on the political and institutional front. Recently, publications by the National Academy of Sciences (NAS, 1983, 1980) have indicated possible solutions. Innovative people and organizations in places such as the Southeastern Wisconsin Regional Planning Commission are showing us examples of what is possible.

In spite of all this, serious technical problems remain to be solved. Surveying and mapping has been and still is a time-consuming and costly proposition. This paper will be devoted to recent and projected developments and innovations that may reduce the time and cost of mapping operations and

allow the presentation of geographic data in a meaningful and useful format.

Any land data or information system must contain several essential components. The following discussion will be organized around the geodetic reference framework, the base map, and data base management schemes--three of these components.

Reference Framework

A geodetic reference framework or control system is an essential part of any land information or mapping system. In the past, the cost of establishing required control has often been a major portion of the total cost of a mapping project. In many cases, time and cost constraints have resulted in the generation of local maps not tied to a geodetic control network. Such maps and information tend to be of minimal use beyond an original narrowly defined purpose. A number of recent developments promise to revolutionize the ways in which we establish geodetic control.

Global Positioning System

The NAVSTAR Global Positioning System (GPS), an array of 18 navigational satellites, is expected to be fully operational in the latter half of this decade. The system is designed to provide instantaneous three-dimensional, all-weather navigation to an accuracy of 200m to civilian users and 16m to U.S. government agencies and other authorized users (Heuerman and Senus, 1983). Signals recorded over a period of one to three hours can be used by surveyors to compute much more accurate positions. Six satellites have been placed in orbital planes that provide a "window" of several hours each day when surveying observations can be made. Several receivers are in the development process, and one instrument, the Macrometer, is already in commercial production and use. A typical observation with the Macrometer requires occupation of two or more survey stations for two to three hours and produces a computed vector connecting the occupied stations accurate to 1:1,000,000 in all three components. Versions of the Macrometer now in the development process promise to be even more accurate than the current generation and more compact and easily carried in the field (Leick, 1984).

The potential of GPS surveying is enormous. It is suddenly conceivable to measure relative positions over almost unlimited distances to centimeter accuracy in a few hours with no requirement for intervisibility between stations. All one needs to see is the sky. With currently available receivers costing in excess of $100,000 each, it is already possible to reduce the cost

of many control surveying projects. It is anticipated that equipment and project costs will be even lower in the near future.

Airborne Laser Ranging System

The NASA Goddard Space Flight Center has done research and development on a multibeam Airborne Laser Ranging System (ALRS) which measures distances simultaneously to six ground-based passive reflectors with centimeter precision. By flying over a grid of ground reflectors at two altitudes, the system can provide reflector positions in latitude, longitude, and elevation over an extended area. High altitude aircraft such as the U-2 and RB-57 can potentially survey areas of up to 60,000 square km in one six-hour flight with an error growth rate of one cm per 100 km (Degnan, 1982).

ALRS represents another possible technique that could significantly reduce the cost and effort required to establish precise geodetic control. Originally conceived as a device to monitor crustal deformation and tectonic plate motion, the system could have many land information applications. ALRS is at this time not heavily supported by NASA. It is not clear if the system will be developed to a working prototype in the near future.

Photogrammetric Triangulation

Photogrammetric triangulation is a mature and well-documented approach to geodetic control establishment and densification. This technique involves photographing an area with a block of aerial photographs usually with more than the normal amount of forward and side overlap. A few previously established ground control points must be available around the perimeter of the area. These points, and all new points to be established, are marked with targets that will form clear, well-defined images on the photographs. Photo coordinates of the target images are measured with precise comparators or analytic plotters. The ground horizontal and vertical positions of the new stations can be computed in the same coordinate system as the original control.

Many of these techniques have been used routinely to extend existing horizontal and vertical ground control used in topographic mapping. A recent series of four papers describes an application by the National Geodetic Survey (NGS) of photogrammetric triangulation to the densification of a county-wide geodetic control network to support large scale mapping (Henriksen, 1984;

Gergen, 1984; Perry, 1984; Lucas, 1984). A block of 750 photographs was taken at a height of 12,000 feet over a rectangle of 900 square km. Seventeen existing geodetic control stations and 380 new stations were targeted. The triangulation yielded horizontal positions on the new stations accurate to approximately 5 cm horizontally and 10 cm vertically. This was accomplished at a total cost of $132,000 (in 1979 dollars) or approximately $350 per new station. This is certainly a lower cost than one would expect had conventional survey techniques been employed. It is not clear if satellite or inertial techniques would have been able to compete with this cost.

Inertial Surveying

The inertial surveying system is based on an inertial navigation unit designed for use in aircraft. A precise inertial platform is oriented in space with gyroscopes on three orthogonal axes. The three axes are oriented to the local vertical, north, and east. A sensitive accelerometer is attached to each axis and defines acceleration in each of the three directions. The accelerations are integrated with respect to time--once to give velocity and again to yield distance traveled in each of the three orthogonal directions. The computations are performed in an on-board computer.

The inertial platforms employed in aircraft navigation systems have a drift rate that is often on the order of one km per hour of flight. This rate is, of course, totally unacceptable for most surveying applications, but the performance can be improved by a factor of several thousand by periodically bringing the inertial platform to a complete stop, i.e., stopping the truck or helicopter in which the instrument is mounted. During these stops, which are called zero-velocity updates, residual velocities attributable to drift are sensed and observations can be at least approximately corrected in real time with the on-board computer. Based on extensive field tests, accuracies on ground stations of 13 cm + 12cm/hour horizontally and 10cm + 8cm/hour can be expected (Mancini, 1977).

The cost of inertial surveying instruments is quite high, with a unit cost of several hundred thousand dollars, but these systems can establish control positions very quickly, and, when a dense control network is required, the cost per point may be quite competitive with other techniques.

Base Maps

A base map is the graphic representation at a specified scale of selected fundamental map information. It is used as a framework upon which additional

data of a specialized nature may be compiled (American Society of Photogrammetry, 1980). In the context of floodplain mapping, the base map provides the primary medium by which the floodplain data can be related to the geodetic reference framework and all other land data sets. The base map may be drafted on mylar or other drafting material or may be in digital form stored in a computer.

Progress has been made in the technology compilation of base maps in recent years, but the progress has not been as dramatic as that described in the field of geodetic control surveying. Topographic maps at the scales and accuracies usually required for floodplain mapping are still compiled from overlapping aerial photographs using stereo plotters with human operators. The plotters are more efficient than those used a few years ago, and the computer is often more intimately involved in the mapping process than it used to be. The output may even be in digital form, but the mapping process is still labor intensive and costly. A few promising areas of anticipated progress are described below.

High Altitude Photography

Since 1978, the U.S. Geological Survey (USGS) has been taking both black and white panchromatic and color infrared 9-inch by 9-inch photographs from a flight altitude of 40,000 feet above sea level. The panchromatic photography is at a scale of 1:80,000 with a frame centered on each 7.5 minutes USGS quadrangle map. The infrared photography is at a scale of 1:58,000.

The NASA U-2 aircraft, based at the NASA Ames Research Center, has a maximum operating altitude of 70,000 feet above sea level. These planes are equipped with a variety of cameras ranging from 100 mm focal length multispectral cameras used for remote sensing to 610 mm focal length panoramic cameras. At a flying height of 65,000 feet above mean terrain, the panoramic camera is capable of a ground resolution of 0.3 m (National Aeronautics and Space Administration, 1978).

Neither of these sources of high altitude imagery has been exploited fully. Significant economies would be possible if, for example, panoramic photography could be used to compile base maps and floodplain data. This would require analytical stereo plotters and the software to handle panoramic imagery, but it is reasonable to expect these capabilities to become more commonly available in the civilian mapping community in the near future.

Satellite Systems

The principle satellite images available for civilian resource mapping applications are those obtained by the NASA Landsat series. These images are useful if repeated coverage of an area is important, and they have been used to revise maps with as large a scale as 1:50,000, but they do not provide particularly high resolution and have very limited potential in floodplain mapping.

Automation

When first introduced to the photogrammetric map compilation process, people often ask why further automation has not been introduced. At first glance, the procedure appears to be a natural for automation, and research and development work has proceeded with some success for the last twenty years. When the compilation process is examined in detail, it is seen to be very complex, posing many difficult automation problems. Elevation data and planimetric detail, two types of data almost always needed in floodplain mapping applications, are two of the types of data extraction least amenable to automation.

This is not meant to suggest that automation of the mapping process is impossible. A great deal of good research has been done over the last twenty years, and much has been learned. Indeed, many of the fundamental problems have been identified, and research is now progressing (Horn, 1983; Wood, 1983). However, the solutions to these fundamental problems are not around the corner, and, at least in the near future, floodplain maps will be compiled by manual methods.

Data Base Management

Frank has identified three generations of interactive graphics systems used to prepare and edit maps (Frank, 1984). The first generation systems were graphics editors capable of storing maps that could be graphically edited and redrawn. A second generation of systems provided the same capability as the first but allowed the user to attach certain types of data to the graphic elements. For example, pipes could be labeled with pipe diameters and pipe functions. Such systems could also potentially answer questions such as how many feet of a particular diameter pipe of a particular age existed within a given region. The third generation of systems, which are still in the development stage, store internal models of reality. Drawings and reports are simply operations to make the internal model visible to the user.

These third generation systems will incorporate the principles of database management systems in which the data storage is separated from application programs by a central database management program. Generalized database systems have been developed for a variety of commercial applications, but these are probably not fast enough to treat geometric data. The primary advantage in the database-oriented systems is their increased capability for structuring data. As the internal computer model approaches the external reality, additional applications become possible. The data can be used not only to create maps but also to direct simulation programs such as power flow calculations in an electric utility net or flood routing in a drainage basin.

Research in the third generation systems is relatively new, and many possibilities have yet to be explored. Floodplain mapping would seem to be a natural area of application for these ideas.

Conclusion

A number of technical ideas and developments in the areas of geodetic control, map compilation, and database management have been reviewed. It must be re-emphasized that in floodplain mapping and many other areas of land information management, we already have a great deal of technology that is not always applied in the most efficient or logical manner. Of course, the technical developments discussed here will not necessarily lead to good floodplain management or even high quality floodplain information. There are, however, exciting possibilities in all of these developments that should lead to improved land management decisions.

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COMPUTER GENERATED MAPS: USE OF AUTOMATED DIGITIZING TECHNOLOGY IN RESOURCE MANAGEMENT

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Resource management requires the assimilation of a multitude of data, much of which are derived from or appear on maps. Overlaying maps and identifying areas of intersecting or nonintersecting data is a common technique used to develop information for proper resource management decision making. When multiple overlays are involved, manual procedures become tedious, expensive, and prone to a high rate of error. Due to advances in computer processing speed and data handling, and to the refinement of the mathematical algorithms for spatial analysis, computer mapping is becoming an economical alternative to manual overlay analysis. However, the drawback now, particularly when enormous quantities of data are involved, is the speed and accuracy of capturing the necessary data into the intended computer system.

Two commonly used terms in data capture are "vector" and "raster." A vector-based data capture system encodes data digitally by capturing coordinate pairs to describe line geometry. The (x, y) value of each point is input to the system--first keyed to a general reference grid such as digitizing table (or CRT) units, and then converted in the computer to the real coordinate values based on the true geographical position of the points. A third "z" value can also be input. It is most often used to describe a third dimension (such as elevation) or as a key to an attribute (such as soil type) assigned to the digitized feature. A raster scan system captures data in a column/row matrix with an intensity value (i.e., grey value) representing the artwork assigned to each matrix element. The matrix elements are called "pixels," short for picture elements. The raster data is then "vectorized" and each line feature "tagged" with an attribute.

Types of Automated Data Capture Systems

Vector Input and Processing Systems

Typical data entry devices include manual digitizing tables with hand-held cursors; direct keyboard entry; or interactive CRTs. Our Autogis System uses this method of data capture.

Raster Input (with Conversion to Vector)

Typical data entry devices include optical raster scanners, line followers, and electro-optical rectification aids with magnification capabilities to assist in manual digitizing. Examples of raster scanners include our KartoScan™ and the Scitex. The KartoScan™[1] has a built-in video unit which allows the user to view the material through the scanner and select various line qualities for calibration. The system measures the grey value intensity of the line work being viewed and builds a histogram of the values. By setting the level of grey values desired off the histogram, the operator actually selects the line work to be scanned. Once scanned, the data can be vectorized, edited in vector format, and transferred to other systems (generally in vector format). Several software enhancements are available: square corners, smooth curves, the removal of solid fills and the leaving of boundary polygons.

Raster Input (without Conversion to Vector)

The data capture devices here are the same except that data need not be vectorized. With data remaining in raster format, editing on a color raster CRT is much faster and more precise.

System Attributes

The advantages and disadvantages of each system vary. Vector systems basically employ a redrafting process that is subject to human error, dimensional inaccuracies of the source document, and equipment accuracy tolerances (typically 3 and 5 mil). Data capture is slow. The principal advantage is that a skilled operator can make decisions about the data while digitizing. This "intelligence" and decision-making ability is only partially available in the newer automated systems and consequently remains an advantage of manual digitizing.

Automatic raster scanning is highly accurate and extremely fast. Total throughput speed to end product (i.e., digital tape) is, however, a function of how much data must be tagged with attribute information, and this system

[1] KartoScan is a registered trademark of SyScan, Inc.

can, in cases, be a slower overall process then manual digitizing. Since scanning duplicates the original source document, the problem of positional versus dimensional accuracy is also prevalent as with manual digitizing. That is, if the original document scanned is not dimensionally accurate, then when true dimensions are inputted to the document, the output plot will be distorted relative to the original. Another major problem with raster scanning is the amount of data captured to replicate the original document. Too little data (i.e., low resolution) will not reproduce the source document satisfactorily. Too much data (i.e., high resolution) increases computer processing time dramatically and also causes problems in data transfer between systems. Other problems occur due to source document inconsistencies (e.g., feature overprints, crossing lines, varying line thickness, etc.). Without software post-processors, a considerable amount of human manipulation is needed. Quality of vectorization is no longer a problem with most systems.

To summarize, data capture by faster scanning becomes economical when the maps or documents to be encoded contain large amounts of dense data or when throughput is a factor. Manual digitizing of data remains economical if the input documents are primarily low in density or mostly straight lines.

Resource management projects for which our systems have been used include:

State of Colorado, Digital Data Base--all attributes are callable either individually or by total topic.

Fort Leonard Wood, Military Assessment--automated combination of soils, slopes, and vegetation overlays to identify helicopter landing zones.

Thailand GIS--combination of seven overlay maps to determine land suitable for agricultural development.

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PART THREE

STRATEGIES FOR MANAGING HIGH RISK AREAS:

Mitigation Planning

A FRAMEWORK FOR THINKING ABOUT MITIGATION

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Research Alternatives, Inc.

Natural hazard mitigation is not a program carried out in isolation from other activities of government. Quite the contrary, its success will be found in an integration with ongoing efforts of governments at all levels. Because this study is about how state governments can best contribute to natural hazard mitigation, the focus of our framework for thinking about mitigation is on the state government. States play a pivotal role in natural hazard mitigation, and a strengthened program at the state level could improve the implementation of mitigation.

In thinking about mitigation, we can begin by recognizing that mitigation can fit into ongoing efforts of society. These ongoing activities provide an opportunity for mitigation to take place within the context of existing programs and processes. What we are suggesting is that the end product of effective natural hazard mitigation can be achieved in some measure by finding the "right" place and time to intervene in existing programs and processes in order to promote and conduct mitigation.

Let us consider the programs or processes of society where mitigation might find a home. We suggest there are three, each of which represents an opportunity for mitigation at the state level. They are:

- During new development, which offers crucial points of review during which the mitigation opportunity can be seized;
- At any time there are existing risk conditions that are recognized as amenable to risk reduction through mitigation;
- During the immediate postdisaster period during which redevelopment takes place, while risk conditions are fresh in the minds of policy makers and/or outside programs act to encourage or enforce mitigation.

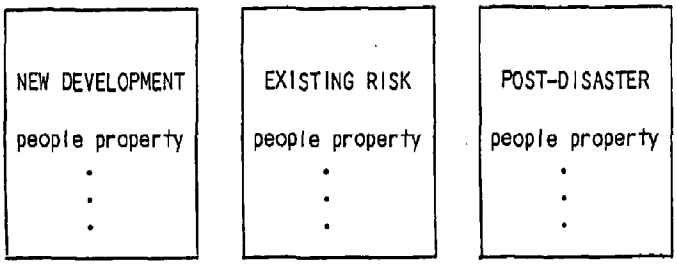
These three circumstances offer an opportunity for intervention in the normal flow of a jurisdiction's life.

What kind of risks can be mitigated through some form of intervention in these processes? We suggest that there are two basic risks--those to people

and those to property. In general, mitigating the risk to property implies a reduced risk to people. However, a rich body of mitigation experience can be found in programs or projects that reduce the risk to people alone. Therefore, as we look at the broad areas of 1) new development, 2) existing risk conditions, and 3) postdisaster recovery, we suggest that looking at people and property independently offers increased mitigation opportunities.

Up to this point, we can illustrate the framework for thinking about mitigation in the following way:

PROGRAMS OR PROCESSES RIPE FOR MITIGATION



What Have We Observed About Mitigation

One of the clearest observations about natural hazard mitigation is that it is implemented at the local level. While some huge programs have been initiated (that is, authorized and funded) at the federal and state levels, the actual implementation occurs at the local level. Indeed, we need only look at the reverse of the situation, in which a local jurisdiction blocks a state or federal mitigation program through nonparticipation, to see the leverage of the local government and its citizens.

In our 1980 study of both natural and technological hazard mitigation, we observed this crucial local role in 81 sites across the country. In that study, and in FEMA's current (draft) guidance on mitigation ("A Mitigation Strategy for the Integrated Emergency Management System," February 1984), it is suggested that mitigation can be accomplished by producing changes in one or all of three parts of the hazardous condition. Specifically:

- Mitigation can act on the hazard to eliminate it or reduce the frequency and intensity of its occurrence;

- Mitigation can change the way a hazard interacts with human systems by protecting people and their support systems that come into contact with the hazard; and

- Mitigation can alter the way people live and the systems and societies they create in order to avoid or reduce the hazard.

Numerous examples of these three classes of mitigation are available and will be included in our final publications. Now, as examples to make certain that all reviewers of this concept and guidelines paper are on the same track, let us suggest cloud seeding as a way to reduce hail and thunderstorm intensity; flood walls, dikes, and levees as people- and system-protecting structures; and relocation of people out of flood-prone areas as altering the way people live and thus avoiding hazardous impacts.

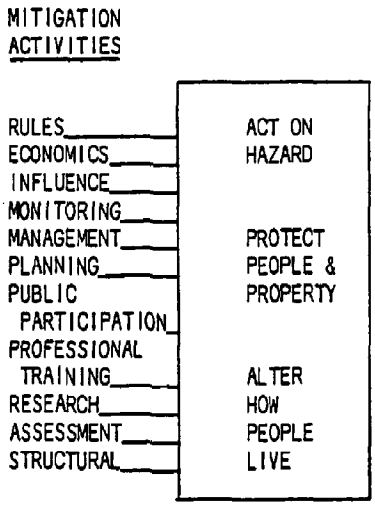
Given that the range of mitigation activities is broad and actually can accomplish some reduction in risk of hazards and vulnerability of people, then the important question is: What is needed at the local level to implement mitigation? Here, our 1980 study and the recent FEMA guidance offer some concrete examples of the necessary components of a local mitigation program. Eleven types of activities were identified as clearly identifiable behavior undertaken by one or more government or private sector mitigators. These eleven categories of mitigation activities are:

- Rules
- Economics
- Influence
- Monitoring
- Management
- Planning
- Public Participation
- Professional Training
- Research
- Assessment
- Structural

Contained in each of these categories are several subcategories that further define the actual tools and techniques employed by the local jurisdiction that has the capability to carry out mitigation activities.

If we were to graphically depict the implementation of mitigation at the local level, it would look something like the following illustration. The eleven categories of mitigation activities are employed by a jurisdiction to implement mitigation which 1) reduces the hazard itself, 2) protects people, or 3) alters the way people live to avoid the hazard.

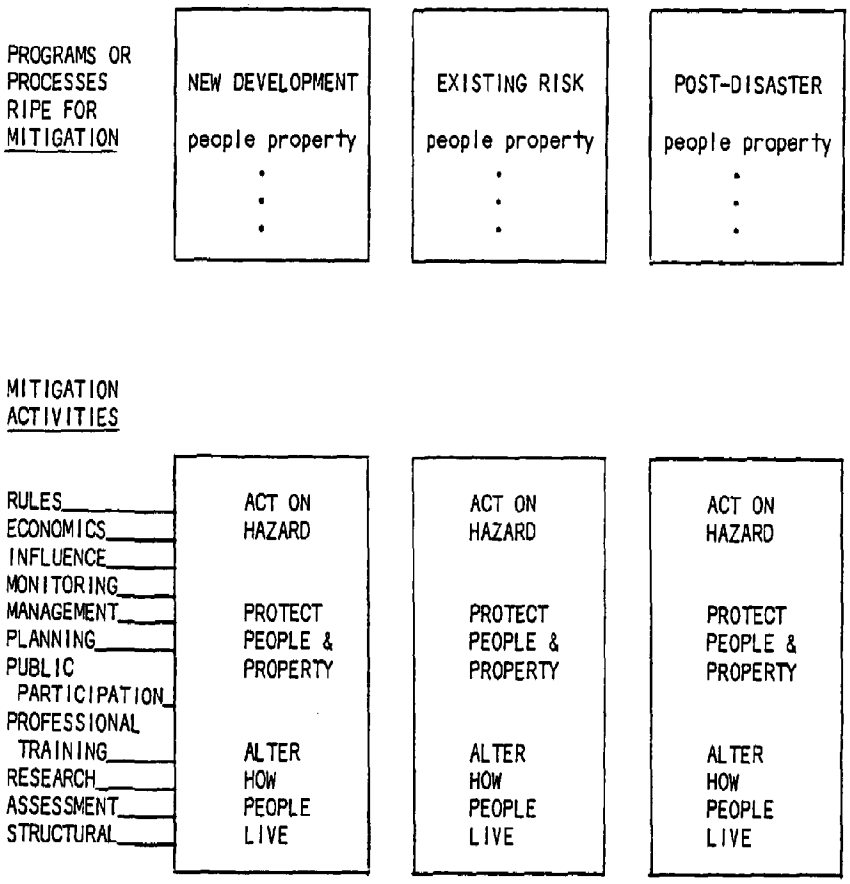
LOCAL MITIGATION IMPLEMENTATION



This illustration suggestions that a local jurisdiction can select from among a variety of alternative mitigation activities to accomplish hazard reduction or avoidance. If we combine this idea with the earlier one that identified three social processes in which mitigation seemed most appropriate, we begin to see a growing framework for thinking about mitigation. Recall that mitigation seemed most promising when incorporated in the processes of a) new development, b) existing risk recognition, and c) postdisaster actions.

Combining the local jurisdiction implement concept with the three processes ripe for mitigation, we get a scheme like the one illustrated on the following page.

OPPORTUNITIES FOR MITIGATION AND LOCAL IMPLEMENTATION



This suggests that the combination of mitigation activities, usually implemented at the local level, can effectively intervene in the processes of new development, existing risk conditions, and postdisaster recovery to produce an effect that results in reduced hazards, protected people, or avoided hazards.

Now, it is possible that a state mitigation program could implement mitigation by selecting from among the mitigation activities. This is the case, for example, on state-owned lands where the state agencies have the authority, economic allocations, etc. to carry out state mitigation. Those instances, however, represent only a minority of the opportunities that a state has to

influence natural hazard mitigation. The following section details how the state can contribute to mitigation.

What Does It Take for the State to Seize the Mitigation Opportunity?

In order to intervene with a mitigation activity in new development, existing risk conditions, or postdisaster recovery, there must be certain organizational capabilities resident at the state government level. These capabilities will combine to produce the state's contribution to mitigation. We say "state's contribution" because, generally, only a small part of a state mitigation effort is expended in actually carrying out mitigation projects. Actual project implementation usually occurs elsewhere.

In order to be in a position to make contributions, the state must have in place a set of mitigation capabilities. There is tremendous variety in the way these capabilities are acquired and maintained. But, there is general agreement that, in some form or other, a successful state contribution to mitigation requires seven capabilities. These are briefly described below.

Hazard Analysis

This term is a general label for the capability to examine the environment in a systematic way and establish an estimate of the risk to people and property caused by natural hazards. The term includes any type of review of hazardous conditions and their potential impact on people or property, including a postdisaster assessment of the consequences of redevelopment on future risk.

Legal Authority

Every mitigation effort must have a basis in law. This capability is, at the state level, almost an "enabling" capability, without which little else can be achieved. Legal authority to mitigate, however, does not necessarily have to be explicitly stated. Many laws are available, for example, that speak indirectly about the safety of people or the protection of the environment and could be expanded in their interpretation to include the objectives of mitigation.

Organization

Mitigation has an organizational component that must be consciously developed to be most effective. The models for such organization range from the formal designation of a lead agency or a hazard mitigation program or a mitigation task force to the informal recognition of mitigation as a problem that is discussed as part of routine agency coordination.

Economics

The economic aspects of hazard mitigation are, indeed, another of the "enabling" conditions. As in the case of laws, however, separate budget line items for mitigation may be a bonus rather than a necessary element. The use of other program initiatives to reach the goals of mitigation is an effective way to minimize costs, although there is no getting around the fact that obtaining funds will be essential at some point in every mitigation project.

Intergovernmental Relations

State governments must work with both federal governments and their own local governments to see mitigation objectives achieved. The state's capability to carry out intergovernmental relations in order to assure the smoothest possible implementation of mitigation is an important part of success. Entering into this capability, as well, are intrastate regional organizations that have a legal role (usually established by the state) in multijurisdictional planning and operations.

Interest Group Relations

The public at large and various private sector business and industry groups have a keen interest in the three processes (new development, existing risks, and postdisaster redevelopment) described above. How the state deals with these interest groups can influence the success of mitigation implementation.

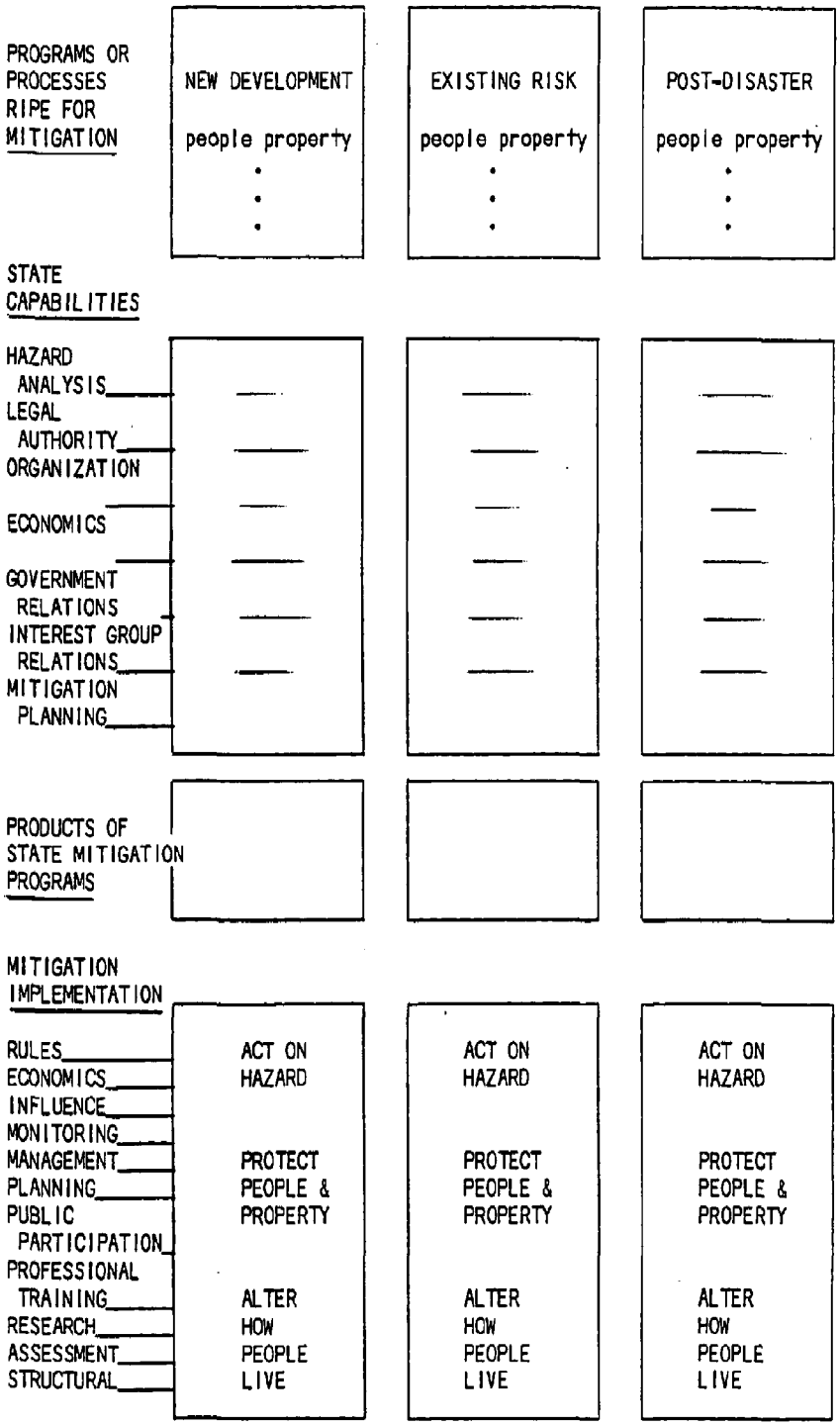
Mitigation Planning

Finally, the state benefits from a capability to actually plan and prepare for its mitigation contribution. In some cases, this will be in the form of formal planning for a mitigation project (on state lands, for example). In other cases, this capability might be called upon in the development of technical information or other products that are indirect contributors to mitigation implementation.

Where Do These State Mitigation Capabilities Fit into the Framework?

The state plays its role in mitigation as an intermediary between the "societal processes" of new development, existing risk conditions, and postdisaster recovery and the actual implementation of mitigation activities to carry out risk reduction. Thus, the framework for thinking about mitigation that we have been developing now looks like the illustration on the following page, with the addition of state mitigation capabilities.

A FRAMEWORK FOR THINKING ABOUT HAZARD MITIGATION



The state needs the seven kinds of mitigation capabilities to fully take advantage of the opportunities to reduce hazards. These capabilities result in what generally could be called the state natural hazard mitigation program. This program will span agencies, ongoing programs, and authorities. It will draw resources from many different areas. The result of this application of mitigation capabilities are products of state mitigation.

As we have discussed before, these products could be mitigation, itself. More likely, from the state level, these products are contributions to mitigation implementation at the local level. Among the products you can think about as examples are: needs assessments for mitigation; mitigation laws; monitoring and enforcement programs; funding; technical assistance; planning assistance; guidelines for local mitigation plans; public information and education materials; information sharing; and coordination of mitigation efforts among jurisdictions. While these are only a few general and broad products of state mitigation, the reviewer can readily see the important contributory role that the state can play in mitigation.

SECTION 406 OF P.L. 93-288: AN OPPORTUNITY IF YOU KNOCK

Allan Williams
Connecticut Department of Environmental Protection

When severe flooding hit Connecticut in June, 1982, I was in Wisconsin at the annual Association of State Floodplain Managers Conference. The term "Section 406" had about as much meaning to me as marriage does among movie stars; it was something you did in the future, you weren't quite sure why, and it was over relatively quickly.

Months later, when the 180-day hazard mitigation report required by P.L. 93-288 was due, I still had never seen a copy of 406, nor had I heard any scuttlebut about a report due.

January of 1983 came and I was approached by a fellow worker.

"Allan," he said, "I'm really tied up in posthazard recovery processes, and I need your help to write an administrative report."

"Sure," I said naively, "as long as it can be done in a few weeks."

He didn't respond, setting the wheels of doubt in motion. I did not know it yet, but once a governor accepts disaster assistance, the state must prepare a report delineating how it will reduce flood problems. Implied is the requirement that if the plan is not implemented the state might not get disaster assistance the next time around.

"So when is it due?," I asked.

"Two weeks ago," he said.

"Well . . ." I prompted. "Don't worry," he said, "we've already asked for an extension."

"How come we are doing it?" I asked.

"Well, the Governor's Office asked the Office of Policy and Management to do it; and the Office of Policy and Management asked the Office of Civil Preparedness to do it; and the Office of Civil Preparedness asked the Department of Environmental Protection to do it; and the Director of Water Resources asked me to do it."

"And you're asking me to do it," I added, now realizing that this assignment required a bit more than copying two pages from an old report and adding a cover.

I began to wonder if maybe I should pass the baton myself, but, alas, I realized that I was the last runner in this race. Besides, I'd feel guilty giving it back to my friend in the other unit; after all, he had put in so much overtime during the flood, while I had been at a meeting in Wisconsin.

So, like Tevyeh in Fiddler on the Roof, I said to myself, "if on the other hand" writing this report could lead to some changes in our programs, "perhaps it's a good thing."

As fortune would have it, in the very next month, February of 1983, the Federal Emergency Management Agency held a special session on 406 at its Emmitsburg training center. At that session, the following major points were made:

- FEMA personnel stressed the unfortunate consequences likely to befall a state not complying with Section 406.
- Collectively we all rewrote the outline for reporting 406 to make it more amenable to the states, while still reporting on the issues FEMA wanted covered.
- The session was particularly useful to me because I left it with many ideas on what and what not to put in our report.
- FEMA personnel stressed how stringent would be their reviews and how seriously they considered the task of preparing and following through on Section 406. It had to be done and done right.

In short, 406 got sized up, FEMA got huffed up, and we, the states, were charged up.

Report Writing

The report writing began in March, 1983, and the report was signed by the Governor in August, 1983, proving such a report could be done in 180 days, even if it wasn't the correct 180 days.

To me and many state agency staff, the process gave us:

1) An opportunity to look at flooding versus other natural disasters and helped convince us of the importance of flood mitigation;

2) An opportunity to measure what we had already done;

3) An opportunity to get attention from other state agencies;

4) An opportunity to work together and directly with the Governor's Office; and

5) The background and the rationale for supporting our programs with the Governor's Office, the state legislature, and with federal funding sources.

I can state categorically that the results of preparing the 406 plan have been more successful than anyone would have thought possible. The Section 406 Hazard Mitigation Implementation Measures report has been the catalyst for numerous positive changes.

For example, during the writing phase, we were technically doing the job for the Governor's Office, and that office carries a lot more weight than any individual agency. Having the attention of the state's executive staff helped us develop a closer relationship with them and helped them understand our issues. This was not only helpful in getting cooperation from many state agencies, but it was invaluable when we had to go before the legislature, the bonding commission, and the Office of Policy and Management.

Because we were doing the job for the Governor's Office, I was able to borrow good staff from other programs and able to get cooperation from the highest levels.

We queried every state agency, asking each for a listing of unaddressed problems in flood mitigation, preparedness, response, and recovery. The results produced literally hundreds of program suggestions from dozens of state programs. Because we were taking the process seriously, they took the process seriously. What we had at the end was a series of 18 first-priority actions and 85 second-priority actions. Each action was directly tied to problems brought up by one or more programs. Use of the input of others, instead of just our own, would be useful in getting new legislation passed, for we had made many converts to good flood management ideas.

Report Approved

At the end, we had the Governor's signature committing the state to attempt each recommendation. Equally important, the Governor's Office took full responsibility to see that all 18 first-priority actions would be addressed.

By the end of the process, we had gained many state agency and executive level supports. What we lost was FEMA's attention. FEMA didn't oppose anything we said; they just appeared to lose interest. We received no written comments or corrections from FEMA on any of the drafts or on the final edition. The only message we did get, repeatedly, was, "Is it done yet?" While I did enjoy and appreciate FEMA giving us a free hand, it did seem a bit unusual that the FEMA national office, which had shown so much interest at the February Emmitsburg meeting, had so little interest in the substance of the report.

It became clear that flood hazard mitigation per se was not FEMA's issue. FEMA's "issue" was only the procedures for which they were directly responsible, i.e., seeing to it that we report, not what we report. State problems and needs were just not as relevant as their direct federal responsibilities. I've realized now, that, like parents who vow to be different from their own parents, we were, in a way, acting like FEMA when all was said and done. I realized that we had only been interested in solving problems for which the state could do something directly. The Section 406 report did not have much municipal input, and that is a shortcoming of our report.

It must be noted that some comment had been received from FEMA on sections in which we had put in work elements for FEMA actions. They did let us know that some of the issues we brought up for them were being addressed, and I think FEMA was really requesting we remove any work items involving them.

Nevertheless, by their silence after the document was signed, one must assume approval of all the action items. If FEMA doesn't do their work items, it would be unreasonable to expect the state to complete all of its items.

A quick note on format. We followed the FEMA suggested format throughout the text and in the action items and found it to be a good outline. I appreciated, however, FEMA's flexibility in not requiring us to follow the format exactly, for this led to a more usable and implementable document. Whether that, too, was an act of omission rather than commission, it was nonetheless appreciated.

Implementation

The threat of loss of federal aid for future disasters is important, especially since we had three such disasters in six years (snow, tornado, and flood). This threat is implicit in the 406 requirements. It apparently is not well-supported though, because FEMA is reluctant to state, categorically and in writing, that such a loss of disaster assistance will occur if a state does not

comply with the writing and implementation of a 406 report. When going to a major political figure, to the legislature, or to some important commission, it would be useful for the sponsoring state agency to be able to say we must do this because it is a federal requirement, not because it might be a federal requirement. Mind you, I'm not asking for a sledge hammer, just a rubber mallet to help prod others along. It would be useful if the only handprints on your back are not your own.

At one critical point during this legislative session, I asked a high official in FEMA and several of his staff if they would write some testimony to support our position. The response: "Why don't you put something in writing to us requesting our testimony?" That's all we needed, a letter from a state agency asking a federal agency to intercede for us in the state legislature. Hence, we asked for and received no help from FEMA in obtaining funds for 406 programs or in obtaining necessary program changes. Again, perhaps it worked out best that way. In the absence of FEMA comments, I explained to key legislators and state officials how I thought FEMA could cut off disaster assistance if we didn't comply with 406.

The writing and acceptance of the Section 406 Hazard Mitigation Implementations Measures report cannot be credited with having accomplished all the gains that have happened since the June, 1982, floods, but it surely did help.

Action items in the report that have been accomplished include:

- Funding a new statewide flood warning system to be initiated this summer and fall;
- Passing new legislation regulating all state actions in the 100-, and in some cases, 500-year flood zone; requiring all state agency regulatory programs like the wetlands and encroachment line programs to require 100-year protection for any application (private or public); and requiring the state to build any flood control project to be at least at the 100-year protection level;
- Holding a commercial and industrial floodproofing conference;
- Holding a dam safety conference for owners of private dams;
- Implementing recommendations of a special dam safety report, including obtaining six new staff members for the dam safety program and obtaining money to repair 15 state-owned dams;
- Studying, designing, or completing about two dozen flood control projects;

- Obtaining approval for a small 1362 project; and
- Revising the Emergency Operations plans for several towns and state agencies.

These items, and there are more, have all been done in about a year and a half, that is, since we began working on the 406 report.

Making It Better

I am, as you might have guessed, a believer in 406. There are a few changes, however, which could benefit the process.

1) It is not the intent of the present 406 process to mitigate the concerns of municipal flood management issues. Perhaps the process could be reformatted and the requirements changed so we bring the towns into the process and hence into the solutions.

2) We didn't start 406 until one year after the floods. I would encourage faster action, and this would result in an easier time with implementation. When it rains, make gains; when it's dry, they only ask why.

3) FEMA is too sensitive about their own programs. Why not have FEMA programs reviewed by and with the states and localities as part of the 406 process? By agreeing to a few changes itself, FEMA can be seen as more of a cooperating agency and less of a distant partner. To that end, it would be useful if FEMA, as well as the governor of a particular state, signed the document.

4) I think it would be more helpful to the states if FEMA had an active role in reviewing the drafts and giving encouragement and assurance to states trying to do a job well. A pat on the back and some positive publicity by FEMA would help.

5) It would be helpful if FEMA had some funds available after the 406 report was signed. Funds are needed for the staff assistance required to initiate and oversee implementation of recommendations.

Some Last Words

Approach the 406 process with a purpose and with seriousness. Be slightly evangelical--but not messianic--and willing to spend a lot of time and staff on the report. Don't be discouraged by setbacks. After all, as serious and difficult as we see the flooding issue, we must keep our perspective. We are fighting something easier than injustice, more controllable than the flu, and less pervasive than promises in a political year. Understand that 406 is a chance to change things and a golden opportunity to build a new foundation for state flood management programs for years to come.

HAZARD MITIGATION IN BROWNWOOD SUBDIVISION

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Background

On August 18, 1983, Hurricane Alicia made landfall over the western tip of Galveston Island. The next day, the President declared a federal disaster. Brownwood, a subdivision in the City of Baytown, Texas, was hit by a 13-foot storm surge. Almost all of the 300 homes in Brownwood were either totally destroyed or substantially damaged. Within ten days of the hurricane a buyout program was presented to the residents of Brownwood and approved by the City of Baytown.

This paper is an account of the events that occurred in the 15 days between the hurricane and the completion of the Interagency Hazard Mitigation Team Report. These events culminated in a successful buyout program. The paper suggests ways to quickly identify future postdisaster mitigation projects and redirect our predisaster emphasis. This event has led me to believe that after any flood, even one as devastating as this one, there is resistance to change. This resistance can be overcome, but only when there is a realization of the hazard, the damage is significant, a quick response is initiated, tools are available, and the residents have discussed mitigation alternatives before the disaster.

Realization of a Hazard

In order to overcome the resistance to change, there needs to be an acknowledgment of the hazard. Residents must believe that the event will occur again. In the Brownwood subdivision, the residents knew and accepted the high frequency of flooding. The site was only one to two feet above high tide. When built, the subdivision was as much as 12 feet above high tide, but through subsidence the land had become extremely flood-prone. Some homes flooded annually, and all homes had flooded within the past five years.

Burton, Michigan, offers a similar example of an area that has an extremely high frequency of flooding, but with only minimal damage. Until these 15

homes were purchased through the Section 1362 program, they experienced flooding two or three times a year but only to a depth of 16 inches. Little permanent damage occurred with any one event, but the aggregate damage was great. For these property owners, frequency of the event was the key factor in overcoming resistance to change.

The importance of frequency was also demonstrated by the Kauai disaster. Hurricane Iwa hit Poipu Beach on the island of Kauai with a force that completely destroyed at least 100 structures. The local city government was willing to undertake a wide range of mitigation efforts providing such a storm would occur with significant frequency. A board of scientists was assembled, and no member was willing to state that the storm was anything but a freak event--something greater in magnitude than a 500-year storm. Because of this, no one was willing to initiate any mitigation efforts.

Significant Damage

It is almost axiomatic that the greater the damage, the larger the number of mitigation opportunities. We all know of major planning and rebuilding that followed the Chicago fire, San Francisco earthquake, and needless to say, Hiroshima and Nagasaki. Extensive damage is not the only significant variable. In the Brownwood subdivision, many homes were totally destroyed, and all but a few had substantial damage. Even so, the residents began to rebuild immediately, even when water covered much of the subdivision. Even though the structures had been severely damaged, the infrastructure and land tenure pattern was intact. This reinforced a conservative attitude toward relocation after the disaster. Reconstruction was only stopped when the city placed a moratorium on all rebuilding in the subdivision.

Quick Response

French Wetmore of the Illinois Water Resources Department has repeatedly argued that unless real opportunities are presented before reconstruction begins to occur, the chances for mitigation will disappear. He has stated that this period lasts about five days. The Brownwood experience supports this conclusion.

Reoccupation of the Brownwood subdivision began before the water had disappeared. I personally helped a mother and her six-year-old child leave their reoccupied home seven days after the disaster. Stagnant water was standing in the building, there was no sewer, no power, and the residents of the area had been warned to watch out for snakes. She had reoccupied the home in

order to begin repairing the second story. She left only after being evicted by the police.

Available Tools

Incentives are needed to overcome resistance to change. These tools may be in the form of money, legislation, or legal advice. The Brownwood subdivision package of tools included:

- The availability of loans under the SBA Involuntary Relocation Package;
- Assistance to the city to clear the damaged homes from the site;
- Funds through the Section 1362 program that were dedicated and set aside to purchase all insured properties;
- Flood insurance claim assistance;
- Individual Family Grant funds to qualified applicants; and
- The possibility of HUD CPD&G and jobs bill funds to purchase uninsured property.

Concurrently with and in support of the city's effort to discourage reoccupation, the city residents were told that if the package was not accepted, the following would occur:

- FEMA would deny all requests for permanent public assistance work targeted for the subdivision under an Executive Order 11988 no-action alternative;
- The city would inform all other federal funding sources of Executive Order 11988 and encourage a no-action alternative by other agencies;
- FEMA would limit eligibility to debris removal only, and only to that which was absolutely necessary to ensure health and safety;
- FEMA would ensure that the minimum NFIP requirements were adhered to for all substantially damaged structures; that is, structures would have to be elevated on site up to 16 feet above existing grade, and FEMA would use claim data as one index for substantial improvement;
- Onsite demolition costs and debris removal, estimated to be about $5,000 per property, would be the responsibility of the property owner, and no direct or indirect involvement by the federal government would be forthcoming; and
- EPA and other agencies would demand that new and substantially improved water and sewer lines located in the saturated soil zone be built to the same specifications as water crossings; i.e., encasement water lines, special joints, special bedding, etc. would be required.

The NFIP was key to the ultimate success of the program but should not be thought of as the only tool. The NFIP claims may total $20 million and will undoubtedly comprise the major source of funds used to purchase the homes. This is because all but a few of the homes were insured, and their replacement value was in excess of their fair market value. Also, the amount of money needed from the Section 1362 budget was minimal, approaching only $1,000 to $2,000 per property. However, without the other program, discussion of alternative mitigation tools before the disaster, and the speed with which these tools were offered, it is doubtful that the subdivision would now be free from flood damage.

Predisaster Planning

The success of any mitigation effort--whether it results in elevation, abandonment, or relocation--depends upon the attention given to the problem before the disaster occurred. This does not have to be a formal plan of action, but having an acceptable strategy in advance surely helped counter resistance to change in Baytown. The postdisaster period is no time to present new ideas. Residents need to return to normalcy after a disaster.

The residents of the Brownwood subdivision organized themselves into the Brownwood Civic Association many years before Hurricane Alicia. The Association actively lobbied for a buyout program. Several years earlier, the Association and the city secured funds from the Corps of Engineers to purchase homes within the subdivision. The program failed only because the city was unwilling to provide its local share of the expense, not because of the lack of support within the subdivision.

It is important to note that even though every resident had analyzed the possibility of relocation and already had come to a conclusion about it, immediately after the hurricane the subdivision residents wanted to move back to their homes. When the city tried to prevent this, local politicians and a large vocal group of residents threatened the city with a lawsuit. This was at a time when the subdivision did not have water, sewer, or power; and only the shells of a majority of buildings were left standing. The residents were apparently striving for normalcy. Only because the Interagency Hazard Mitigation Team could offer a realistic package quickly did the city capture the support needed to prevent the reoccupation of the subdivision.

One of the most significant activities of the Brownwood Civic Association was to promote the sale of flood insurance. The almost total coverage of flood

insurance provided the key tool used to purchase the homes and, indeed, to remove the hazard.

Future Direction

Mitigation should be thought of as change. Change is resisted unless a set of conditions are met that provides the force to overcome the inertia. If we think of these conditions as frequency, significant damage, response time, tools, and predisaster planning, we can come up with new directions in each of these five areas, and increase our chances of future successful mitigation efforts.

The frequency of a hazard, like resulting damage, is largely out of our control. However, we could expand our effort to identify and publicize dangers in high risk areas. For example, under the NFIP the majority of 100-year floodplains in the country has been mapped. The enabling legislation also requires lenders to give notice. However, all action is directed to the 100-year floodplain, and this is a frequency many people are willing to live with. Since the program has also identified those developed areas falling within a ten or 20-year floodplain, ways to use this information and to explore and identify mitigation opportunities should be explored.

Naturally, we cannot increase or decrease the amount of damage resulting from any event. On the other hand, we can make restoration easier. We could develop tools that would make it easier to minimize potential damage to existing homes, elevate structures, reassemble land or build new infrastructures.

The interagency teams have been increasing their ability to respond quickly after a disaster. Realistic opportunities are being identified earlier, and we are starting to create a set of tools capable of supporting local mitigation efforts. Just a few years ago the use of debris clearance, temporary housing, IFG grant money for minimization, SBA loans, and temporary housing assistance would not have been so readily available as part of a complete mitigation package as used in Baytown. The set of tools used in Baytown should be expanded and research into other possibilities encouraged.

As an agency, FEMA is beginning to devote attention to predisaster planning. Much more could be done. Herein lies a real opportunity. The Integrated Emergency Management System could provide a key tool in helping states and communities identify mitigation opportunities before the disaster occurs. Like Burton, Michigan, many regions have targeted future Section 1362 possibilities. They have talked to the property owners, encouraged them to purchase

flood insurance, and have begun the discussion of relocation within the community. When a disaster occurs in these areas, the residents will not be so apt to want to return to the predisaster conditions. Similarly, through the SAP program, states like Illinois, Indiana, and Wisconsin have worked with communities to develop preparedness and predisaster mitigation plans, many elements of which will be activated or will become opportunities after disaster.

Conclusion

We can learn much from the Brownwood subdivision mitigation project. It is to be hoped that this will be only one of many analyses. Often we devote our evaluation efforts to failed projects. The Brownwood project was clearly a success. Each of the five conditions presented in this paper contributed to that success. The sum of these created the force needed to counter the residents' natural, spontaneous response to reoccupy their homes in the floodplain.

In analyzing the Brownwood experience in light of other mitigation efforts, I have concluded that each condition is needed if postdisaster mitigation opportunities are to be achieved. The relative importance of each condition may vary but all five conditions must be addressed to some degree. Not only must each condition be present, but as the importance of one decreases, others must increase. In the Burton, Michigan, example, the amount of damage for any single event was extremely small. Yet on balance, the high frequency of occurrence provided the force needed for mitigation. Understanding the issues involved in flood mitigation can help us identify realistic postdisaster mitigation opportunities early enough to take advantage of them. This understanding can also help us redirect our predisaster planning efforts.

THE BAYTOWN, TEXAS EXPERIENCE
HAZARDS MITIGATION LESSONS FROM HURRICANE ALICIA

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Baytown, Texas and the Brownwood Subdivision

Baytown is located on the north end of Galveston Bay, adjacent to the mouth of the San Jacinto River. The Brownwood Subdivision is located on the west side of the city on a peninsula of land jutting into small bays off the San Jacinto River. It contained some 300 homes, all of which were built in the 1950s before a hazard was recognized. Recognition came with Hurricane Carla in 1981, during which rising water covered the entire peninsula and put at least eight feet of water in every home.

Since then, Brownwood and in fact the entire Baytown/East Harris County area, have suffered from another hazard--subsidence. The Brownwood Subdivision has subsided approximately five feet since 1963, and an estimated nine feet since 1915. Although the subsidence has been halted by the conversion to use of surface water rather than groundwater, the effects are permanent, and have resulted in the Brownwood area being just above sea level and subject to periodic tidal flooding. In the last six years the city has had to deal with numerous flood alerts in Brownwood due to high tides, and has supervised the evacuation of homes in the area numerous times. In 1979, for instance, there were five flood alerts in Brownwood and four evacuations. The Brownwood residents formed an active civic association, the main function of which was to maintain their high tide alert system. When high tides threatened, they notified all residents in order to speed evacuation. The residents of the worst areas would evacuate; others would merely elevate their furniture, pull out their carpets, and ride out the flooding. The city had installed several high speed pumps to help drain the low interior bowl of Brownwood in an effort to minimize flooding.

Although most of the residents had experienced tidal flooding, 23 years without a hurricane had encouraged most of them to view hurricanes as remote

threats, although the city continually warned its residents that the average occurrence frequency for the area is one hurricane every ten years, and that they were therefore 13 years "overdue."

A Corps of Engineers project to purchase the entire peninsula fell through in 1979 when the citizens of Baytown failed to approve a $7 million bond program to finance the city's share of the proposed $35 million buyout. This would have been, of course, the best possible predisaster mitigation strategy. This program was significant, however, in that the residents had been exposed to, and preconditioned to think in terms of relocation.

Hurricane Alicia

With the arrival of Hurricane Alicia, Baytown was no longer overdue. Twelve to 13-foot tides and 125 mph winds caused city-wide damage. Over 600 housing units within the city were destroyed and many more than that damaged. Approximately 300 of the destroyed housing units were in Brownwood. Although the high tide from Alicia was lower than than that from Carla, the subsidence during the intervening years resulted in a much higher water level in Brownwood. Most homes had 10 feet of water or more in them. More damaging was the wave action, which had not been a factor in Carla. Many homes were completely swept away by waves, leaving only a concrete slab. This was an aspect of hurricanes for which most people were unprepared. Residents who had been through Carla, or had stayed in their homes during numerous tidal floodings, thought they could ride out Alicia only to find their homes being battered and destroyed around them. Rescue crews picked numerous people out of trees or from the roofs of remaining structures.

One failure of past flood hazard regulations has been their failure to address wave action and other storm results besides those from rising water. Simply providing for flood protection to the 100-year flood level is not enough. I doubt that structures elevated to heights above the floodplain in Brownwood would have survived the wave action. Any flood hazard planning should take wave action into account.

Lessons from Brownwood

Predisaster Thinking

Some predisaster thinking or planning aids any mitigation effort. Many of the residents of Brownwood were already predisposed towards a buyout, and welcomed the Section 1362 program FEMA offered. In retrospect, some additional

predisaster planning by the city might have been useful. The city had not considered the Section 1362 program as a vehicle for a large-scale buyout, and we had not familiarized ourselves with the program. Other communities want to look at their flood hazard problems to see if Section 1362 can aid them in the event of a disaster. Some thought should be given to problems that may arise. Advance planning could assist in dealing with some of the problems Baytown encountered:

> Opportunists--Some people saw the disaster in Brownwood as an opportunity to make a few dollars. Numerous rumors were started concerning what FEMA would or would not do under Section 1362 and what the city was going to do with the area. These rumors were of course untrue and used to encourage property owners to sell to the opportunists rather than to FEMA. Some people were convinced the city was going to take the lots we received and sell them to Exxon for a huge profit. No one could tell me, however, what Exxon planned to do with the flood-prone property that would be restricted to open space use. A clear understanding of the Section 1362 program and publicity concerning the program aided in dealing with opportunists, but new rumors still surfaced occasionally.

> Die-hards--A few Brownwood residents wished to return and rebuild regardless of the risk or cost, stating that the area was their home and they did not want to give it up for any reason. While some of the die-hards had other motives, and some spoke from emotion created by their forced removal, a small minority sincerely wanted to move back. While Baytown has not found a method to convince these people that the best thing to do is relocate, other mitigation planners should recognize that there will always be people who want to remain in a hazard area, regardless of the risk.

> Profiteers--Some Brownwood property owners resisted mitigation efforts because they had learned to make a profit from flood insurance. These property owners recovered flood insurance numerous times, made minor repairs and pocketed the insurance benefits. Some of these owners no longer lived in the homes, but rented them to unfortunates who suffered through the various floods while receiving no aid. One property owner reportedly stated that he counted on at least one good flood a year in order to improve his cash flow (through flood insurance claims).

Another aspect of predisaster thinking is the publicizing of hazard areas. Despite Brownwood's long history of flooding, some residents stated after Alicia that they had bought their houses only within the last year or two and had not realized it was in a flood-prone area. Although a common sense look at the subdivision height in relation to the surrounding bays should have forewarned anyone, a few residents were genuinely shocked that they got flooded. Many of these surprised residents were newcomers to the community and may have

been unaware of Brownwood's problems. I would advise communities with similar known hazard areas to continue to publicize the hazards and not to assume that "everyone knows about Brownwood."

Quick Response

A quick response to disaster is necessary for effective mitigation. The residents of Brownwood lost everything they owned in Alicia, and had no place to stay except for emergency shelters. Their immediate concern was "what are you going to do to help me?" The quicker answers can be given to victims to allay their fears about the future, the more likely they will agree to mitigation efforts. Although FEMA was at the disaster immediately afterwards and presented its plans within a matter of days, the victims' primary concern was when implementation would begin. Many owners were prepared to sell their property the minute the program was announced. The several months it took to get the Section 1362 program to the purchase stage allowed some to change their minds. The delay also allowed the spread of rumors and misconceptions about the program. It is obvious that it takes time to implement any program, particularly for a large area such as that involved in Baytown, but anything that can shorten the implementation time will aid the mitigation effort.

After FEMA decided to implement a Section 1362 program for Brownwood, the city convinced FEMA to open a local office in Baytown, since FEMA's main office was in Houston, some 25 miles away. It was difficult for victims to travel into Houston; they also had trouble telephoning, due to the large volume of calls the Houston office received. By opening an office in Baytown, FEMA was able to deal more quickly with disaster victims. I believe the opening of the local office helped facilitate the mitigation efforts more than any other single act. Victims were able to go to that office and have their questions answered--questions about the program which, if not answered, might have caused them not to participate. The local office also made it easier for city officials to work with FEMA on the buyout.

Judging by the questions asked at the public sessions, any mitigation effort should include a means to clearly describe how the mitigation program works, with examples of how it will affect individual situations. A generalized description of a program will not suffice. The victims need to have a clear enough understanding of the mitigation program to determine how it will affect them. While the mitigation workers cannot address every variable, an

attempt should be made to provide several examples of how the mitigation program will operate. The victims are anxious for definite answers to their problems, not vague possibilities.

City Regulation of Brownwood

As part of the mitigation effort, the City of Baytown took special action after the hurricane. Alicia destroyed the numerous lift stations in the subdivision, making it impossible to pump sewage from the area. Raw sewage was evident in the water left in the subdivision. Power lines were down throughout the area. The water system was out, making it impossible to provide fire protection. Debris and fallen trees were everywhere. The fact that the subdivision was obviously unsafe and a health hazard prompted the City Council to pass an ordinance banning the occupancy or repair of any structure within the Brownwood Subdivision. Property owners with proper identification were allowed in the area only during daylight hours in order to retrieve what few valuables might remain. This ordinance was intended to prevent anyone from being injured and to prevent the possible spread of disease, and had the added benefit of keeping homeowners from going back and secretly doing repair work that might be prohibited by the floodplain building provisions.

This action carried some risk, however. A few property owners filed suit against the city alleging a taking of their property without just compensation. The city asserted that such action was within its police powers to protect the health, safety, and welfare of its citizens, and that it is simply a limitation in the use of the property, not a taking of it. As of this date, the lawsuit is still pending, the court having rejected plaintiff's request for a temporary injunction to stop enforcement of the ordinance. While the final outcome of this lawsuit cannot be predicted, even if the city loses, the loss will not be catastrophic. The city can simply rescind the ordinance and pay damages, which should be limited to the rental value of the properties during the period the ordinance was in effect. As the rental value of the property is minimal, the exposure in dollars is small. Meanwhile, FEMA will have completed its Section 1362 program, allowing those who wish to leave to do so. City Council was made aware of the risk at the time the ordinance was passed, but considered it acceptable in view of the need to protect and help the citizens of Baytown.

Frequency of Events

While I agree that the frequency of the event is a key factor in overcoming resistance to change, I believe this issue should be refocused by floodplain managers. Brownwood's major disaster was a slow moving one--subsidence. It was Brownwood's elevation and location that were hazardous, and these were the issues that needed to be addressed by mitigation. Residents of such an area should be shown and reminded that the hazard lies with the property they own, not the hurricane that may come. Stressing this may help overcome resistance to change.

Conclusion

Some of the problems encountered in Baytown may be instructive to those involved in mitigation planning. Quick response is essential to an effective mitigation plan. In known hazard areas, mitigation efforts should actually start before the disaster with attempts to predispose the residents towards a mitigation plan. Alicia demonstrated that planning based on simple flood levels, without recognizing wave action, will not anticipate total possible damage. Finally, communities should be imaginative in developing plans for assisting mitigation efforts. Baytown's declaration of Brownwood as a hazard area carried with it some risk, but so far the benefits have outweighed the risks. While a city's powers are not without limit, the law does recognize a governmental entity's right to take action that may be detrimental to the few, if such action benefits the public as a whole. Although our mitigation efforts have been opposed by a few, the majority support our efforts. On that basis we stand by our actions and would repeat them in a similar situation.

PART THREE

STRATEGIES FOR MANAGING HIGH RISK AREAS:

Protecting Existing Buildings

A PROPOSAL TO REDUCE FEDERAL FLOOD DISASTERS

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Background

In the United States there are 6.8 million buildings subject to flooding with average annual damages of $1-1/2 to $2 billion. In Illinois, which can be considered to have a representative sample of the nation's riverine flood problems, there are approximately 140,000 buildings currently exposed to flooding in the 100-year floodplain. Of these, approximately 21,500, or only 15%, will be protected over the next ten years by structural flood control projects.

We cannot expect structural flood control measures to take a substantial bite out of the remaining 120,000 flood-prone buildings. Given the requirement that structural projects be cost effective, such projects can only be justified where large numbers of flood-prone buildings are concentrated. In addition to the environmental problems and the tremendous costs for structural projects, the areas left to be protected are dispersed in rural areas or in long, narrow floodplains. Therefore, it will be increasingly difficult to justify structural projects to protect the remaining flood-prone buildings.

Nor can we expect the floodplain management requirements of the National Flood Insurance Program (NFIP) to effectively reduce the number of flood-prone buildings. The NFIP's regulations say that if a building is damaged to 50% of its value, it must be rebuilt protected from the 100-year flood. This 50% threshold is based on an examination of court experience with similar zoning requirements. It is likely that a tougher national standard would be overturned as a "taking" of property without adequate justification.

In Illinois, slow moving and shallow riverine flooding does not create substantial damage to a building. The average flood insurance claim in Illinois has been less than $4,000. This confirms our field experience that the vast majority of flood damages will never be enough to result in mandatory flood protection measures being taken.

Therefore, we must realize that the vast majority of the 120,000 flood-prone buildings in Illinois will continue to be exposed to flood damage. Assuming that there are 6 to 8 million flood-prone buildings in the nation and that only 15% of them will be protected by structural projects, there will be 5.1 to 6.8 million buildings that will continue to be exposed to flood damage throughout the country.

The Subsidy

The federal government has assumed a role of assisting flood victims. Some of this assistance is in the form of repayable low interest loans and is therefore not counted as a "subsidy". Neither are structural flood control projects, because they are only built where they are shown to have a net economic benefit. Therefore the cost figures in this proposal actually estimate flooding's drain on the federal treasury.

The federal government's subsidy comes in the form of two programs for flood victims--disaster assistance and flood insurance--both of which are administered by the Federal Emergency Management Agency (FEMA). Over the last 10 years, disaster assistance payments for flood damages have averaged $225 million annually.

Over the last five years the National Flood Insurance Program has spent an average of $300 million annually for claims and administrative expenses. When insurance premiums are subtracted, the net cost to the Treasury has averaged $135 million. These figures add up to $525 million in average annual payments to flood victims, of which $360 million is a direct federal subsidy.

Since 1979, Illinois has received over $85 million in disaster assistance and flood insurance claims from FEMA. In return for these payments, floodplain residents paid approximately $25 million in flood insurance premiums. In other words, for every dollar that is paid by Illinois floodplain residents, approximately $3.40 is returned to pay for flood damages. The federal government is therefore subsidizing 70% of the cost of rebuilding after a flood. This percentage holds true for the nation as a whole.

This tremendous subsidy would make sense if there were reason to believe that the payments are used to reduce flood damages. This is not happening. Not only are there no strings attached to flood insurance claims payments or disaster assistance to require recipients to protect themselves from future floods, but also most of the disaster assistance programs prohibit use of the funds to improve or otherwise protect the property.

One Solution: Emergency Preparedness

What can be done to protect existing buildings and thereby reduce this federal subsidy? There are two types of programs that will have an effect on these buildings: local emergency preparedness programs and protection of individual buildings. Local emergency preparedness programs have two facets to reduce property damage: flood warning and flood fighting. Simply warning property owners in advance of a flood has been shown to reduce flood damages by 10-30%. When a warning is coupled with a flood response such as sandbagging, emergency protective measures, and other flood fighting efforts, damages can be decreased even more.

The Other Solution: Protecting Buildings

There are two ways to protect individual buildings from flood damage: removing the building entirely and retrofitting. Removing the building through demolition or relocation to a flood-free site has been tried successfully by various local, state, and federal agencies. Its use by state and federal flood control agencies, however, has been limited to areas subject to very destructive or very frequent flooding, where it is obviously cost effective to eliminate damages. The only federal program specifically authorized for acquisition of flood-prone properties, FEMA's Section 1362, now has requests for funding equal to three times the amount available. There are four ways to retrofit a building so that it stays on the flood-prone site but will not be damaged by floodwaters. These are listed in order of increasing cost:

- Wet floodproofing the building by relocating utilities and other hard-to-move items permanently and moving damageable contents after a flood warning;
- Dry floodproofing the building by waterproofing the walls and floor and closing openings so that shallow floodwaters will not enter the building;
- Constructing a small levee or floodwall around one or more buildings; and
- Elevating the building on fill, stilts, or walls above the flood level.

To the federal government, retrofitting is the newest and most untried solution. However, these measures have been used in many instances by property owners, and they have been proven to reduce or eliminate damages. Furthermore, FEMA and the Corps of Engineers are funding additional research to refine the technology so that it can be viewed with the same trust as flood control struc-

tures. However, other than Section 1362, there is presently no federal program to assist property owners to protect their buildings.

The Cost of Protecting Buildings

According to FEMA's recent assessment of Section 1362, it costs approximately $40,000 per building to remove a structure from the path of flooding. This number is consistent with the findings of recent research and work done by the Illinois Division of Water Resources reviewing actual retrofitting projects with local contractors. We calculated the approximate cost of each of the six nonstructural building protection methods and estimated how many could be protected by these methods:

Technique	Average Cost	Number of Buildings
Demolition	$50,000	7.4
Relocation	$25,000	11.4
Elevation	$15,000	17.0
Levee or Wall	$10,000	11.4
Dry Floodproofing	$ 5,000	52.8
Wet Floodproofing	$ 2,000	(not considered)
		100%

Based on the number of buildings to be protected, we calculated that the average cost of protecting the remaining flood-prone buildings with the first five nonstructural measures is $10,700 per building.

If the cost of protecting individual buildings is so low, why hasn't it been done more? It has not been done by individual property owners to any great extent because people are people. They may not be aware of these protection measures, but, more likely, they do not make their decisions based on pure economic calculations of benefits versus costs. Many of them do not expect to be flooded, and those that have been flooded often cannot afford any more expenses.

Probably the greatest reason is that for the last 50 years floodplain property owners have expected the federal government to protect them. Many residents hold out hope for a structural flood control project, and, because it takes many years to decide whether one will be built, they defer taking any measures on their own. More recently, floodplain residents have come to expect disaster assistance and federally subsidized flood insurance to bail them out.

As a result, private individuals' actual out-of-pocket costs to protect themselves are much larger than the cost of rebuilding after a flood.

Flood insurance and disaster assistance neither eliminate the aggravation nor pay for all flood expenses. For example, Illinois River residents have been subjected to three severe floods within the last five years. As stated by one resident, "We were married to the river, but after it entered our living room three times, we decided it was time for a divorce."

Implementing These Solutions

To effectively reduce the $360 million flood subsidy, the federal government must support flood emergency preparedness and building protection measures on a scale approaching its support for flood control, insurance, and disaster assistance. While this may sound like a tall order, we have four recommendations that could be implemented relatively easily:

1) Change some of the existing rules for federal assistance programs to permit and promote building protection.

2) Change the NFIP insurance rating system to recognize and encourage local emergency preparedness and building protection programs.

3) Create a flood hazard mitigation fund to support state and local emergency preparedness and building protection programs.

4) Continue the research and public information programs on floodproofing and other protection measures.

The first three recommendations deserve more discussion:

Recommended Changes to the Federal Assistance Programs

A detailed review of seven major federal assistance programs was recently conducted for and is available from the Division of Water Resources. The report reviews three types of federal assistance programs: community development assistance, disaster assistance, and structural flood protection.

Community development programs such as HUD's block grants do permit relocation and retrofitting of flood-prone buildings. The CDBG has had a significant impact on mitigation work in some hard hit communities. However, recent program changes mean that flood victims must compete with economic development and low-income housing criteria. Because of this, not many nonentitlement communities have been able to obtain funding.

The disaster assistance programs of FEMA, the Small Business Administration and Farmers Home Administration have the advantages of moving quickly and

being able to assist floodplain property owners when they are most open to thinking about reducing future damages. However these programs suffer from a common problem in that they do not allow funding of improvements to the properties unless required by local law. Because most flood damages in Illinois are not severe enough to warrant mandated retrofitting, most flood victims are not eligible for extra funding. These programs should be amended to permit funding of mitigation activities.

The beginnings of such an amendment have been proposed in Senate Bill 2517, Amendments to the Disaster Relief Act of 1974. This bill proposes that an amount equal to 2.5% of the total disaster assistance for public facilities be made available at a 50/50 cost share for local mitigation projects. While we support this arrangement, the formula only provides a limited amount of funding, and the funds would only be available to areas after a disastrous flood.

The flood control programs of the Corps of Engineers and the Soil Conservation Service suffer from a different common ailment. Each project must be justified with a favorable benefit/cost ratio. This is difficult to do for relocation because there is little benefit gained by vacating land. It is difficult to do for retrofitting buildings, because the techniques have not been generally accepted by the funding agencies and because calculating benefits and costs on individual buildings is time consuming and problematic.

We therefore recommend that FEMA or the Corps of Engineers continue their floodproofing research to identify where individual retrofitting techniques are shown to be generally cost effective on certain categories of buildings. For example, research has shown that most masonry buildings on slabs can be economically dry floodproofed if flood depths are less than two feet. As part of the project planning, the Corps and the SCS should review nonstructural alternatives by checking these building categories and flood hazard parameters rather than conducting house-by-house detail benefit/cost analyses.

Recommended Changes in the NFIP Rating System

The NFIP can encourage flood protection measures by recognizing them in its rating system. This is a common practice in the private insurance industry as shown by these examples:

- Fire insurance rates are lower in communities with better fire departments and water systems and in buildings with smoke alarms;

- Jewelry stores have reduced rates for a variety of strategies such as alarms, extra locks, and removing valuable items from show windows; and
- Safe drivers and nondrinkers can receive reduced automobile insurance cost premiums.

A community rating system has been proposed by FEMA. This system would provide lower rates for all policies in those communities that implement flood damage reduction activities such as a flood warning system. We strongly support creation of such a community rating system.

The NFIP rating system should also provide reduced rates for individual buildings that are protected from flood damage. Currently, the system does recognize relocation and elevation by providing lower rates. However, it discourages small levees, floodwalls, and floodproofing of residences by not recognizing these techniques. We therefore recommend that the NFIP follow the lead of the private insurance industry and offer reduced rates for these other loss reduction measures. A detailed report on this recommendation is available from the Divison of Water Resources.

A Flood Hazard Mitigation Fund

The Illinois Division of Water Resources proposes that a new program be created to establish a flood hazard mitigation fund. The program would be a joint federal, state, local, and private effort similar to and built on the NFIP. The federal government would provide the basic funding, the states would provide guidance and technical assistance, and local governments would work with private property owners and lending institutions to protect buildings.

In return for mitigation funds a state would establish a new mitigation assistance program, seek statutory authority if needed, conduct training, and provide technical assistance to local programs. The state's program would set minimum standards for building protection measures, identify where they should or should not be used, and train building officials and engineers in these techniques. The state would also promote mitigation and the sale of flood insurance.

The state would pass the funds through to local governments willing to initiate flood hazard mitigation programs that would include the following elements:

- Participation in the National Flood Insurance Program
- Development of a flood warning and flood fighting program meeting minimum criteria set by the state emergency management agency
- Development of a floodplain redevelopment plan that identifies the most appropriate protection measures for existing buildings and plans for reuse of any vacated sites
- Administration of the mitigation fund for low interest loans or other cost sharing to property owners willing to retrofit or relocate their properties.

The staff needed for planning and financial management is already available in many community development departments. Small communities without such staffing could obtain help through intergovernmental cooperative agreements, or the program could be run at the county or multicounty level.

Property owners could be required to protect their property to higher than the base flood elevation where feasible. For example, if a building is appropriate for elevation and the 500-year flood is only one or two feet above the 100-year flood (a common occurrence in Illinois), then the building could be elevated above the 500-year flood. The property owner would also be required to buy a flood insurance policy to cover the property for damages higher than the protection level.

Operation of the Hazard Mitigation Fund

The most appropriate source of the federal share of the fund would be a percentage of the NFIP premiums paid from a state. This arrangement automatically allocates the money where the federal subsidy is greatest. It also provides an incentive for states to promote the sale of insurance, one of FEMA's goals.

We recommend that 20% of the flood insurance premiums be returned to each state for a flood hazard mitigation fund. While 20% of the premiums may sound like a large contribution, in fact it represents only 5% of FEMA's flood relief expenses. This percentage is also below similar percentages used by the private insurance industry. Specialty companies such as Factory Mutual or Factory Insurance Association spend 7% to 8% on engineering services. Boiler and machinery specialty writers allocate a substantially higher percentage of their premiums to safety inspections.

In comparison with this effort in private industry, the Federal Emergency Management Agency spends an average of $525 million for flood insurance and

disaster assistance. In addition to these payments, FEMA spends 10% of this amount for technical studies and assistance to prevent future development from increasing the loss potential. However it spends only 1% for loss reduction to existing buildings (the $5 million for Section 1362). Given the predictable nature of flooding and the technology available to prevent and reduce damages, this percentage is surprisingly low.

FEMA is also the logical agency to implement a flood hazard mitigation fund for other reasons. First, the flood subsidy is being paid by its National Flood Insurance and disaster assistance programs. Second, FEMA has the organization and the experienced staff to administer a program that would pay for flood protection in those communities that adopt a mitigation program.

Finally, the fund would complement one of FEMA's major efforts: to reduce the NFIP's subsidy by making the program self-sufficient. The current approach, to raise rates and cut coverage, has reached the point of no return. As a result of this approach, Congress has told FEMA to temporarily stop rate increases, and many policy holders have dropped their policies.

The real problem with FEMA's approach to date is that it does little to eliminate the cause of the subsidy--raising rates and cutting coverage do not protect existing buildings that are and will continue to be flooded and damaged. The proposal for a mitigation fund and local mitigation programs will do that.

The exact mix of loans and grants from the fund would depend on criteria such as owner's income and cost of the project. The low interest loan is the preferred approach for two reasons: the mitigation fund would be reimbursed by the borrowers, and fund money can be augmented with local funds. For example, with an assumed average project cost of $10,700 and 5% as the low interest rate, total interest payments over a 10-year loan would be $3,300. At an assumed local mortgage revenue bond interest rate of 11%, $3,300 would be the interest accrued by a 10-year loan of $4,300.

The fund could provide $6,400, and the community could loan the $4,300 balance needed for a $10,700 loan. Both the fund and the community would be paid their share of the principal, but the community would receive all the interest payments to retire its bonds. This arrangement results in $150 in financial assistance for every $100 from the mitigation fund.

Illinois residents are currently paying $5 million in annual flood insurance premiums. If 20% of this amount, $1 million, were put into a low interest

loan program according to the above-described federal 2/3 local 1/3 cost share, $1,500,000 would be available for mitigation projects. At an average cost of $10,700 per project, this fund would be able to assist 156 properties in the first year.

The amount of money available would increase each year as borrowers from the previous years repay the principal and as flood insurance coverage increases. If the number of policies doubles in five years (FEMA's target), after ten years a total of 4,300 projects would be funded for a total federal cost of $19 million. This arrangement compares very favorably with Section 1362. At its current funding level, 1362 will cost $46 million over the next ten years and will protect 1,150 properties at $40,000 each.

Such an expense is appropriate because Section 1362 will assist the worst flood problems, and it has been shown to have an early impact on the flood insurance fund. On the other hand, the federal funds under this proposal can help nine families for every one protected by Section 1362. If the federal government is willing to fund 1362 to the tune of $40,000 per property, it should be willing to complement its current financial assistance arrangement, help more property owners, and reduce the drain on the flood insurance fund.

Summary

We must recognize that the federal government's $360 million flood subsidy will not be substantially reduced by current approaches. The existing federal programs to reduce flood damages, structural flood control projects, disaster assistance and subsidized insurance, and local regulations, cannot be expected to remove more than 15-20% of the buildings exposed to flood damage.

What is needed are new federal incentives for local emergency preparedness programs and nonstructural building protection. We have recommended four ways to do this:

1) Change some of the existing rules for federal assistance programs to permit and promote building protection. Without such changes federal funds will continue to be poured into existing buildings--to repair them in order to be flooded again--and continue to drain the National Flood Insurance Fund.

2) Change the NFIP insurance rating system to recognize and encourage local emergency preparedness and building protection programs. A rating system that reflects flood protection measures taken by the community and by each property owner will make the NFIP more consistent with private industry.

3) Create a flood hazard mitigation fund to support state and local emergency preparedness and building protection programs. By using the fund for low interest loans, federal dollars can be matched and the fund can be replenished, bringing much greater returns than Section 1362.

4) Continue the research and public information programs on floodproofing and other protection measures.

In its enabling statutes, the NFIP was designed to be re-examined as experience was gained in this new federal initiative. At first, the NFIP focused on obtaining data on flood hazards and having local governments enact minimum regulations to ensure that future development would not be subject to flood damages. By having the majority of the flood-prone communities studied and converted to the regular program, FEMA has successfully accomplished this first step.

The second effort of the NFIP was to ensure effective local floodplain management programs. This, too, has been successfully addressed through the CAPE process and the State Assistance Program.

FEMA's current effort is to make the program self-sufficient by 1988. Its approach to this has gone about as far as it can, and it still does little to address the cause of the federal subsidy or the concerns of most flood victims: damages to existing flood-prone buildings. This proposal will do that, and it can be implemented with the existing organization at only a slight cost to the insurance fund. The benefits gained will be well worth the cost.

FORT WAYNE/ALLEN COUNTY FLOOD PROTECTION PLAN

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Introduction

The purpose of this paper is to present and explain the local perspective of what happens after a presidentially declared flood disaster. I will try to provide the local perspective through 1) a brief description of the flood; 2) a discussion of the Fort Wayne/Allen County Flood Protection Plan--its content, citizen and agency input, and implementation; and 3) lessons learned.

What I hope to leave you with is an understanding of 1) the importance of the development of a local plan; 2) the idea that the plan should be completed rapidly; 3) the need for much citizen and agency input; 4) the need (when complete) to carve off a first-phase implementation work program; 5) the need to tap multiple funding sources; and 6) the need to have an undying commitment to the plan and to the cause of flood protection. (The work takes an incredible amount of time and tenacity).

The Flood

Fort Wayne, Indiana, experienced a severe flood in March, 1982, and was declared a Presidential Disaster Area. The flood crested near the 100-year elevation and remained over flood stage for approximately one week. Although the city initiated a flood fight with 35,000 volunteers, filled a million sandbags, and saved 1,860 properties, the flood water damaged 1,760 residential structures and approximately 260 businesses. The total cost of the 1982 flood was over $53 million. The cost would have been over $80 million if the areas saved had been lost.

After the crest, Fort Wayne established three task forces to deal with the flood and to plan for the future. The task forces reported to a policy committee so that they could be directed along a similar path. One task force dealt with evaluating the flood fighting effort and the Emergency Operation Center. The second dealt with recovery from the disaster. This involved examining all aspects of getting people back into their homes after the flood--including cleanup, temporary housing, assistance programs, housing inspections,

and security against looting. The third task force was given the responsibility of developing a flood protection plan. The plan, put together after 30 days of city/county effort, is published in its entirety in a document called the Fort Wayne/Allen County Flood Protection Plan, and is also published in abstract form.

Fort Wayne/Allen County Flood Protection Plan

Documentation of Flooding History and Cost

The plan spends considerable time documenting the history of flooding and the cost of flooding in Fort Wayne. This is important in order to establish the record and thereby insure that people do not forget the events of the past. It was found that Fort Wayne is often flooded. In fact, one damaging flood has occurred, on the average, every five years throughout the 1800s and 1900s. In addition, it was found that Fort Wayne was declared a Presidential Flood Disaster Area in 1959, 1978, and 1982. The plan documented that there had been a series of studies drafted after the major floods--in 1913, 1943, 1959, and 1976. It was determined that very little comprehensive implementation of those studies had taken place, although incremental dike improvement and other miscellaneous flood protection activities had been carried out. The plan also documented the extent of flooding in 1982. This was done with slides as well as graphics, and identified the residential, institutional, industrial, and commercial areas that were inundated by flood waters in 1982.

Finally, the plan documented the cost of the flood of 1982. It is very important that this cost data be based upon a sound methodology because it must stand the scrutiny of FEMA, which is also putting together cost data. It also has to stand the ongoing test of the Corps of Engineers, because they use cost data in their cost/benefit analysis.

The plan based the cost data upon private, as well as, public costs in terms of the emergency itself, the primary impact area, the secondary impact area (not flooded but affected by truck traffic and other associated problems), and the costs for the potential impact area (that area saved). It is important to have "worst case" data to explain what could have happened. (It was close to a miracle that Fort Wayne was able to get the volunteers, sandbags, and weather conditions necessary to avoid suffering additional damages).

Alternative Solutions

The plan studied nine solutions to the flooding problem in Fort Wayne/Allen County based upon six alternative concepts. The concepts included

diversion channels, evacuation of the floodplain, floodproofing, dams and reservoirs, river channel improvements, and massive dike building. The cost for these alternatives ranged from $108 million to $232 million. The alternatives were evaluated on social, economic, and natural environment characteristics as well as effectiveness, reliability, and public acceptance. A solution containing both short-range and long-range plans was selected. The short-range plan consisted of many improvements including diking, channel improvements, tide gates, acquisition, pumping stations, etc., that could be started immediately. The long-range project called for a major diversion channel to be constructed that would not be possible to implement without Corps of Engineers involvement.

Citizen and Agency Input

During the development of the plan (as well as after it was drafted) our staff worked hand in hand with the Indiana Department of Natural Resources, Corps of Engineers, and FEMA to assure that our plans and efforts were well coordinated. We traveled to Washington, D.C., twice, once immediately after the flood, and once after the plan was completed. In these sessions we discussed with our senators, representatives, and the Corps of Engineers the aspects of the flood in Fort Wayne. At home we conducted some 45 public meetings and involved over 3,000 people. In addition, the staff testified in front of the State Natural Resources Commission and provided testimony to the State legislature. In the final analysis, the plan was adopted by the Fort Wayne Common Council.

Implementing the Plan

The 18-Month Work Program

The entire plan outlined in the document would cost somewhere in the neighborhood of $120 million to implement. Therefore, it was essential to divide that plan into some manageable increments that could be funded. This was accomplished through the development of an 18-Month Work Program. I am pleased to report that the 18-Month Work Program, which included $11 million worth of work, is nearly completely accomplished. The Work Program involved eight different funding sources. They were the U.S. Geological Survey, the State Department of Natural Resources, Community Development Block Grant funds, FEMA, the City budget, the Corps of Engineers (Public Law 84-99), a Park Bond, and finally the Fort Wayne City Utilities. I would also like to point out that

it is important to make maximum use of the funds available through the Damage Survey Reports.

A diversity of projects were undertaken in the 18-Month Work Program. River gauges, a flood hazard early warning system, and a floodproofing program were funded. Minor repairs were made to dikes, major dike repair using Public Law 84-99 was accomplished, the height of certain dikes was increased, and new dikes were installed to protect certain public improvements. In addition, backwater gates have been installed, certain channel improvements were implemented, and the City has acquired 24 houses and removed them from the floodplain. Finally, the Work Program calls for the restoration of two major pumping stations.

It should be pointed out that local government is required to come up with 25% of the costs associated with projects covered by the Damage Survey Reports. In Fort Wayne's case that was nearly $1.7 million. All DSR work was included in the 18-Month Work Program.

Other Implementation Measures

Four additional elements outside the Work Program are important to implementation. One is the development of an Emergency Action Plan. The Emergency Action Plan is designed to clearly identify the items that need to be done before and during the flood. It identifies a time frame to be repeated each year to prepare neighborhoods that are subject to flooding and to prepare the city through internal meetings. It addresses sandbag storage and various other items associated with being prepared for the possibility of a flood. The Emergency Action Plan outlines all of the processes that are necessary for managing a flood, including dike building, dike patrol, media involvement, solicitation and maximum use of volunteers, and the management of food and transportation problems.

Secondly, it is absolutely essential that some entity be established outside local government to implement flood protection. This entity needs to have the following characteristics: the power to work across jurisdictional boundaries, the primary responsibility for flood control, the ability to be isolated from political change, and the ability to raise funds. In Fort Wayne we are still working to accomplish this objective. We are pursuing a law that is on the Indiana books that allows for the creation of a Conservancy District. The process is very long and frustrating, but we are pursuing it with vigor.

In addition, implementation is assisted by making necessary revisions in the floodplain zoning ordinance. We are making improvements to the zoning ordinance to bring it in compliance with the National Flood Insurance Program. Among other changes, we are taking steps necessary to insure that floodway development is prohibited in the future.

Finally, the success of any major flood protection program is dependent upon the involvement of the Corps of Engineers. Fort Wayne recognized that fact from the start and worked closely with the Corps of Engineers in the development of the Fort Wayne/Allen County Flood Protection Plan. The Corps is currently finishing a reconnaissance study that may lead to the next step--a feasibility study of Fort Wayne/Allen County watershed--and ultimately to the involvement of the Corps of Engineers in constructing the improvements that are necessary in Fort Wayne.

Conclusion

There are several lessons to be learned by floodplain managers from Fort Wayne's experience:

1) Target planning efforts before the flood occurs. Promote flood insurance, floodproofing, and wise land use planning through floodplain zoning. In extremely hazardous areas, consider relocation as early as possible.

2) Create a mitigation planning team immediately. Because of the pressing recovery work that needs attention, there is a temptation to defer planning until later and thereby miss opportunities.

3) Develop a local plan quickly. In order to be in control of your own destiny, it is necessary to develop a local plan. The local planning process must spawn an understanding of the problem, a thorough examination of alternative solutions, and a commitment to implementation. The plan must be used to communicate locally, to the state, as well as to the federal government.

4) Coordinate state and federal plans. The Federal Emergency Management Agency and the state natural resources department are mandated to develop hazard mitigation plans. These plans must be coordinated with local planners.

5) Seek assistance. You are not alone in dealing with the disaster. A number of organizations, reading materials, and private consultants can help--including, of course, the Association of State Floodplain Managers.

6) Coordinate and organize. The need for coordination and organization cannot be overemphasized. Support from local citizens, FEMA, the state, the Corps, your senators and representatives, and leadership from your local executive branch are absolutely necessary to success of a plan.

7) Develop an undying commitment to the cause. In Fort Wayne, the 1982 flood is still a large consumer of staff resources. Within the past three months the staff has participated in two conservancy district hearings--one convened by a district court judge and one conducted by the Department of Natural Resources. In both of those cases, the staff had to come fully prepared to discuss the flood and all the associated data that had been gathered as part of the Flood Protection Plan. In addition, the Corps of Engineers has just left Fort Wayne with the cost data that they needed for the reconnaissance study. Finally, the ongoing request for funding, the ongoing public presentations, and in some cases lawsuits, require a continued commitment. It can be somewhat frustrating to present (again and again) information that was developed some time ago, but it is necessary to have the fortitude and the professionalism to keep the project moving.

PART THREE

STRATEGIES FOR MANAGING HIGH RISK AREAS:

Evacuation

CRITICAL HURRICANE EVACUATION PROBLEMS: THE NEED FOR INNOVATIVE EVACUATION PLANNING

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Introduction

In the last five years, the availability of new quantitative hurricane hazard analysis tools and a planning method linking transportation, demographic, and behavioral evacuation analysis has allowed comprehensive studies to answer critical questions on a given area's hurricane vulnerability. The two major, previously unanswered, questions were 1) what specific geographic areas must be evacuated in advance of the approaching hurricane? and 2) how long would such a prestorm relocation of vulnerable residents take (evacuation time)?

In 1978, a hurricane evacuation planning effort for Lee County, Florida, yielded an analytical method, combining all quantifiable factors of local hurricane vulnerability, to calculate county evacuation times. The limited geographical scope of the study (it only addressed Lee County) did not allow the examination of how concurrent adjacent county evacuation would affect Lee County's evacuation time. Since a hurricane will demand the evacuation of several contiguous counties, merging evacuees from neighboring counties will increase a given county's evacuation time. Hence, a conclusion of the Lee County effort was that quantitative evacuation planning must be multicounty or regional in scope, yet the resulting plan must be able to be implemented at the local level.

In 1980, the Lee County Evacuation Plan methodology was utilized to formulate a four-county evacuation plan for the Tampa Bay region. The Tampa Bay Plan not only was the nation's first regional comprehensive hurricane evacuation study, but also was the first effort to utilize the newly-developed SLOSH numerical storm surge model as its primary hazard analysis tool. For the first time, the computerized SLOSH (sea, lake, and overland surges from hurricanes) model made it possible for planners to identify land areas predicted to be inundated by overland hurricane storm surge based on several factors beyond simple land elevation (offshore bathymetry, track of storm, hydrologic

friction, etc.) The use of the SLOSH model resulted in answers to the questions of which specific geographic areas would have to be evacuated due to various intensities of hurricanes. In addition, the SLOSH results were combined with population/vehicle data, a behavioral survey, and computerized transportation modeling to calculate the time necessary to evacuate those areas before the hurricane made landfall (evacuation time). Indeed, the findings of the Tampa Bay Region Hurricane Evacuation Plan Technical Data Report quantitatively answered the two major questions of local hurricane vulnerability. The report was also adopted by the four counties of the region as the basis for their individual hurricane evacuation operations plans. However, the answers to those two questions presented a sobering picture of potential loss of life given the traditional response to an approaching hurricane. 1) The geographic areas of the region that would have to be evacuated from the direct strike of a hurricane would mean the relocation of between 200,000 and 800,000 coastal residents from the four counties, depending upon the intensity and track of the hurricane. 2) The amount of time necessary to evacuate those residents to safe shelter before hurricane landfall ranged between 12 and 18 hours, again depending upon the intensity and track of the hurricane.

The magnitude of these population figures and evacuation times now makes one thing evident: the traditional response to an approaching hurricane will not prevent large-scale loss of life. The reasons for this are evidenced by the critical hurricane evacuation problems defined and discussed below.

Evacuation Time vs. Warning Time

The paramount problem in hurricane evacuation recently confirmed by the above quantitative studies is that there are indeed some coastal regions of Florida that need more evacuation time than the National Hurricane Center can currently provide in the form of confident warning time. For example, as noted above, the Tampa Bay Region requires from 12 to 18 hours prior to hurricane landfall to successfully evacuate all vulnerable residents; the National Hurricane Center currently strives to provide confident predictions that a hurricane can actually be expected to strike a particular area 12 hours in advance. The problem is quite clear, especially when other regions (Southwest Florida and the Florida Keys) have been found to have even higher evacuation times.

Does this mean that it is impossible to conduct successful evacuations from these areas? Does it mean that evacuation plans that have quantified evacuation times longer than 12 hours are unworkable? The answer to both of

these questions is no. To explain this answer, one must first go back and examine why we are "all of a sudden" confronted with this problem and who is responsible for preventing loss of life from hurricanes.

First, although we have, just in the past couple of years, confirmed the problem through quantification of evacuation times, the evacuation time/warning time differential has probably existed for over a decade in some urban coastal areas. Its evolution is simple: coastal residential development has gradually increased to such density that the roadway systems can no longer accommodate an emergency mass exodus inland in under 12 hours. Fortunately, a major hurricane has not struck one of these areas in Florida since the coastal population explosion. If one had, a disaster more catastrophic than the 6,000 deaths in the 1900 Galveston hurricane would probably have occurred. If state-of-the-art hurricane forecasting could keep pace with the increase in coastal population, the problem could be mitigated. Unfortunately, that is not the case. A major breakthrough in hurricane forecasting and prediction, based on a new technological advance, is not expected in the near future, yet the coastal population continues to grow, pushing evacuation times even higher.

Legally, the responsibility for protecting people from an approaching hurricane rests with the state and local elected officials of the jurisdiction in which they reside. The responsibility to advise those officials of such an impending meteorological threat ultimately rests with NOAA's National Hurricane Center. This distinction in responsibility is a key to the immediate remedy of the evacuation time vs. warning time problem. So what is the immediate remedy? First, some ancillary problems uncovered by the quantitative evacuation studies are examined below.

Shelter Capacity

Another alarming problem identified by analyzing the amount of population shown by the SLOSH model to be hurricane-vulnerable is that most coastal areas are greatly lacking in the amount of public shelter capacity they can provide for an evacuation. Traditionally, in various parts of the U.S., only a small percentage (10-20%) of hurricane evacuees have sought public (usually Red Cross managed) shelters as their evacuation destination before a hurricane. However, recent behavioral surveys of the Tampa Bay study and other studies in Florida indicate that as many as 40% could seek such public shelter in a future hurricane. Florida's high percentage may be explained by the large elderly population often detached from northern relatives (homes of relatives are a local

alternative to a public shelter) and thus more dependent on public facilities. Comparative analyses of public shelter demand vs. actual existing capacity have revealed substantial shortfalls for evacuation planning. Such analyses have spurred increased efforts for new public shelter searches, designation, and staffing. However, these efforts may not be taking place fast enough.

Maintaining Florida's Comprehensive Regional Hurricane Evacuation Plans

Identifying and taking the first step in solving the "evacuation time vs. warning time" problem occurred when a pilot regional evacuation plan for the Tampa Bay region quantified the evacuation time for those four urban coastal counties. For how can a local emergency official successfully order a hurricane evacuation when he/she does not know how long it will take? Comprehensive and quantitative hurricane evacuation studies have been conducted for the Tampa Bay Region and the Southwest Florida Region. A similar effort is currently underway along the Southeast coast. It is hoped that funding will also be made available to develop a comprehensive evacuation plan for Florida's hurricane-vulnerable panhandle coastline. Fortunately, the SLOSH model, almost a prerequisite for conducting a comprehensive/quantitative evacuation study, is being developed for the remainder of the urban coastal regions of the state.

Although Florida has taken a giant step forward in hurricane preparedness as a result of the comprehensive/quantitative regional evacuation plans, the fact that those efforts were "pilot" studies has left us with the huge problem of how to keep those plans up-to-date and accurate enough to save lives. Because so many elements of the plans are quantitative, Florida's rapid coastal population growth renders critical factors, such as evacuation time, inaccurate in one to two years. No one can question the cost-effectiveness of these efforts given the constant threat to Florida from hurricanes. But the question becomes, "Who will provide the resources necessary to maintain comprehensive regional plans all along Florida's vulnerable coast?"

Alternative Solutions to Florida's Hurricane Evacuation Problems

The evacuation time vs. warning time problem has two basic alternative solutions. Unfortunately, neither is attainable without substantial costs in the form of money, inconvenience, and/or political credibility.

Early Evacuation Orders

The first solution, probably better defined as an immediate remedy, is the issuing of early evacuation orders by local and/or state elected officials. Rather than wait for a confident warning from hurricane forecasters with as little as 12 hours lead time, local officials must be guided by the pre-quantified evacuation times of their comprehensive evacuation plans. Such times might demand that the local officials order evacuation as early as 24 hours in advance of potential landfall--a point at which the state-of-the-art of hurricane forecasting cannot provide a confident prediction that the storm will actually strike that locality. In fact, such early evacuation orders will, in most instances, evacuate thousands of coastal residents unnecessarily, as the hurricane eventually does not strike that local area.

What has been created by this situation is what can be called a "cry wolf" dilemma. It is a dilemma of emergency decision making caused by the potential for causing inconvenience, financial losses, and loss of governmental/political credibility by issuing an early but ultimately unnecessary evacuation order. But the cost of not issuing such an early evacuation order upon the approach of a large hurricane are much, much higher: the loss of thousands of lives.

The immediate remedy to the evacuation time/warning time differential problem through early evacuation orders described above requires three major elements. The first is a very close and mutually understanding relationship between hurricane forecasters and local/state emergency officials. This relationship must itself be based on a constantly accessible communication system between both entities. Each entity must realize that all evacuation concerns are not necessarily meteorological concerns, and vice versa. Again, the local coastal areas must be able to secure all the emergency meteorological information they need to implement their quantitative evacuation plans.

The second element is a clear integration of the evacuation-ordering authority that is delegated to both county and municipal senior elected officials by state law. This is critical to the coordination necessary between counties and municipalities as they implement regional hurricane evacuation plans. For example, a municipal evacuation order, if not coordinated with the county or surrounding cities, could compound an already congested emergency situation. Similarly, any county should order evacuation only in coordination with its constituent cities. Unfortunately, the current state statute is very vague on county vs. municipal evacuation ordering authority.

The third needed element is an understanding by the public that there is a high probability of an ultimately unnecessary evacuation based on an early evacuation order. The "cry wolf" situation must be viewed by the public not as a mistake in judgment by emergency officials, but as the safest way that officials can guard against large-scale loss of life from a relatively unpredictable natural phenomenon. Hurricane-vulnerable coastal residents must begin to accept the fact that for every three, four, or even five times they might be ordered to evacuate their home due to a hurricane over the next 20 years, that only one of those trips may ultimately be necessary. But the price of not evacuating every one of those times could be much, much higher than the cost of a trip inland to a public shelter or the home of a friend or relative on high ground.

So the immediate remedy to the evacuation time vs. warning time problem in a given area is the acceptance by state/local officials of the responsibility for issuing an early evacuation order without a confident warning from the national Hurricane Center that the hurricane will actually strike their area. For this immediate remedy to be effective, the hurricane forecaster must recognize and be sensitive to the prequantified evacuation times of a local area's comprehensive evacuation plan. In addition, evacuation orders must be carefully and completely coordinated between county and municipal decision makers. And finally, the vulnerable resident must respond and evacuate immediately, even with full knowledge that the trip may ultimately be unnecessary.

Lowering Evacuation Times: Vertical Evacuation

The second alternative solution to the evacuation time vs. warning time problem is to lower evacuation times by planning and implementing the vertical evacuation of vulnerable coastal residents. Vertical evacuation is the relocation of residents into the higher floors of multistory structures--either their structure of residence or a nearby structure. The ultimate advantage of this type of evacuation movement is that it should take less time for such relocation to be carried out since those "upward" evacuation trips would be much shorter in distance than a horizontal trip inland. In addition, many vertical evacuation trips might not require the use of an automobile, somewhat mitigating time-consuming traffic congestion and backups and thus lowering evacuation time. This type of evacuation could also substantially aid in solving the problem of limited public shelter capacity.

The concept of vertical evacuation appears to be a local solution to the evacuation time vs. warning time problem if it indeed can lower evacuation times. However, the reality of implementing this type of evacuation is burdened with many unknown factors, many of which could be life threatening in themselves. For example, how can an existing coastal high-rise structure be determined to be suitably constructed to withstand hurricane conditions? Even if building design specifications point toward such structural worthiness, poststorm examinations of structures after Hurricane Eloise on the Florida panhandle have shown that design specifications are not always incorporated into the actual construction of a building. An even bigger question is who will "certify" a structure as hurricane-resistant, to be used as a vertical evacuation shelter? Who will accept the potential liability accompanying such certification? Who should accept such liability? Another unknown factor is which geographic areas are appropriate for vertical evacuation. Is it prudent to direct residents of barrier islands (even the inland sides of barrier islands) to vertically evacuate from an approaching Category 4 or 5 hurricane? Is it prudent to direct thousands of residents upward on a barrier island that, even if it survived the hurricane, would be isolated from life sustaining resources such as food, water, and electricity? Neither a consensus of the structural/hydrologic engineering community nor the actual experience of that situation exists to answer these questions.

The key to any hurricane evacuation plan is a sound and understandable system of public information. Incorporating vertical evacuation into local plans will raise a whole new set of questions in the minds of coastal residents: Should I evacuate vertically or inland? How high must I go in the building? If I escape from the surge, will I also be safe from the high winds?

Although the concept of vertical evacuation is rapidly becoming one of the only alternatives to high evacuation times, it is becoming quite evident that the incorporation of a vertical element into local evacuation plans cannot safely be done unless local preparedness authorities obtain answers to the above questions. Many of these questions are so complex that they would require legislation to address potential liability and structural certification issues. Vertical evacuation is a concept whose time has come as a potential solution to the evacuation time vs. warning time problem. Unfortunately, the local emergency management community is neither equipped nor ready to implement it.

Long-Range Solutions

There will probably come a time when even an early evacuation order of 30 hours before hurricane landfall will not be sufficient to permit the successful horizontal evacuation of the dense coastal population. Also, there will probably come a time when there will not even be enough multistory structures to serve as vertical evacuation shelters for the dense coastal populations of the future. Unfortunately, there will probably never come a time when hurricanes will cease to threaten the Gulf and Atlantic coasts of the U.S. In the future, the pressure to develop our coastline residentially will continue for the same aesthetic, recreational, and economic reasons that it now exists. The only real long-range solution to ever-increasing evacuation times is hurricane-conscious land use decisions in our remaining undeveloped hurricane-prone coastal areas. How high will the evacuation times rise? That question can only be answered by the same entity that is faced with issuing an early evacuation order, directing vertical evacuation, and making the day-to-day land use decisions that make the former two decisions so difficult--the local government official.

Conclusion

It is possible to evacuate people of any U.S. coastal area from an approaching hurricane. Any number of people can be successfully evacuated--if the process is initiated early enough. The basic problem is that "early enough" in many coastal areas is too early for a confident warning from the hurricane forecaster, too early for a doubt-free evacuation order from a local elected official, and too early for every evacuation trip by the public to be an ultimately necessary one. The problem demands that each of these three entities--the hurricane forecaster, the local elected official, and the public--do their part to avoid loss of life.

The hurricane forecaster must recognize and be sensitive to the fact that local areas with evacuation times higher than 12 hours need a "somewhat less than confident" warning of actual hurricane landfall. Evacuation times over 12 hours do not render an evacuation plan unworkable. But a workable plan demands work from the hurricane forecaster as well as the local emergency officials and general public. Until vertical evacuation can be safely implemented, we must deal with the reality of high evacuation times.

The local (or state) elected officials must be willing to accept a potential loss of credibility if they "cry wolf" by issuing an unneeded early evacu-

ation order. They must recognize that the first and foremost responsibility of their position is to protect the health, safety, and welfare of the citizens of their jurisdiction.

Finally, the general public must realize and understand that the evacuation order they receive is based on the best possible information and judgment by meteorologists and emergency management experts. The public must also recognize that, when dealing with a force of nature such as a hurricane, its relative unpredictability will cause evacuation "false alarms" in areas of dense coastal population. It must be realized that the best way of surviving a hurricane is to listen to and follow the instructions of local emergency authorities. However, unless those local emergency authorities are assisted in solving the evacuation problems described in this paper--through both the provision of resources and the establishment of a firm legislative base--the potential for large-scale loss of life will continue to increase.

PART THREE

STRATEGIES FOR MANAGING HIGH RISK AREAS:

Natural Values

THE LEACHATE OF POOR FLOOD CONTROL

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Filling in banks
So perceptively slow
Paving Forests
Flood Heights grow
Cartons, cars, scraps
of us all
Bonded by bricks
In back of the
mall
Nobody's happy
An eyesore
It's Fate
The Seasonal Floods
The object of hate
Come boxed and
walled channels
Those Coffins of
Streams
All sit by
The discarding of
dreams
The sidewalls will
stabilize
And conduit will
Rule
While abutments replace
The meandering pool
This floodplain is broken
How sad is the soul
Witness this leachate
of Poor Flood Control.

As I travel throughout this nation by air, train, raft, foot, and horseback, I see large, undeveloped floodplains like those of the Missouri and Mississippi, Columbia and Colorado whose need for protection is not only obvious but imperative. I also notice a constituency of professionals and private citizens who seek to protect such areas.

In sharp contrast, I see thousands of small streams badly bruised by the construction of boxed or walled channels. For these streams, the needs of

individual property owners, the ambivalence of government, and the pressing political demands for flood control seem to set floodplain protection into the unenviable position of being a minority without representation in the decision-making process.

I focus this presentation on the issue of incremental loss of stream habitat due to the construction of boxed or walled channels for flood control. As flood control or drainage projects, these are the smaller, less noticed projects that generally involve only a few thousand feet of stream at a time. The channel work occurs in areas often considered high hazard--not in terms of floods over large areas, but in terms of concentrated damage potential in very small areas. It is often the case that, over time, many such small projects spell the demise of larger areas of streams. Mind you, I am not talking about the larger federal projects but those done by state and local governments.

In the case of one watershed near my home, I see the results of such incremental damage. The 79-square mile Park River drainage basin is replete with sterile trapezoidal channels, 90° walled channels with flat bottoms, dozens of small tributaries that do not appear above ground, and finally a main stem, itself enclosed in twin pressure conduits. Why did this happen and who was responsible?

Was it the famous Samuel Colt, who in 1851 constructed the first dikes on the river's banks to protect his munitions factory? Was it the farmers of the 1880s who dumped slaughterhouse wastes into it? Was it the 1910 tenement owner who literally built to the water's edge? Was it the tripling of population in the basin from 1868 to 1978? Was it the first government flood control project in 1940 that cut off this stream from its natural outlet to the Connecticut River? Was it the trapezoidal, flat-bottomed, shadeless channels constructed in the 1950s, 60s, and 70s to minimize channel width during highway construction?

The fact is that there never was any particular development, any one factor, any single road crossing about which one could say, "This destroyed our river."

What role did the flood managers have in the process? Were they just doing their job when they designed and built the various conduits and channels? Or were they, in fact, making some societal assumptions that their job was more than flood control; that it also included helping property owners to develop

these "useless swamps and debris laden streams," and to put the land to some "productive use?"

It is ironic that many of the problems that so severely degraded the Park River--water pollution, aesthetic nuisances, etc.--have now been corrected, but that the flood control projects pre-empt recovery of the stream habitat.

We have come a long way these past ten years or so in integrating environmental concerns into our flood projects. But how many of our agencies and how many of our towns are still putting streams in boxed or walled channels or putting them underground altogether?

One might say it is not our job to consider the environmental consequences of a flood project. Other people, other programs are supposed to do that. Despite having passed through the "environmental decade," we are still depending on the regulatory or review process to make our projects "fit" environmentally.

I believe we are attempting to protect stream habitat from the effects of a flood control project by using regulatory measures. I also believe this is a superficial and inadequate treatment of the problem.

The problem with this process is similar to the problem of retrofitting a house for solar heating. You add insulation, upgrade heat transfer materials, and seal doors and windows; but in the end, if the house is in a shadowy ravine and its roof not facing south, then all the changes just cannot bring more of the sun's energy into the home. We cannot make an intrinsically environmentally unfit channel design acceptable just by addressing the peripherals: erosion control, a few plantings, or a stone wall here or there.

Why are environmental concerns still peripheral and retrofitted to small projects instead of being designed into the projects from the beginning?

What are some of the constraints making it difficult to integrate flood management and natural resource protection into small projects?

1) In designing a flood control structure, it is almost always more costly to do it environmentally correctly. The tendency is always to try to keep financial costs down and development opportunities up. Compounding the problem is the fact that environmental values are difficult to estimate in dollars, so they often are not considered at all. In some ways, environmental values are often measured in PFD--"People Flak Dollars," i.e., the more people watching and concerned, the more important the environmental values become.

2) By the time a flood control project is needed, the outcry--usually made by a specific group lobbying for a solution to their immediate needs for water-free property--often overshadows other issues. There arises a political force lobbying for a flood control project, and it is only concerned with getting something done fast. From the beginning, then, the designers of a flood control project are under the gun to do something quickly, to solve a single-purpose problem with a single-purpose project. The project is designed and submitted for regulatory review, leaving the environmental concerns limited to output controls, instead of input controls.

By this time in the process, there is considerable time, money, and staff interest involved. Add existing political and economic forces to this, along with the professional pride of the design engineers, and those involved in the regulatory process may feel that they have no constituency--that there is little they can do, or that it would be too costly to change anything. In this position, the regulators often see themselves as "roadblocks." By now, they are not willing to go out on a limb to protect stream habitat. Another reach of river is discarded.

What can be done to prevent this, to prevent the constant loss of small stream habitat due to small flood control projects?

Among the first choices for relief must be the development of basin-wide stormwater management standards and, in turn, stormwater management plans intended not merely to improve the efficiency of flows but also to guarantee the existence of viable stream corridors. It has taken so long to get floodplain regulations adopted in this nation, to implement controls outside the floodplain may seem like too much for municipalities to bear, but it must be done.

Second, those responsible for flood control projects must have written policy to promote interdisciplinary predesign studies of alternatives. Before the first calculations or the first lines on a blue print are made, it is critical that the ecological professionals visit the site with the design engineers, that they discuss and develop alternatives together.

Third, there is a need to increase cross-professional training of engineers, ecologists, soil scientists, and others for the purpose of increasing their understanding about each other's duties and constraints.

Fourth, there is a need to develop written guidelines for approval of state or local flood control projects. These guidelines should delineate a

process that requires environmental concerns to be built into a project, not tacked on after design.

I would like to close with the following words about the Park River.

Mark Twain wrote most of his famous novels, including Tom Sawyer and Huckleberry Finn at his Hartford home, called Nook Farm, which was on a hill overlooking the Park River. There is now no evidence that a river ever existed on the property, as in the past two years the last stage of a flood control project put the last pieces of the river underground.

Perhaps we all owe an apology to Mark Twain, Samuel Clemens, and his daughter, Clara.

An Apology to Mark Twain

Her banks willow, maple, and grass
When Huck, Tom, and that Becky Lass
But that was then; now it's dark
Deep in the bowels of the River Park.

In soaking springs, most usual years
Water on yards, yet very few tears
Sediments and stone hardly perturbed
They alone, to be annually disturbed.

Public officials, lacking reproach
Did not comprehend, to encroach
Bank to bank, row by row
We slowly watch, the buildings grow.

Came '55, a flood of wrath
Sweeping over the now-occupied path
Voices rose that triggered the end--
"Eliminate it, eliminate every last bend!"

Twin pressure conduits soon replaced
The peaceful view Nook Farm had faced.
Where Clara and father skated to shore
Parking and steel mechanically roar.

So substitute for clam shells and trout
By counting the miles of masonry grout;
In greying water cast your concern
Lest from river to sewer all must learn.

WETLAND AND FLOODPLAIN MANAGEMENT: A SUMMARY

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Wetlands Protection and Floodplain Management: A Comparison

Land Use Controls

Wetlands protection and floodplain management are aspects of land use planning. This is still principally a legal power of the states, exercised at the local level through zoning, subdivision, and health controls and at the state level through state wetlands laws, scenic rivers programs, and coastal zone management strategies.

General Legal Principles

Courts have been supportive of the right of states and localities to ban the use of high-hazard floodplains. The leading case is Turnpike Realty Co. vs. Town of Dedham, 362 Mass. 221 (1972). The principle involved is that prevention of public hazard outweighs the right of private landowners to develop their land. The hazard can include danger to persons occupying the floodplain, danger to upstream and downstream owners, and even (according to two Massachusetts cases) the "hazard" of increased public expenditure due to unwise choices in land development.

Courts have been more conservative in upholding bans on the use of privately owned wetlands, probably because the hazards of their destruction are more remote and speculative. In one Massachusetts case, however, a ban on filling of wetlands was upheld because there was some evidence that the fill might damage the quality of groundwater which was a potential (but not current) drinking water supply (Lovequist vs. Conservation Commission of Dennis, 1979 Mass. Ad. Sh. 2210).

Because of the "public trust" and special public interest in coastal wetlands, a ban on destruction of productive saltmarshes may be upheld (see Sibson vs. NH, 115 N.H. 124). Thus, on common law (decisional) grounds, it may

be legally feasible to ban development in a wetland or a floodplain, especially the latter.

A contrary result may be reached by statutory regulation, however. In Massachusetts, under the new Wetland Protection Act regulations effective in 1983 (310 Code of Mass. Regulation 10.00, interpreting Mass. Gen. Laws ch. 131, s. 40), floodplains may be given less protection than vegetated wetlands bordering surface waters. For these "BVWs", a special waiver from the Commissioner of DEQE is now required for more than minimal fill. These wetlands are presumed valuable for public or private water supply, groundwater supply, flood control, storm damage prevention, prevention of pollution, and protection of fisheries/shellfish; whereas floodplains are presumed valuable only to flood control, storm damage prevention, and, sometimes, groundwater and may often be filled if compensatory storage is provided.

Engineering solutions of this sort for development of floodplains provide interesting legal questions. If state or local regulations provide that a developer may come forward with plans for compensatory storage, fill, pilings, breakaway fronts, or floodproofing, and the reviewing authority nevertheless rejects an application to develop, the burden of proof will shift to the regulating body to prove why it rejected these solutions. Nevertheless, the state of the art is not such that a court is likely to require a regulatory body to accept such solutions if the regulation is properly drafted. The regulations should thus begin with a presumption that development of high risk floodplains is undesirable because such development is presumed to result in serious public hazards. It may then allow the developer to submit technical solutions for such development with the understanding that the solution will be rejected unless the developer convinces the regulating body of the proven workability of the solution. This approach will help keep the burden of proof on the applicant.

When regulating wetlands, on the other hand, the regulating body's language should emphasize the proven values of wetlands and any hazards concurrent with their destruction. Mitigation efforts such as creation of substitute new wetlands should be given low priority.

Regulations for both kinds of development should emphasize the residual economic uses of the land which may benefit the landowner: farming, forestry, recreation, plus the accessory value of the land in making up lot sizes, providing value to adjacent uplands, etc., which has been recognized in one

Massachusetts appeal court case (S. Kemble Fischer Realty Trust vs. Board of Appeals of Concord, 1980 Mass. App. Adv. Sh. 637). Mere diminution of value will not generally invalidate a restriction on the use of land validly adopted under the state or local "police power," provided the landowner is left with some kind of economic use of the property. One should avoid references to uses that are really public uses of public lands (e.g., flood storage areas, water supply, public recreation), as this suggests to courts that, by regulation, public benefits are being sought which should be accomplished by purchase of the property.

Coordinating Protective Efforts at the Local Level

Municipalities and counties are still the main controllers of land use outside LURC areas of Maine. Many different local bodies can be made interested in protecting floodplains and wetlands, e.g.,

- Birders, schools, and people who like outdoor recreation
- Farmers, foresters, hunters, and fisherpeople
- Fiscal conservatives who fear need of future public expenditures for sewers, schools, dikes, dams
- People who just think the community is growing too fast

The coalition aim should be to review the present picture of local control of land use with a view towards removing the "magnet effect," and encouraging compatible uses of floodplains.

The magnet effect is achieved when the community actually, although often unintentionally, points development into the floodplain by inappropriate zoning and/or development of public infrastructure. Many New England towns were built around mills in floodplains and have continued this pattern by industrial/commercial zoning and the building of roads, sewage treatment plants, parking areas, and airports, not to mention trailer parks. Sewage treatment plants are particularly problematic since engineering practice tends towards building them on the floodplain; it is then legally difficult to prevent access to the pipe. Road building has similar effects, although few think beyond the immediate impact of road building (the flood insurance program attempts no ban on road building in floodplains).

Communities should therefore adopt public infrastructure policies, review zoning codes, and also review local health laws: both floodplains and wetlands

are generally poor places for either individual septic systems or public sewer lines.

The community should eschew the one-foot rise permitted, but not encouraged, by FEMA regulations in setting the floodway; this will effectively make the 100-year floodplain the regulatory floodway, and the flood insurance prohibitions against fill will give force to local bans.

Compatible uses for wetlands and floodplains include:

- Public ownership as parks.
- Public restrictions purchased from landowners preventing development and allowing at least educational access. Consequent reduction in real estate taxes on undeveloped land will generally be minimal.
- Farming and forestry--compatible in floodplains, but not always in wetlands.
- Modest recreational facilities. One should avoid a general "use as of right" for "water dependent activities" such as boating, but rather require a special permit for control of size and placement.
- Accessory uses such as the "toes" of large lots.

In downzoning areas for protection one should emphasize good mapping, public hazards, residual uses and avoid the implication that regulation is being used as a cheap substitute for purchase by the public.

Coordinating Protective Efforts at the State Level

Efforts that may be mounted by state officials with local support include:

- States should adopt executive orders similar to federal EO 11988 and EO 11990 banning use of public funds for floodplain/wetland destruction unless specially justified. These executive orders should include all federal funds and all high risk floodplains, whether privately or publicly owned.
- CZM plans should be reviewed to make sure protection is maximized and impact funds are not available for counterproductive activity, and controls on roads, sewers, airports, and utilities should be checked. Officials should emphasize use of CZM public access funds for access to beaches and rivers.
- States may give preference to floodplains/wetlands in grants for groundwater protection, agricultural preservation restriction purchase--depending on the regulations.

- State scenic rivers programs should be reviewed. Is the setback adequate?
- State health codes for septic systems, sewer construction and dumps should be reviewed for adequacy--many are outdated.
- States should resist delegation of the U.S. Army Corps of Engineers Section 404 wetlands program, as well as the Corps' "nationwide permits."
- States could do more in pushing for more funding of FEMA's Section 1362 acquisition program for frequently flooded areas.

PART THREE

STRATEGIES FOR MANAGING HIGH RISK AREAS:

Training and Education

TRAINING AND EDUCATION NEEDS FOR THE PRACTITIONER

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Indiana Department of Natural Resources

Training and Education Needs

In Indiana, we have found that training and education must provide local officials with information and data that is pertinent to their way of life. This requires data from other Indiana experiences, not data from events or situations from other states. If this is not possible, then the out-of-state experiences must be those from a similar type of community. It is very important that, if you go into a small rural community tucked away in the mountains, your data be those of a similar community in a similar locational setting. Credibility is very important. The story of the relocation of $100,000 homes in Minnesota will not enlighten those situated in $10,000 homes in a mining camp.

For years we have provided training tools, seminars, etc., on federal regulations, state laws, and agency responsibility. However, in many cases the data have been overly complex (Federal Register, state laws) and not keyed to the local lifestyle. It is very hard to discuss the development of grandiose mitigation plans with a community with no budget for mitigation, particularly when you are offering no financial assistance yourself. Through the State Assistance Program (SAP), Indiana has finally begun to provide the necessary management tools to help local officials and floodplain managers.

The development of handbooks written in language easy to understand, highlighting the major issues and regulations that a local official needs, has been a big plus for our agency. These handbooks have gone a long way in assisting the local community to understand the maze of federal and state regulations on floodplain management and disaster response. In addition, our agency has developed a floodproofing slide show illustrating examples of Indiana experiences in floodproofing. The cost of undertaking the floodproofing measures is also illustrated. The depiction of costs is a major element in achieving credibility with the local community.

As our agency becomes aware of more examples of Indiana floodproofing experiences, we are acquiring slides to update our slide show. This will make the presentation flexible, thereby allowing us to provide examples that closely resemble the types of communities where we are providing the training. In this way we hope to establish better credibility for our programs, thereby leading to increased activity at the local level.

Meeting Training and Education Needs

At present, our agency provides funding for staff to attend public meetings and provide technical assistance to meet local community needs. Through the SAP we now have an excellent information base (management tools) with which to assist local communities. Our agency has no problem with setting up local workshops and/or seminars and providing staffing to conduct these training and education programs. The only problems we encounter are with the scheduling of our staff, since we do not have staff assigned solely for training and education, and with reproducing handbooks and manuals. Currently, our budget is not flexible enough to handle mass reproduction of large manuals. In the future, this may not be a problem, but until then, we must conserve our resources. We are able to conduct small workshops that require limited amounts of material reproduction. As a result, our training efforts have been in response to requests by local communities versus an organized effort initiated by our agency.

Funding Training and Education

Additional funds, therefore, are needed for travel and material reproduction. Once in a while our in-state travel funds become depleted thereby reducing staff's ability to conduct normal business. Therefore, additional traveling associated with training exercises would be out of the question. However, if funds become available to cover these travel costs, it would be no problem to have our existing staff conduct meetings. It should be noted that our staff scheduling problem would not be a problem if normal travel funds were scarce, since more of our staff would be in the office.

In the case of material reproductions, additional funds would be greatly appreciated. Our current budget does not allow for large sums to be applied to manual/handbook production. This is one reason why the SAP has been such a tremendous plus to our program. (For example, the Handbook for Local Planners costs $1,600 for 500 copies. This only allows one copy for each community in Indiana. This is in no way sufficient for adequate training and education).

In terms of cooperative arrangements, something could be worked out with the FEMA Regional Office and the State Civil Defense through their training and education contracts. The agreement might be for the FEMA Regional Office to supply a staff person to work with our agency and have a program like SAP provide funds for travel and material reproductions. Another possibility might be for our agency to use the Civil Defense training and education contract (Public Officials Conferences) to set up meetings and draw the local participants. With funding from FEMA for material reproduction, our agency could conduct training seminars.

Benefits

Providing training and education on the NFIP, floodplain management and disaster preparedness to local officials/communities, along with providing mitigation, would go a long way towards the establishment of effective local floodplain management programs in Indiana. Experience has shown that when people understand a program, they are willing to abide by the rules. It is the complexity and uncertainty of programs that causes confusion at the local level thereby leading to poor administration. We hope that, through our efforts to simplify floodplain management, we will begin to see better administration and implementation.

The Floodplain Management Handbook for Local Planners is a good example of how we have tried to simplify floodplain management. This handbook is an excellent reference tool that locals can use to answer questions as they arise. Previously, communities were left with a pile of materials, a lot of which were written in terms foreign to them. As a result, when questions arose, they had no place to go to find the answers. The handbook, we hope, provides that single source to meet their needs. In addition, the handbook contains a list of places to contact for assistance, broken down by topic or issue.

Unlike other parts of the country, Indiana does not usually suffer from floods that cause total destruction. Due to the relatively flat terrain, most of our flooding is the slow rising type . Therefore, our losses are not as great as in some other parts of the country. Bad floodplain management decisions therefore cause damages, but not of monumental proportion. Thus, the reduction in flood damages caused by sound land use decisions will not be as noticeable in Indiana as other states, but nevertheless it would be noticeable.

A real key to what will be accomplished will be the efforts our agency expends in two areas:

1) Providing data/information to locals who already have a detailed FIS, but lack adequate training to understand the data; and

2) Enforcing our laws against violators, many of whom undertake their activities as a result of a lack of understanding or knowledge of the law.

With better local floodplain managers, we feel we will see a reduction in our agency's efforts to handle these latter activities. As a result, our agency can spend more time in providing data to communities where adequate data does not exist. It is in these areas that we can improve our efficiency to respond to local requests and thereby dramatically reduce future flood losses.

We have found that with timely responses to local requests, we see more communities willing to seek advice for future construction in flood-prone areas. Once the response time drags out, especially in the building season, communities tend to develop according to their instincts, without regard for the regulations.

NFIP TRAINING AND EDUCATION IN REGION III

Martin J. Frengs
Federal Emergency Management Agency

The jurisdiction of FEMA Region III includes Delaware, Maryland, Pennsylvania, Virginia, West Virginia, and the District of Columbia. The training and education of local officials and building professionals in the National Flood Insurance Program (NFIP) within Region III has historically been in the form of final meetings, Community Assistance and Program Evaluation (CAPE) meetings, FEMA/State Coordinating Agency workshops and conferences, and presentations at meetings sponsored by professional organizations.

Final Meetings

In these meetings--usually the first FEMA contact with a community official--detailed floodplain data are presented and the NFIP "Regular Program" rules and regulations are discussed.

Costs

The costs of these meetings vary depending on the distance the FEMA staff person must travel. Minimum, maximum, and average estimates are presented below. Naturally these costs could be higher if they included the travel and salary for the state coordinator. Salary estimates include overhead at 100% of the hourly rate and include the time it takes to set up, travel to, and conduct the meeting.

Minimum	
Travel (rented auto plus gas) (one day)	$ 35.00
Salary (5 hours)	160.00
say	$ 200.00
Maximum	
Travel (2 days)	
Air Fare	$ 300.00
Auto Rental	80.00
Per Diem	100.00
Salary (20 hours)	640.00
	$ 1120.00
Three meetings per trip, say	$ 380.00

Average

3/5 x (380-200) = 110 + 200 = $310 per community

Advantages

- Person to person, one on one contact where specific community problems and situations can be discussed.

Disadvantages

- Relatively high cost per community.
- Many, if not most, community officials do not express an interest in the maps and the ordinance at this early stage of the conversion process.
- Many times the meeting does not include the best community officials, e.g., the mayor vs. the code enforcement officer.
- Many community officials, along with code enforcement officers, leave office between the final meeting and the effective date of the ordinance and maps.

CAPE Meetings

While viewed by Region III as primarily a community "audit" to determine if new development is compliant with the minimum NFIP regulations, experience shows that roughly 50% of the these visits result in a refresher course in the relationship between the maps, the Floodway Data Table, and the flood profiles. This does not include the (roughly) 5-10% of the cases in which no one knows where the Flood Insurance Study (FIS) and ordinance are filed.

Costs

Again, a range and an average estimate are provided depending on the time of travel; the costs would be higher if the state coordinator was included. While most CAPEs exceed final meetings in length, the minimum CAPE meeting would compare with a final meeting.

Minimum	
Same as a final meeting	$ 200.00
Maximum	
Travel (3 days)	
Air Fare	$ 300.00
Auto Rental	110.00
Per Diem	150.00
Salary (28 hours)	900.00
	$ 1460.00
Two meetings per trip, say	$ 730.00

Average

3/5 x (730 - 200) = $320 + 200 = $520 per community

Advantages

- Person to person, one on one contact where specific community problems and permits are discussed and evaluated.
- Meeting is usually held with the proper community official who is now interested because the maps and ordinance are now effective.
- By reviewing individual permits, the code enforcement officer's ability can be evaluated. This is a big advantage over workshops for which attendance is voluntary and which this individual may therefore choose not to attend.

Disadvantages

- Very time consuming and expensive for the amount of training provided.
- 1,711 communities in Region III (about 55%) are on the Regular Program. Five staff members doing 20 CAPEs a year would need 17 years to visit each community once. This is significantly short of FEMA's original goal of having at least one CAPE meeting per community every five years.

DCA Workshops

These are one-day floodplain management workshops for community code enforcement officers sponsored by the Pennsylvania Department of Community Affairs (DCA). A FEMA staff person participated in these workshops as one of the presenters.

Cost

The cost estimates presented were provided by DCA and represent the average cost experienced for all their workshops.

Travel (state employees)		$ 375.00
Salaries (state employees)		1,700.00
FEMA (travel and salary)		300.00
Conference Room ($50 to $100)		75.00
Lunch ($10/person, 20-30 people)	say	250.00
Flyer (printing and mailing)		200.00
		$ 2,900.00
Subtract Fee ($20/person)	say	500.00
Total Cost		$ 2,400.00
Cost per Community (assuming 20 our of 25 are from different communities)		$ 120.00

Advantages

- Twenty to thirty code enforcement officers, who may represent 20 to 25 communities, can be trained at a relatively low cost.

- Participants can benefit from problems and solutions experienced in other communities.

- Usually the proper community official attends and is interested in learning.

Disadvantages

- Much state staff time is spent to set up and organize each workshop.

- The Code Enforcement Officer who cannot afford (in either time or money) to attend or is not interested in learning about the NFIP regulations is eliminated from this process.

- During the last two years, ten of these workshops have been held averaging 20 communities per workshop. Therefore, only about 200 communities out of the 2600 communities in Pennsylvania have felt the need to send a representative. Experience indicates that many community officials, other than those volunteering to attend these workshops, need training .

Meetings with Professional Organizations

These meetings are arranged with local chapters of professional organizations involved in the building profession (builders, architects, real estate agents, engineers, etc.) to discuss a specific NFIP topic. In this particular case, coastal construction presentations were held at the normal monthly meetings of local chapters of the national Association of Home Builders.

Costs

Because the time to prepare and conduct one of these presentations is similar to that of a final meeting, the average cost of one of these meetings is roughly $300. The cost per community benefited is difficult to determine. If the builders at the workshop account for 10% of the construction in the region, then 10% of the communities in the region are assumed to benefit.

Advantages

- Staff time and effort to organize the meeting is minimized. The local chapter reserves the space and provides the refreshments and invites the audience.

- Dealing directly with the people who are most affected by the NFIP regulations eliminates the community officials as the go-between.

- If the builders comply with the requirements in the design stage, the community review time is reduced and changes in design are minimized.

- If the requirements are exceeded, flood insurance premiums decrease, increasing the structure's marketability.

Disadvantages

- The meeting schedule is dictated by the sponsor; dates and times may conflict with other work.
- The length of the presentation and, therefore, possibly the content, is limited by the sponsor. Thirty to 45 minutes seems to be the maximum that most people care to pay attention.

Conclusion

Given the existing options within the present FEMA/State Coordinator structure for the training and education of local code enforcement officers, it is evident that changes must be made if FEMA's goal of reducing flood damage susceptibility to new development is to be met. While the DCA workshop is the most cost effective option presently underway for training local officials and should continue to operate, most communities are not voluntarily participating, and, therefore, most of the code enforcement officers who need this training are not receiving it. With the number of staff available to perform CAPE meetings in Region III being reduced by 50% during the last three years, CAPEs can no longer be considered a significant training and education option. Given the present CAPE return period per Regular Program community of one meeting every 17 years, and given the high turnover rate of local code enforcement officers and local elected officials, FEMA would be meeting with every third or fourth community permit officer at best. Along with Final Meetings, CAPE meetings are too expensive for the amount of training and education provided.

This leaves us with the option which makes the most sense, given our limited resources. The whole spectrum of the building profession, from the real estate agent, through the designer, and up to the builder, most be educated to the benefits of not only complying with the minimum NFIP and state related requirements, but exceeding these requirements. This training and education option, along with complimentary actions such as requiring state certification of all code enforcement officers as in New Jersey and amending National Building Codes to include some of the basic NFIP regulations, should be a significant, if not the major job element of each FEMA and state employee involved in floodplain management. Naturally, the techniques and methods used to inform these professionals can and should be altered depending on need and individual preference.

TRAINING: WHAT WORKS, WHAT DOESN'T

Janie Douglass
Kentucky Flood Control Advisory Commission

The Perspective From the Bottom of the Totem Pole

One of the keys in determining the training and education needs of the local practitioner is to take a closer look at exactly who this local practitioner is. Is he the mayor's brother-in-law who needs a job to keep him out of trouble? Perhaps he or she is the underpaid city engineer who is disgruntled at the additional work load foisted on the office by the National Flood Insurance Program (NFIP). Maybe he or she's a highly motivated citizen dedicated to community service. However, more than likely, you'll recognize the local practitioners by the many different hats they wear as the city's building code inspector, fire inspector, plumbing inspector, flood insurance coordinator --maybe even the dog catcher.

So the "local practitioners," as we are calling them, could be anyone from those who "just barely made it through high school" to very specialized professionals--hopefully in a field that meets the needs of the NFIP.

With this in mind, the basic consideration is one of selling the flood insurance program. These are some of the more frequently mentioned selling points:

1) The community needs to maintain eligibility for flood insurance (which is often the only game in town) by enacting a flood damage prevention ordinance, implementing a floodplain management program, and enforcing the permitting requirements.

2) A community faces certain questions of liability with regard to its enforcement or lack of enforcement of such an ordinance.

3) Current federal disaster policy requires a 75/25% split of recovery costs for public facilities, which would place additional strain on already drained local governments to meet the match requirements.

4) No matter what kind of state and federal assistance is available after a disaster, there are still other costs associated with flooding, which further drain the community's resources.

5) Most importantly and most frequently overlooked is the fact that in addition to avoiding the costs of recovery, local governments can benefit from implementing floodplain management techniques by obtaining the optimal use of the floodplain. The most obvious reason behind the ordinance is the protection of life and property from the danger of floods.

Once the local practitioners are sold on the NFIP and its requirements, they will need some tools to do their own selling job to the people who are going to be most affected--the floodplain residents. In Kentucky, the Soil Conservation Service (SCS) provides field personnel with a Dale Carnegie-type course on selling conservation programs. Besides the technical aspects of floodplain management, sessions should be included to address the human/psychological aspects--salesmanship if you will. The local practitioners need to be able to maintain an ongoing dialogue with the community and its residents to promote an informed citizenry that will accept the program based on its merits, not just because the "Feds say we have to do it this way" if we want flood insurance and disaster recovery assistance.

Federal agency personnel must be more easily accessible. Most importantly, they need to speak the vernacular and accept the local practitioner as a valid partner in this venture.

Training Tools

There are only a few tools that translate the technical information into lay language, though more are becoming available. Still fewer provide all the essentials needed under one cover. A good example of a working tool is the recently completed manual developed by the Kentucky Flood Control Advisory Commission designed to serve as a local practitioner's field guidebook. The Kentucky Model Flood Damage Prevention Ordinance takes the local practitioners by the hand, explaining the need for the ordinance and the ordinance itself with a running commentary which translates legal terms into everyday terms. It provides a job description and a diagram showing the permitting process and includes sample letters covering situations that could develop, public hearing notices, and a step-by-step permit form.

Public Relations

In turn, the local practitioner needs to have the necessary tools to pass this information on to the pubic. Public relations campaign material for all forms of media dissemination should be available in the vernacular. These materials should include, but not be limited to, the regulations and the reasons behind them, with emphasis on how individual actions impact on others

and how the program benefits individuals.

The public relations campaign should not be limited to the more traditional media outlets such as radio, TV, and newspaper public service announcements. Other avenues should be explored to broaden the basic communications network. For example, the free classified papers that are so popular now are a highly visible and easily accessible form for disseminating public service announcements.

The use of already existing groups at all levels is essential to a pervasive public relations campaign. Conservation districts, state extension agencies, and public libraries span the nation. Such groups often need information themselves and would be interested in disseminating useful information on floodplain management as well as other integrated emergency management concepts.

The District is currently working with SCS to sponsor a floodplain tour to introduce people to flood hazards on a local basis by showing flood-prone areas that are undeveloped, high water marks on existing developments in the floodplain, areas that are being considered for development and their relationship to flood hazards. The occasion can be a successful way to develop an awareness of flood-conscious development. Such a program should be geared to the audience and conducted for several different target audiences, i.e., realtors, developers, insurers, bankers, consumers, and local units of government.

State extension agents often have daily talk shows and/or newsletters, and might be willing to develop a series on the basics of floodplain management, flood insurance, evacuation and warning, floodproofing and other related issues.

Public libraries are a great place to build up a reference section on floodplain management as well as to disseminate brochures.

Such professional associations as the home builders, real estate agents, and insurers may be willing to assist in providing and disseminating information. They routinely hold national, regional, and state conventions, and issues of community interest such as the NFIP would be a welcome addition to their agenda. Such groups also have a variety of publications that are valuable vehicles. A brochure published by a national appraisers' group was placed in the deed room of a local county clerk's office to highlight what to look for when buying property, but no mention was made about a determination of whether the property was hazard-prone. This was an opportunity lost.

County fairs, folk festivals and other community events offer excellent opportunities to distribute information. Local service groups such as Jaycees, Kiwanis, and automobile clubs have established credibility within the community and serve as willing volunteers to help with public information programs.

In Harlan, we worked with a small community group called the Fellowship Center to establish a landmark program. From the information gathered by volunteers at the Center, we not only made the residents aware of procedures to follow during an emergency situation, but also established high water marks in the area. We coordinated this information with the flood insurance study for the area and, with the aid of SCS, transferred the high water marks to all the telephone poles in the flood-prone area by simply spray painting the water mark at the correct height on the pole. Such activities need continuous maintenance and follow-up with bulletins showing how water marks coincide with weather warning announcements for evacuation purposes. As with any education program or public relations campaign, to be successful it has to be an ongoing process.

Technical Assistance

Some technical assistance programs are simple approaches requiring a minimum of financial expenditures. Others require technical assistance from the various state and federal agencies. This can take any number of forms:

- Development of a do-it-yourself book on floodproofing. A specialty publishing house such as Sunset Books or Time-Life could do a popular rendition of principles and techniques of all of the IEMS concepts.

- Development of working scale models for a floodmobile (much like the various Smithsonian vans) to travel with models to show the impact of fill in a floodplain, the difference in uncontrolled and controlled development in a floodplain, how to build a shield for picture windows or sliding glass doors. The vehicle could also disseminate literature and present slide shows.

- Curriculum development for an adult continuing education course or vocational education courses that include full-semester courses covering a variety of concepts and techniques for hazard mitigation as well as a short one-day course on how to anchor a propane tank.

These and other types of technical assistance could have far-reaching impacts in developing a self-help ethic among residents living in hazard-prone areas who have become too reliant on the federal dollar to solve their problems.

Agency Coordination

These kinds of approaches can and should be developed, but the various state and federal agencies need to talk to each other. For example, the USDA Forest Service has a series called Investigate Your Environment, which is designed to teach teachers how to teach environmental concerns. The course was really very good, but in one role-playing activity concerning land use planning there was no mention in the printed fact situation that the land was flood-prone--and no one thought it necessary to add this fact to future printings of the material.

At the state level, there are frequent problems deciding who has what authority in dealing with disaster and emergency services groups and the natural resources groups. Agencies tend to shy away from cooperating with each other because of these "turf battles," and thus a valuable resource and frame of reference has been lost.

Another problem is the failure of federal and state policy decisions to trickle down to the planners and implementers in the agency. Staff people are still following traditional authorities, while the policy makers and theorists are exploring new possibilities with new implications for old plans still on the drawing board. Perhaps miniregional conferences are needed for the middle levels of bureaucracy and the field personnel. Do state and federal agencies really take advantage of Emergency Management Institute courses and if not, why not?

The final key to implementation is local involvement in the decision-making process. Why don't the states conduct conferences (like the annual NFIP coordinators' conference) for the local and regional planners to pass on the knowledge they have acquired? Why is there no representation from local government and regional planners at the annual coordinators' conference? Perhaps agencies could set up working advisory groups with a broad cross-section of individuals to include citizens (the eventual benefactors) and such professionals as architects, engineers, educators, and planners. Such an advisory group could also be set up to examine EMI course needs and content.

The bottom line to training and educating the local practitioner is to make sure the local practitioner is involved in the process.

PART THREE

STRATEGIES FOR MANAGING HIGH RISK AREAS:

Emergency Management

THE RAPID GROWTH OF COMMUNITY FLOOD WARNING SYSTEMS

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NOAA/National Weather Service

The NWS is currently experiencing a substantial demand by communities for technical support for local flood warning systems. This demand is occurring because federal, state, county, and local governments are becoming more aware of the benefits of operating local flood warning systems. This trend will probably continue as flood damages continue to increase and as the NWS and other agencies assist communities to solve their flood problems. This paper deals with the present and future role of the NWS in working with communities in operating local flood warning systems.

Present Approaches to Identify High Risk Areas

In 1975 the NWS contracted with the University of Texas to evaluate the flash flood potential of the entire nation. This study used a magnitude of flash flooding index, flash flood frequency index, and a flash flood warning time index to evaluate flash flood potential. However, it only provided the NWS with a partial solution in the definition of high risk flash flood areas.

FEMA has identified 20,000 locations in the U.S. that are vulnerable to the occurrence of floods and flash floods. This "data base," which contains useful information for each community, is another source to help identify "high risk" areas subject to floods. Other factors that need to be considered are the population located in the floodplain, present level of warning service, location of dams in the river basin, and the general level of awareness and enthusiasm of community officials regarding solving their flood problems.

The NWS does not, in general, market local flood warning systems but rather responds to requests from communities for technical support. The NWS does not have the resources to provide a sustained marketing effort to communities located in high risk areas.

Classification of Communities for Assistance

Communities are not classified for receiving assistance. Instead, the NWS policy (Draft chapter E-08. WSOM) for supporting communities needs is that:

1) The NWS will provide technical assistance to requesting communities as resources permit.

2) Communities are responsible for the purchase, installation, maintenance, and cooperation of local flood warning systems.

Other federal agencies such as the Corps of Engineers, the Federal Emergency Management Agency, and the USDA Soil Conservation Service have provided cost-sharing financial support to high-risk communities.

New Approaches

The design, development, and implementation of local flood warning systems is an evolutionary process. As technology advances, so will our capability to enhance flood warning services.

In particular, the capabilities of automated local flood warning systems will continue to expand. In the present versions of ALERT and IFLOWS, the hydrometeorological analysis and modeling is limited. Development is now underway to 1) display and process multimeteorologic sensor data, 2) include hydrologic routing techniques, 3) model snow melt, and 4) develop a coastal surge/riverine interface model. Dam break procedures are planned. Automated flood warning systems will eventually evolve into a system of hydrometeorological models and techniques that will meet the many needs of communities.

Future Role of the Systems

The human element will always be the critical one in the warning process. Local flood warning systems are simply tools to be used by those individuals responsible for preserving human life and property. Because of this fact, the NWS designs forecast and warning systems that are interactive. Since there are no perfect hydrologic models, and since data scarcity is the greatest source of error in river and flood forecasting, manual and automated system performance can only provide "guidance" to the forecaster. Of course, the more accurate and timely the objective guidance, the more warning time and accuracy we can provide communities to prepare for floods.

In all cases, automated or manual, the key individual (flash flood coordinator) must assimilate data, guidance, and information; interpret the "system" results; and make decisions about the appropriate actions.

Warning Systems and Floodplain Management

Warning systems are one nonstructural approach to mitigating flood losses. Basically, a warning system provides lead time for response actions, flood magnitude, and location of flooding. In order for a local flood warning system to be effective, an emergency action plan must be available. Other structural and nonstructural methods can be linked with a flood warning system to further reduce flood losses. For example, floodproofing linked with a manual flood warning system in Lycoming County, Pennsylvania, is credited with reducing flood losses by 90%.

In order for warning systems to become more effective, forecasts generated for river gauges must be related to the area inundated by the flood. This translation from a point forecast to an area forecast would greatly enhance flood response actions. Also, it is desirable for automated flood warning systems to include the community emergency action plan as part of the forecast system. Thus, forecasts would automatically be translated to actions.

In general, the important point to note here for floodplain managers is that flood warning systems are usually not the sole solution but rather one solution among many in an overall floodplain management effort.

FLOOD FIGHTING IN THE CHICAGO METROPOLITAN AREA

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Northeastern Illinois Planning Commission

Background

The Chicago metropolitan area or Standard Metropolitan Statistical Area is composed of six counties and 261 municipalities with a population of over seven million people. All six counties are in the regular phase of the National Flood Insurance Program (NFIP). Two hundred twenty municipalities are in the regular phase and ten are in the emergency phase of the NFIP. Chicago is the largest municipality, with a population of over three and one half million. Overland flooding problems in Chicago are minimal, although sewer back-up problems are quite common. The heavily populated suburbs have severe overland as well as sewer back-up flooding problems.

Overland flooding in Northeastern Illinois is generally shallow, with low velocities, and is of a short duration. Floods at the same location are usually infrequent, although some areas do have annual flood problems. The Chicago SMSA is so large that heavy rainstorms can cause severe flooding in one area and only minimal problems several miles away.

The damage from floods can be quite extensive because of the large number of structures located in the floodplains of northeast Illinois. In 1981, flood damage in the southern part of the metropolitan area amounted to $84 million, and in 1982 one northern suburb had over $8 million in damage. Average annual overland flood damages in the suburbs of the Chicago area have been estimated at $12.4 million.

Flood fighting problems in the metropolitan area are compounded because the flood-prone areas are occupied by numerous small municipalities that lack the capability and expertise to adequately handle flooding situations. These small municipalities lack the proper staff, have a shortage of equipment and supplies, and have no lead time when it comes to flood warning.

It is difficult to convince the municipalities that a flood response plan is needed. Though flooding can affect many structures and cause much damage, the percentage of structures that are flooded is very small in relation to the

total number of structures in the metropolitan area. While many of the municipalities have witnessed a 50-year or greater flood within the last 20 years, there are still many other municipalities that have not. There is a general feeling that a severe flood will not occur again, that a structural project will handle the problem, or that the problem is better left ignored. For these reasons, flood fighting is a very low priority item for most municipalities.

Planning for flood fighting is almost nonexistent. Flood fighting decisions are normally made "on the spot" by administrators who often have neither witnessed a flood nor had flood fighting training. Some municipalities have Emergency Services and Disaster Agency emergency response plans, but these "all-emergency" plans normally do not provide the necessary answers for flood fighting. While most of the municipalities have capable staffs, the rapid onset of the flooding, the last-minute decisions, the lack of trained personnel, and the frantic search for equipment and supplies can cause severe strains on the municipal staff and leave the public with many questions about the capabilities of their municipal personnel.

Evaluating the Problem

During December, 1982, floods inundated various locations throughout the metropolitan area. Eyewitness accounts by several representatives from the Illinois Division of Water Resources led to a general belief that the flood fighting capabilities of the municipalities were lacking.

Because of this, the Division of Water Resources conducted a flood fighting conference in March, 1983, attended by over 250 representatives of local police departments, fire departments, public works departments, building and zoning departments, ESDA coordinators, and elected officials. The purpose of the conference was to explain to municipal officials what flood fighting and floodplain management services were provided by the various state and federal government agencies.

At the end of the conference a feedback session was held to determine what federal and state governments could do to improve local flood fighting capabilities. Approximately seventy of the conference attendees participated in the community feedback session. They were asked, "Based on your experience, what assistance could be provided by the state and federal governments and neighboring communities to help you before, during, or after a flood?" Based upon their decisions, a rank order of the assistance that state and federal govern-

ments could provide was developed. The following kinds of assistance were considered the most important (in order of decreasing importance):

1) Guidance and assistance in preparing flood response plans;

2) Aid in establishing local or watershed flood warning systems;

3) Better coordination and tougher enforcement of regulations on floodplain development, channel obstructions, and stormwater management;

4) More information on how to fight floods and what assistance and resources are available; and

5) Better coordination to provide mutual aid and share equipment among communities in the same area or watershed.

After the conference a flood fighting coordination committee was formed to discuss the outcome of the community feedback session and how it should be addressed. The committee was composed of representatives from the U.S. Army Corps of Engineers Chicago District, the Illinois Division of Water Resources, the National Weather Service, the Illinois Emergency Services and Disaster Agency, the regional planning commission, and selected municipal and county representatives.

Flood Fighting Manual

The main outcome of the flood fighting coordination meeting was to develop a flood fighting manual that could be used by local municipalities to prepare flood response plans. It was felt that such a manual could address many of the concerns raised by the local government officials at the feedback session. The manual was funded mainly by the State of Illinois but also partially by the State Assistance Program of the Federal Emergency Management Agency. The flood fighting manual is still in the draft stage, and some municipalities have already expressed an interest in working with the state to develop a flood response plan, using the manual as a guideline.

The flood fighting manual is a "how-to" guide that provides instructions on systematically designing a flood fighting program through a planning process. The process is similar to the planning process in the Integrated Emergency Management System (IEMS) developed by the Federal Emergency Management Agency. The flood fighting chapters of the manual are:

- Chapter 1, "Flood Hazard Analysis"--explains that different types of floods demand different responses. Flood data must be collected and analyzed. A flood stage forecast map is needed to determine the flood hazard impact and to set priorities for emergency response needs.

- Chapter 2, "Capability Assessment"--shows how a municipality should make an inventory and assessment of the three types of resources--personnel, equipment, and facilities--that would be needed to fight a flood, and how to obtain assistance from state and federal agencies.

- Chapter 3, "Flood Warning"--explains different types of warning systems and how the warnings should be disseminated.

- Chapter 4, "Flood Fighting Plan"--provides an overview of everything that should be done immediately after a flood warning is issued.

Practical Application

The manual would have been of little benefit unless it could be applied to a practical situation. About the same time that the flood fighting committee was formed, a drainage district questioned what they could do to control flooding. It was suggested that they consider developing a flood warning system. Flood warning systems on a watershed level have not been developed in the Chicago metropolitan area. With the encouragement of the State of Illinois' Division of Water Resources, four communities within the watershed of the West Fork Branch of the Chicago River have almost completed the preparatory work for a manually operated flood warning system, with the necessary technical expertise being provided by the U.S. National Weather Service.

The precipitation and streams gauges are read by police departments, fire departments, public works and volunteer ESDA officials from the four municipalities. The U.S. Army Corps of Engineers, Chicago District, has agreed to develop a flood stage forecast map. Once the flood stage mapping is complete, the Illinois Division of Water Resources and the Emergency Services and Disaster Agency intend to assemble the municipalities to develop a flood fighting plan based upon the flood fighting manual.

The process has been very slow. It was initiated almost one year ago and the flood stage mapping has yet to be prepared. It was expected that it would take time to develop a flood warning system and response plan, since this is the first time that it has been done on a watershed basis in the metropolitan area. However, a shortage of state and federal personnel who can devote time to the project has greatly hindered its completion. Those personnel assigned to work on the project have other responsibilities that take priority. Because

of this, the flood response plan for the North Branch of the Chicago River watershed remains undone, and many other watersheds need assistance on flood warning systems and response plans.

Conclusion

The capability and the willingness of municipalities to prepare flood warning systems and flood response plans is evident. Their desires are even more pronounced after flood events. Intergovernmental cooperation is a difficult task that has to be worked out, but is not a major obstacle. The big challenge lies in making the proper people available to the local municipalities, and this includes for planning as well as technical assistance.

The lack of assistance is not a result of the capabilities of the people in the state and federal agencies, but rather of the lack of time that can be devoted to such efforts. More emphasis needs to be placed on assistance by those agencies with the staff to provide it to the local municipalities. This includes the U.S. National Weather Service, the U.S. Army Corps of Engineers, the Illinois Department of Transportation Division of Water Resources, the Illinois Emergency Services and Disaster Agency, and the Illinois State Water Survey.

The Division of Water Resources has made great strides in showing municipalities how they can develop a flood response plan with the flood fighting manual. Many municipalities that had not thought about developing such procedures now have something to help them visualize how it can be done. However, technical and planning assistance is still needed. None of the suburban municipalities or the counties have a hydrologist who can develop flood forecasting procedures. Of the municipalities with an engineering staff, many do not have the time, or for that matter, the expertise to properly prepare flood forecast maps. These are the kinds of things that can be done by the U.S. National Weather Service, the U.S. Army Corps of Engineers, and the State of Illinois. The expertise is there, but time must be allocated.

UTAH FLOODS--1983-84

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The settlement of Utah and the West dates back to 1776 with the expedition of Father Escalante, followed by exploration by early mountaineers, fur trappers, and the John C. Freemont expedition. In 1847, the first of many Mormon pioneers entered the Salt Lake Valley. These people were the first to maintain records of the fluctuations of the Great Salt Lake. The lake's frequent flooding of vast areas of land caused the early settlers many problems.

According to historical records, the Great Salt Lake reached its highest elevation of 4,212 feet during the years 1872-1874. For a period of ten years (1868-1878) the lake was above the 4,209-foot level. In 1963, the lake declined to its lower elevation of 4,191.5 feet. During this time, the Utah Legislature passed a resolution that set forth the idea that the lake should be maintained at the 4,200-foot level. In spite of the efforts of the Utah Legislature, the lake today is at an elevation of 4,209 feet. Drawing from past as well as from present facts, we can reasonably expect more flooding from the lake.

Today, industry, developers, engineers, and others have a difficult time trying to determine the fluctuations of the lake. This scenario holds true for much of the state as we attempt to deal with the lakes and rivers of Utah. This is because Utah is a land of contrasts. For example, the Great Salt Lake Basin receives an average of 5.3 inches of rain annually whereas the ski resort at Alta receives an average of 100 inches per year. (This year, Alta received 197 inches of rain.) Normally, Utah is a desert state, with only Nevada being drier. However, past and present records indicate that flooding is a common problem.

Utah experiences three types of flooding: two types of snow melt flooding, and short-lived summer torrential downpours associated with cloudbursts and thunderstorms. The first snow melt floods take place during the months of January and February while the ground is frozen. These floods are difficult to control because corrective measures are hampered by winter weather. The second

snow melt occurs during the last week of April and continues through May. The runoff is often increased by rain. The Salt Lake area was affected by such floods in 1922, 1952, and again in 1983-84. (It is of interest to note that the floods of 1922 and of 1952 did not have the highest volume of total runoff, but that the floods resulted because of above average spring temperatures.)

The flooding of 1983-84 is, we believe, a repeat of the high water that was experienced by the Mormon pioneers of 95 years ago. Could this be a true 100-year event? We believe that it is. As a result of rising waters, the following events have occurred:

1) Interstate 80 from Salt Lake City west to Nevada was damaged and required reconstructive work.

2) The Great Salt Lake Mineral Company went out of business, resulting in the loss of 240 jobs.

3) Saltair Entertainment Park also went out of business, resulting in 20 to 50 lost jobs.

4) Many agricultural operations were flooded, resulting in the loss of millions of agricultural dollars.

5) Additional diking of Rose Park (northwest of Salt Lake City) was required.

It must be noted that the jobs lost because of the lake's flooding are to some extent offset by the new jobs generated in the fighting of the flood. Loss of income has also been experienced by all of the major hotels of the state as a direct result of the news coverage of the floods of 1983 and 1984.

Based upon our experiences during the flood fight of 1983-84, our most serious problems were those dealing with unknown factors such as mud/landslides and dam failures, coupled with the fact that homeowners and small business people were unwilling to accept even minimal losses from flooding. As a result some dwellings were saved only at great public expense.

Another thing that caused some confusion was the practice of county officials contacting the Governor's and the U.S. Senators' offices directly instead of working through the proper channels. Because of this, some emergency equipment was misappropriated. We are taking measures to better inform local officials on the procedures to follow in the case of an emergency.

As a result of the extensive damages Utah experienced in the last few years, we are taking preventive measures. For example, many debris basins are being constructed. River banks are being riprapped to prevent excess bank erosion. To counter mudslides, landslides, and extensive hillside erosion, we are installing electronic instrumentation for early warnings. These stations provide up to 30 minutes of lead time. One worry that we do have concerning these stations is that too many false alerts may condition property owners not to heed the warnings. Also, a new area for lawsuits could arise if people seek recourse for disasters that may have been avoided if adequate warning had been given.

Would predisaster plans be practical for a state such as Utah? Yes, we believe any planning to be practical. In many instances, county/city crews were able to predict the extent of a flood enabling them to fortify stream banks and reduce possible losses. However, it must be noted that all of the mud/landslides that have occurred in Utah these past two years were in areas thought not to be subject to land movement. Areas of greatest concern did not move.

Agencies that were a part of the flood fight of 1984 were:

Federal Agencies

Federal Emergency Management Agency
Federal Highway Administration
National Weather Service
Small Business Administration
U.S. Army Corps of Engineers
USDA Soil Conservation Services
USDA Agriculture Stabilization Services
USDA Forest Service
U.S. Geological Survey

State Agencies

Department of Agriculture
Department of Community and Economic Development
Department of Health
Department of Insurance
Department of Natural Resources and Energy
Department of Transportation
Utah National Guard

The following recommendations are offered for future flood mitigation:

1) Have the Army Corps of Engineers combine mudflow and flood-zone data onto one FEMA map. This is being done for Davis County.

2) Propose legislation requiring that owners of dams have liability insurance.

3) Where possible, swap lands between federal agencies and local communities in areas in which debris basins and flood control measures are to be constructed.

4) Further define the role of the state engineer to include regulating storage reservoirs.

5) During disasters, arrange fro property owners to receive their flood insurance payments from their individual insurance agents.

6) Provide for the payment of flood insurance for structures rendered unusable as well as for those destroyed.

Utah has and will continue to experience floods. We hope that our present mitigation efforts (both regulatory and structural), coupled with past experience will reduce the severity of that flooding.

PUBLICATIONS OF INTEREST

from

Natural Hazards Research and Applications Information Center
Institute of Behavioral Science #6
Campus Box 482
University of Colorado
Boulder, Colorado 80309

SPECIAL PUBLICATIONS

#2. Regulation of Flood Hazard Areas to Reduce Flood Losses, Volume 3. Jon Kusler. 1982. 300 pp. $8.00

#3. Strengthening State Floodplain Management, Appendix A to Volume 3 (SP #2). Patricia A. Bloomgren. 1982. 123 pp. $8.00.

#4. Innovation in Local Floodplain Management, Appendix B to Volume 3 (SP #2). Jon Kusler. 1982. 262 pp. $8.00

#5. Floodplain Regulations and the Courts 1970-1981. Jon Kusler. 1982. 51 pp. $5.00.

#7. Preventing Coastal Flood Disasters: The Role of the States and Federal Response. Proceedings of a National Symposium, Ocean City, Maryland, May 23-25, 1983. 1983. 386 pp. $10.00.

#9. Improving the Effectiveness of Floodplain Management in Western State High-Risk Areas: Alluvial Fans, Mudflows, Mud Floods. Proceedings of a Workshop, Palm Springs, California, February 15-16, 1984. 1985. 97 pp. $7.00

#10. Evaluating the Effectiveness of Floodplain Management Techniques and Community Programs. Proceedings of a Seminar, Washington, DC, April 30-May 1, 1984. 1985. 143 pp. $8.00.

MONOGRAPHS

#29. The Flood Breakers: Citizens Band Radio Use During the 1978 Flood in the Grand Forks Region. Thomas E. Drabek et al. 1979. 101 pp. $8.00.

WORKING PAPERS
Subscription Rate: $3.00/paper
Regular Rate: $4.50/paper

#4. A Selected Bibliography of Coastal Erosion, Protection and Related Human Activity in North America and the British Isles. J.K. Mitchell. 1968. 70 pp.

#12. Technical Services for the Urban Floodplain Property Manager: Organization of the Design Problem. Kenneth Cypra and George Peterson. 1969. 25 pp.

#29. Flood Insurance and Community Planning. N. Baumann, R, Emmer. 1976. 83 pp.

#31. Warning for Flash Floods in Boulder, Colorado. T.E. Downing, 1977. 80 pp.

#32. What People Did During the Big Thompson Flood. E.C. Gruntfest. 1977. 62 pp.

#35. Hazard Mitigation Behavior of Urban Floodplain Residents. M. Waterstone. 1978. 60pp.

ANNUAL BIBLIOGRAPHIES

A Selected, Partially Annotated Bibliography of Recent (1982-1983) Natural Hazards Publications. David Morton. 1984. 124 pp. $5.00

TOPICAL BIBLIOGRAPHIES

#02. Bibliography on Flood Proofing. Anita Cochran. 1977. 9 pp. $1.00

#03. Flash Flood Warnings Bibliography. Kathleen Torres and Anita Cochran. 1977. 22 pp. $1.00

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