Strategies and Tools for Floodplain Management

Strategy A. Modify Susceptibility to Flood Damage and Disruption

1. Floodplain Regulations
   a) State regulations for flood hazard areas
   b) Local regulations for flood hazard areas
      1) Zoning
      2) Subdivision regulations
      3) Building codes
      4) Housing codes
      5) Sanitary and well codes
      6) Other regulatory tools
2. Development and Redevelopment Policies
   a) Design and location of services and utilities
   b) Land rights, acquisition, and open space use
   c) Redevelopment
   d) Permanent evacuation
3. Disaster Preparedness
4. Disaster Assistance
5. Floodproofing
6. Flood Forecasting and Warning Systems and Emergency Plans

Strategy B. Modify Flooding

1. Dams and Reservoirs
2. Dikes, Levees, and Floodwalls
3. Channel Alterations
4. High Flow Diversions
5. Land Treatment Measures
6. On-site Detention Measures

Strategy C. Modify the Impact of Flooding on Individuals and the Community

1. Information and Education
2. Flood Insurance
3. Tax Adjustments
4. Flood Emergency Measures
5. Postflood Recovery

Strategy D. Restore and Preserve the Natural and Cultural Resources of Floodplains

1. Floodplain, Wetland, Coastal Barrier Resources Regulations
   a) Federal regulations
   b) State regulations
   c) Local regulations
      (1) Zoning
      (2) Subdivision regulations
      (3) Building codes
      (4) Housing codes
      (5) Sanitary and well codes
      (6) Other regulations
2. Development and Redevelopment Policies
   a) Design and location of services and utilities
   b) Land rights, acquisition, and open space
   c) Redevelopment
   d) Permanent evacuation
3. Information and Education
4. Tax Adjustments
5. Administrative Measures

GENERAL PRINCIPLES FOR FLOODPLAIN MANAGEMENT

- *The federal government has a fundamental interest in how the nation's floodplains are managed, but the basic responsibility for regulating floodplains lies with the state and local governments.*
- *Floodplains must be considered in the context of total community, regional, and national planning and management*
- *Flood loss reduction should be viewed in the larger context of floodplain management, rather than as an objective in itself*
- *Sound floodplain management embodies several aspects*
  - *goals (wise use, conservation, and development of resources),*
  - *objectives (economic efficiency, environmental quality, and social well-being),*
  - *consideration of future needs and the role of the floodplain,*
  - *evaluation of alternative strategies for alleviating flood losses;*
  - *accounting for benefits and costs and interrelated impacts of floodplain management actions,*
  - *motivation of decisionmakers,*
  - *coordination of agencies at all levels for all aspects of floodplain management; and*
  - *evaluation through continuous monitoring and reporting to the public*

Source: A Unified National Program for Floodplain Management, 1976

tection of the natural and cultural resources of floodplain. Today's floodplain management framework is a product of planned initiatives, evolved methods, and fortuitous circumstances. Many aspects of the framework developed independently and then were incorporated for the common purpose. Many were intended at the outset to complement each other Many apply to floodplains only incidentally but nevertheless serve an important function.

The idea of a unified national program for reducing flood losses was first set out in House Document 465 and has been refined and expanded since to produce *A Unified National Program for Floodplain Management* It establishes as a basic national goal the wise use of floodplains; sets forth the conceptual framework of a multiobjective approach to use of the nation's floodplains, including flood loss reduction and natural values protection; identifies implementing strategies and tools; and recognizes the respective roles of each level of government and the private sector in the decisionmaking process.

There are four main strategies for reducing floodplain losses. They are described in detail in the Unified National Program documents. Each strategy can be carried out by using one or more specified "tools"—activities undertaken by governments, individuals, or the private sector that have an impact on floodplain management:

- Modify susceptibility to flood damage and disruption.
- Modify flooding
- Modify the impact of flooding on individuals and the community.
- Restore and preserve the natural and cultural resources of floodplains.

At all levels of government and within the private sector, the tools and strategies for floodplain management take various forms, including components of broader initiatives, legislation, and policy directives in water resources management, emergency management, environmental protection, and projects for community development and redevelopment. Federal, state, and local programs and private efforts to manage the natural and cultural resources of floodplains are usually focused on the particular resource or activity that happens to occur on the floodplain rather than on the floodplain itself.

The Federal Government

At the federal level, flood loss reduction is accomplished through a network of laws, executive orders and directives, administrative regulations, interagency actions, and agency policies and programs. These components of the framework address various aspects of floodplain management, including insurance, land use, disaster preparedness and relief, information and education, warning systems, and structural flood control. At least 25 subdivisions of 12 departments and agencies have significant responsibility for some aspect of floodplain management

The water resources values of floodplains are managed through programs for water quality, pollution control, watershed management, erosion control, and groundwater and aquifer protection. Restoration and preservation of the living resources of floodplains have been addressed in multiobjective federal programs or activities aimed at protecting inland or coastal wetlands or barrier islands. Other federal programs have been specifically directed at protecting habitat. Cultural resources have been protected through a variety of federally supported programs for open space, recreation, urban renewal, waterfront redevelopment, and historic preservation.

State Government

State activities for floodplain management have responded to and often paralleled federal activities. States administer locally adopted and enforced floodplain management regulations pursuant to the National Flood Insurance Program. All coastal states have some type of permitting program for development activities below mean high water and most coastal and Great Lakes states have federally approved coastal management programs. Every state has a multihazard emergency operations plan that covers floods. All coastal states and some inland states have wetland protection programs of some sort which include mapping, permitting, and protection.

SOME COMPONENTS OF THE FEDERAL FRAMEWORK FOR FLOODPLAIN MANAGEMENT

The Clean Water Act of 1972 • Coastal Barrier Resources Act (1982) • Coastal Zone Management Act of 1972 • The Dam Safety Act (1986) • The Disaster Relief Act of 1974 • The Disaster Relief and Emergency Assistance Amendments of 1988 • The Emergency Wetlands Resources Act of 1986 • The Endangered Species Act of 1973 • Executive Order 12127 (1979) • Executive Order 12148 (1977) • Executive Order 11296 (1966) • Executive Order 11988 (1977) • Executive Order 11990, Protection of Wetlands • The Federal Crop Insurance Act (1980) • The Federal Insecticide, Fungicide, and Rodenticide Act • Federal Interagency Floodplain Management Task Force established 1975 • The Federal Land Policy and Management Act of 1976 • Fish and Wildlife Coordination Act of 1958 • The Flood Disaster Protection Act of 1973 • The Food Security Act of 1985 • House Document 465, *A Unified National Program for Managing Flood Losses* • The Housing Act of 1961 • The Housing and Urban Development Act of 1969 • The Housing and Community Development Act of 1977 • The Housing and Community Development Act of 1987 • The Land and Water Conservation Fund Act (1964) • The National Dam Inspection Act of 1972 • The National Environmental Policy Act (1969) • The National Flood Insurance Act (1968) • The National Forest Management Act of 1976 • The National Historic Preservation Act (1966) • The North American Waterfowl Management Plan (1986) • OMB Memorandum, "Nonstructural Flood Protection Measures and Flood Disaster Recovery" (1980) • The Omnibus Budget Reconciliation Act of 1981 • The Reservoir Salvage Act of 1960 • The Safe Drinking Water Act of 1974 • The Soil and Water Resources Conservation Act of 1977 • The Tax Reform Act of 1986 • United States-Mexico Boundary Treaty of November 23, 1970 • The Water Bank Act (1970) • Water Pollution Control Act Amendments of 1972 • The Water Quality Act of 1987 • The Water Resources Development Act of 1974 • The Water Resources Development Act of 1986 • The Water Resources Development Act of 1990 • Water Resources Planning Act of 1965 • The Watershed Protection and Flood Prevention Act of 1954 • The Wild and Scenic Rivers Act of 1968 • Flood Control Act of 1917 • Rivers and Harbors Act of 1930 • Flood Control Act of 1936

Several states have adopted their own statewide floodplain management regulations, and in some states executive orders compel state agencies to consider flood hazards before carrying out their activities Several states have adopted environmental policy acts that require analysis of the impacts of proposed state and local actions on natural resources, including those of the floodplain. Every state has an agency involved in planning, funding, or sponsoring structural flood control projects. Floodplain management is further accomplished through state-level regulatory and nonregulatory programs directed at wetlands, dune protection, restoration and protection of living resources and natural areas, mapping, flood conveyance and storage, dam safety, pollution control, natural crops, groundwater supply, wildlife habitat, historic preservation, recreation, and shoreline management.

Local Government

The adoption and enforcement of local floodplain regulations is now widespread because of the National Flood Insurance Program Many local zoning and subdivision regulations protect the natural and cultural resources of floodplains through shoreline setbacks, density limits, historic preservation guidelines, or specification of compatible uses. Local governments are almost exclusively responsible for local drainage and stormwater management. Many localities participate as cosponsors of structural projects, providing a small financial contribution to the cost of the works. Some localities have coastal management programs within a state framework, and some states provide for local application of state controls, usually established under legislation geared toward multiple goals like protection of wildlife and sensitive shoreland areas, or erosion control Some communities have developed multihazard emergency preparedness or operations plans

Regional Entities

Regional entities can be extremely effective in managing floodplains, whose boundaries typically do not conform to traditional governmental jurisdictions. Special districts are the most numerous and fastest-growing type of governmental entity in the country; nearly one-quarter of them have natural resource functions—soil and water conservation, drainage and flood control, and sewerage. The nation's 3,000 counties also have floodplain management functions, including storm drainage, land acquisition, flash flood warning, emergency response, land use planning, and building regulation (usually of unincorporated areas). Nearly 3,000 conservation districts exist, covering more

THE IDNDR

In 1987 the United Nations General Assembly declared 1990 to 2000 AD as the International Decade for Natural Disaster Reduction (IDNDR) It is anticipated that this assessment will provide useful input to the United States program for the Decade

SELECTED PROFESSIONAL AND NONPROFIT ORGANIZATIONS ACTIVE IN FLOODPLAIN MANAGEMENT

American Institute of Architects
American Land Resource Association
American Littoral Society
American Planning Association
American Rivers Conservation Council
American Society of Civil Engineers
American Water Resources Association
Association of Conservation Engineers
Association of State Dam Safety Officials
Association of State Floodplain Managers
Association of State River Managers
Association of State Wetland Managers
The Coastal Society
Coastal Conservation Association
Coastal States Organization
Connecticut River Watershed Council
The Conservation Foundation
Conservation Law Foundation of New England
Council of State Governments
Environmental Defense Fund
The Environmental Law Institute
Environmental Policy Institute
Freshwater Foundation
Friends of the Earth
Friends of the River
Land Trust Alliance
League of Conservation Voters
National Association of Conservation Districts
National Association of Counties
National Association of Home Builders
National Association of State Recreation Planners
National Association of Urban Flood Management Agencies
National Audubon Society
National Center for Urban Environmental Studies
National Emergency Management Association
National Fish and Wildlife Foundation
National League of Cities
National Organization for River Sports
National Recreation and Parks Association
National Trails Coalition
National Trust for Historic Preservation
National Water Resources Association
National Waterways Conference
National Wetlands Technical Council
National Wildlife Federation
The Natural Areas Association
Natural Resources Defense Council
New England Natural Resources Center
North American Lake Management Society
The Oceanic Society
The River Conservation Fund
Save the Dunes Council
Sierra Club
Society for Range Management
Soil and Water Conservation Society
The Sounds Conservancy
The Trust for Public Land
Urban Land Institute
Wetlands for Wildlife
The Wilderness Society
Wildlife Management Institute

than 97% of the country. They provide planning and technical assistance to individual landowners for controlling soil erosion and water pollution, and they implement swampbuster, wetland restoration, and erosion reduction portions of the Food, Agricultural, Conservation, and Trade Act of 1990

The Private Sector

Besides undertaking basic and applied research on floodplain management, academic institutions also provide education in the field, although so far no university offers a program of study specializing in floodplain management. Many states have Water Resources Research Institutes, as authorized by the Water Resources Act of 1964.

Over 700 national and local land trusts exist throughout the nation. Most are nonprofit organizations that receive land, either through donations or purchase, and manage it as open space or for historic purposes.

There are a large number of professional and nonprofit organizations involved in floodplain management. Most are national in scope and accomplish their objectives through meetings, publications, lobbying, and fostering professional communication The number of private conservation and watershed organizations is even larger. Usually nonprofit with a broad public membership, they are typically directly involved in environmental issues with flood loss reduction as an indirect goal or benefit. These citizen-based groups serve a tremendous public education function, are largely unaffected by partisan politics, and can usually respond to an issue more rapidly than government agencies.

Individuals and for-profit corporations have become more involved in floodplain management since the 1960s, helping develop floodproofing techniques and materials, automated flood warning systems, geographic information systems, remote sensing techniques, and computerized information management.

Modifying Susceptibility to Damages and Disruption

Modifying susceptibility to flood damage and disruption is the floodplain management strategy of avoiding dangerous, uneconomic, undesirable, or unwise use of the floodplain. The tools used to implement this strategy are regulations; development and redevelopment policies; disaster preparedness; floodproofing and elevation; and flood forecasting, warning systems, and emergency plans.

Regulations

Regulations have a potentially greater impact on flood loss reduction than any other single floodplain management tool and have been widely used over the last 15-20 years. Development that conforms to regulations is less prone to flood damage than pre-existing development

Regulation is largely a local government responsibility, but throughout much of the country there is still widespread resistance to any type of land use regulation and concern among jurisdictions that it will be ruled an unconstitutional "taking" of private property. Effective enforcement often requires more training, personnel, and financial resources than many communities can provide. Regulations cannot provide full protection, they have a limited impact on existing buildings and infrastructure already subject to flooding, and they do not prevent development in floodplains. In addition, most floodplain regulations do little to protect the natural resources of floodplains. In fact, to the extent that floodplain regulations allow development in floodplains—even though it may not be subject to damage—they can contribute to the loss of natural and cultural resources. On the other hand, current regulations do provide a de facto prohibition on development in wetlands.

Academic Institutions Engaged in Natural Hazards and Emergency Management Research and Education

Arizona State University, Office of Hazard Studies • Charleston Southern University, Earthquake Education Center • Brown University, Alan Shawn Feinstein World Hunger Program • Clark University, Center for Technology, Environment, and Development • Colorado State University, Hazards Assessment Laboratory • Cornell University, Cornell Institute for Social and Economic Research/Program in Urban and Regional Studies • Memphis State University, Center for Earthquake Research and Information • New York Medical College, Center for Psychological Response in Disaster Emergencies • New York University, Industrial Crisis Institute • State University of New York at Buffalo, National Center for Earthquake Engineering Research • Texas A&M University, Hazard Reduction and Recovery Center • Texas Tech University, Institute for Disaster Research, Wind Engineering Research Center • University of Arizona, Office of Arid Lands Studies and Arid Lands Information Center • University of California, National Information Service for Earthquake Engineering • University of California, California Earthquake Education Project and Chemical Education for Public Understanding Project • University of Central Florida, Florida Sinkhole Research Institute • University of Colorado, Natural Hazards Research and Applications Information Center • University of Colorado, U.S. World Data Center for Glaciology, National Snow and Ice Data Center • University of Delaware, Disaster Research Center • University of Hawaii, Pacific Islands Development Program, Disaster Preparedness and Rehabilitation Project • University of Maryland-Baltimore County, Emergency Health Services Program • University of Massachusetts, Land and Water Policy Center • University of North Carolina, Center for Urban and Regional Studies • University of North Texas, Emergency Administration and Planning Degree Program • University of Pennsylvania, The Wharton School, Risk and Decision Processes Center • University of Pittsburgh, Center for Social and Urban Research • University of Wisconsin Extension, Disaster Management Center

Source: Natural Hazards Research and Applications Information Center

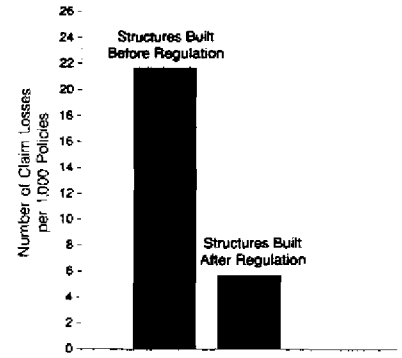
The most widespread floodplain regulations are the minimum requirements of the National Flood Insurance Program, which must be enacted and enforced by communities participating in the program. The minimum regulations vary depending upon the risk studies and mapping that have been done in the community, but include

- permitting for all proposed new development;
- reviewing subdivision proposals to assure that they will minimize flood damage;
- anchoring and floodproofing structures to be built in known floodprone areas;
- safeguarding new water and sewage systems and utility lines from flooding; and
- enforcing risk zone, base flood elevation, and floodway requirements after the flood insurance map for the area becomes effective.

There are numerous performance and prescribed standards applicable to each of the zones on flood insurance maps. The Federal Insurance Administration has several programs to help states and communities adopt and comply with the regulations. Other federal agencies provide technical and planning assistance and support.

Since the 1960s the number of state and local governments exercising regulatory authority over floodplain uses has increased markedly, and the variety of regulatory approaches has expanded. A given state may directly regulate the flood hazard area, set standards for local application, or regulate the flood hazard area as part of a broader resource protection and management program. To meet these requirements, local governments adopt specific floodplain management or stormwater management ordinances and incorporate floodplain management provisions into zoning and subdivision regulations, housing and building codes, and resource protection regulations. The number of communities with regulatory requirements more stringent than those of the National Flood Insurance Program is unknown, but clearly is in the thousands.

Average Losses per 1,000 Flood Insurance Policies on Unregulated versus Regulated Structures, 1978-88



Source: FEMA/FIA

ENFORCING LAND USE REGULATIONS IN MAINE

In 1983 the Maine legislature enacted "Rule 80K" to allow less expensive and faster enforcement of local land use regulations. Once local code enforcement officials are trained, they can take a violation directly to the district court without an attorney. Procedures are followed that are less formal than usual but do not sacrifice the defendant's due process rights. The court can levy a fine and order abatement of the violation.

THE SOUTH CAROLINA BEACHFRONT MANAGEMENT ACT

The South Carolina Beachfront Management Act establishes a "no construction" zone beginning at the crest of the actual or theoretical dune line and extending landward 20 feet or 40 times the average annual rate of erosion, whichever is greater. The legislature anticipated that the Act would result in the gradual elimination of structures built too close to the ocean and hence subject to damage or destruction from hurricanes and other coastal storms.

Development and Redevelopment Policies

Federal, state, and local governments all have established programs, policies, and directives to avoid inappropriate development and redevelopment of the floodplain.

Federal policies relating to the design and location of services and utilities (roads, bridges, and sewer lines, etc.) in floodprone areas include the National Environmental Policy Act, Executive Order 11988, and the Coastal Barrier Resources Act. All of these either restrict federal participation in development in floodprone areas or require careful review of the impacts on the floodplain of proposed federal or federally supported activities.

Several states have issued executive orders or other directives comparable to the federal ones, and every state now has a statute or executive order to govern construction of state projects, such as prisons and universities, that are exempt from local regulations. All coastal states have policies on development in coastal flood hazard areas. Some states have more stringent flood loss reduction standards for roads and bridges than those of the federal aid system.

In some cases, the only way to preclude future uses incompatible with the flood risk is to permanently evacuate a portion of a floodplain and to obtain full title or easements on its development rights. Although this process (called "acquisition") is expensive, the long-term benefits in reduced floodplain losses, protection of natural resources, and public use of the land, may make it worthwhile.

Most redevelopment relating to flood loss reduction occurs after one or more major floods. Usually a control structure is built to protect what development remains, and a temporary moratorium is imposed to allow evaluation and planning. Unfortunately, legislative and regulatory requirements often encourage a quick return to the preflood status quo, wasting opportunities to mitigate and revitalize the area.

Disaster Preparedness

Disaster preparedness encompasses plans for mitigation, warning, and emergency operations; training, public information activities; exercises to test disaster preparedness plans; readiness evaluations; research; review and coordination of disaster preparedness plans and programs; and postdisaster evaluations. Individual preparedness is important but severely underutilized. Preparedness plans often are developed in concert with flood forecast, warning, and emergency plans. There are several federal programs for disaster preparedness, and every state has an integrated emergency management plan and an agency responsible for preparing for floods. Each Gulf and Atlantic

SOME FEDERAL PROGRAMS FOR DISASTER PREPAREDNESS

- Under the authority of Section 201(d) of the Disaster Relief Act of 1974, the Federal Emergency Management Agency provides up to 50% matching grants to help states develop and improve state and local plans for preparedness and mitigation. Interagency flood hazard mitigation teams are formed after each Presidentially declared flood disaster to offer technical assistance to communities and states and to identify mitigation measures that may be implemented in the affected areas.
- Under Section 409 of the Act, any jurisdiction receiving federal disaster assistance must prepare a hazard mitigation plan within 180 days of the declaration; future federal assistance may be curtailed if such a plan is not filed.
- The Federal Emergency Management Agency, the U.S. Army Corps of Engineers, and the National Weather Service have formed a program of comprehensive hurricane evacuation planning in association with Gulf and Atlantic states. The NWS develops the SLOSH (Sea, Lake, and Overland Surge from Hurricanes) model for each coastal basin, and FEMA funds the running of the models by the NWS's National Hurricane Center to predict storm directions, speeds, and intensities. Evacuation plans are prepared from the studies. Their value was proved during Hurricane Hugo in 1989, when hundreds of thousands of people were evacuated and loss of life was kept to a minimum.
- The Federal Emergency Management Agency provides grants to states to conduct hazard mitigation projects.
- The Federal Energy Regulatory Commission requires emergency action plans at its licensed projects and periodically holds in-depth exercises to test the plans and the licensee's coordination of responsibilities with the appropriate state and local disaster agencies.
- The Soil Conservation Service has done flood audits of structures in the floodplain of the Yantic River in Norwich, and the Quinnipiac River in Southington, Connecticut, to complement the response to flood warnings.
- The U.S. Army Corps of Engineers conducts technical evaluations to determine what types of warning systems and preparedness plans are appropriate for certain areas.

coast state has a hurricane preparedness plan completed or underway. Many localities also have emergency management plans, but relatively few have detailed plans specifically for floods, and even fewer have plans for mitigation after a flood. This is probably due to lack of expertise and funding to develop such plans, the hope that the flood problems will be taken care of through some structural measures, and the expectation of receiving federal disaster assistance when the flood does occur

Flood Forecasting, Warning, and Emergency Plans

Warning systems and accompanying emergency response have long been recognized as effective ways to save lives and reduce flood damages in both riverine and coastal floodprone areas. The joint hurricane evacuation study is a good example of this. As the cost of the required equipment continues to decrease, more and more state and local governments are funding the development of flood warning systems and emergency plans.

The National Weather Service conducts research, provides specific flood forecast and warning services to over 3,100 communities, and works with many of the 900 communities that have local warning systems The Corps, the Tennessee Valley Authority, and the Bureau of Reclamation collect hydrometeorological data and prepare operational forecasts, often in cooperation with the National Weather Service, for their flood control structures. The U.S. Geological Survey collects streamflow and other data that can be used for flood forecasting.

About half of the states are involved in flood warning, including cooperation in IFLOWS (the Integrated Flood Observing and Warning System) in Appalachia and installation of automated data collection equipment. Some large urban communities have included forecasting and preparedness planning in their operations for years, participated in regional warning systems, or have developed their own systems.

University and private research has contributed substantially to the knowledge about and design of warning systems, disaster response, and system effectiveness. The private sector is vital to the design, installation, operation, maintenance, and modification of local flood warning systems. In many instances, industries have cooperated in the installation and operation of flood warning systems and reduced their own flood losses.

Floodproofing and Elevation

Floodproofing is the use of permanent, contingent, or emergency techniques to either prevent flood waters from entering buildings or to minimize the damages from water that does get in. Some of the techniques involve using water-tight seals, closures or barriers; using water-resistant materials; and temporarily relocating the contents of a building. Elevating a structure means raising it on fill, piers, or pilings so that it is above expected flood levels. Most new floodplain structures are now designed to incorporate floodproofing and/or elevation, primarily because it is required by the regulations of all National Flood Insurance Program communities. There are millions of existing floodprone homes to which floodproofing could be applied retroactively ("retrofitted"), but this technique is not yet routinely used. One obstacle has been that flood insurance rates stay the same when a residence is retrofitted, the new Community Rating System of the National Flood Insurance Program should help remove that disincentive.

Floodproofing is probably the tool most widely used by the private sector with only limited government assistance. Many of the early floodproofing techniques were developed by architects, engineers, and building contractors as they worked with individual property owners, especially on small commercial buildings and industrial facilities. The American Institute of Architects, the National Association of Homebuilders, university researchers, and private engineering firms have conducted considerable research on and developed technical information about floodproofing. The private sector is also the source of many floodproofing products, such as vinyl sheathing, devices to prevent sewer backflow, substitutes for sand bags, equipment for filling sand bags, and flood shields to temporarily seal windows, doors, and other openings.

LYCOMING COUNTY'S EARLY WARNING SYSTEM

Lycoming County, Pennsylvania, lies almost entirely within the drainage area of the West Branch of the Susquehanna River and contains close to 2,200 miles of streams. Most of the county's people live on or near the river After major flooding from Hurricanes Agnes in 1972 and Eloise in 1975, a self-help early warning system was developed with an initial investment of $500. With the help of the National Weather Service, forecasting procedures were established for each watershed within the county, and the system was put into operation within three months Over 100 volunteer observers were recruited and trained to observe and monitor stream gages and make reports to a stream coordinator. The coordinator assembles the data for a watershed and conveys it to a system coordinator With the help of expert personnel, the data is evaluated and a determination of expected flooding and appropriate response is made.

Over the last 10 years improvements to the system have been made To assure adequate backup for data transmission, the county provided National Oceanic and Atmospheric Administration weather radios to the volunteer observers, and NWS distributed base station radios to the stream coordinators In addition, a system of 10 automated rain gages and 4 automated stream alarm devices was installed to supplement the manual data collection

Examples of Retrofitting

Relocation: Moving a building to high ground, above flood levels

Elevation: Raising a building so that flood waters will go under it

Floodwalls Building a wall of concrete or earth to keep flood waters from reaching a building

Dry Floodproofing: Making building walls watertight and sealing openings so flood waters cannot enter

Wet Floodproofing: Altering a building to minimize damage when flood waters enter

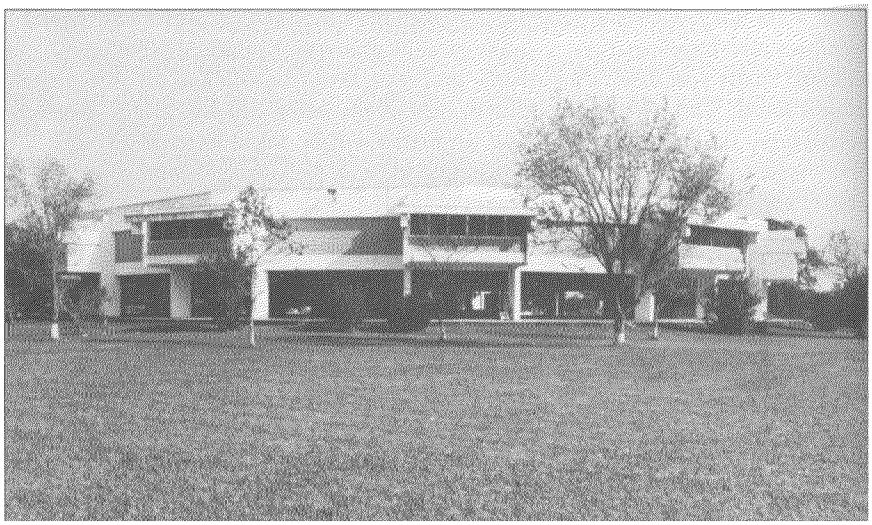
Source: Floodproof Retrofitting Homeowner Self-Protective Behavior, Shirley Bradway Laska, 1991

FLOODPROOFING AND THE CORPS

In the early 1960s the Tennessee Valley Authority and the U S Army Corps of Engineers jointly produced the first comprehensive report on floodproofing In 1972, after further review and evaluation of different techniques, the Corps released Floodproofing Regulations, *which has since been incorporated into or recommended by all the major regional building codes and many of the state and local codes. The Corps routinely evaluates the potential for using floodproofing in all its project feasibility studies It also provides technical assistance to local communities and is involved in several projects to floodproof large numbers of homes in communities with chronic flood problems*

FLOODPROOFING IN ILLINOIS

After floods in Illinois in 1982, 1985, 1986, and 1987, the state provided technical assistance on floodproofing to victims who visited the local Disaster Assistance Centers. Over half of the flood victims eventually altered their houses and/or yards to protect themselves from future flooding The average homeowner implemented three different floodproofing measures The median costs ranged from $42 for a standpipe or sewer drain plug to $2,350 for sewer backup valves, most cost between $200 and $600 Most of the floodproofing measures were installed within two months after the flood Those who were flooded again in the 1987 floods found that their floodproofing measures were generally effective



One floodproofing technique is to elevate a structure so that flood waters can pass beneath Sebastien Roy Elementary School, Verret, Louisiana

Most states distribute information about floodproofing and provide technical assistance to individuals and groups of property owners. Several states have promoted floodproofing by publishing technical manuals, helping localities obtain funding, holding seminars for industry and individual owners, establishing loan programs, and cooperating with disaster assistance centers so that victims can begin to retrofit immediately. Local governments have floodproofed individual structures. A few communities have provided their own funding for larger projects, and others have provided technical and financial assistance to local businesses and residences.

Modifying Flooding

Modifying flooding is a floodplain management strategy of using structural means to alter the flood itself. Structural measures—dams, reservoirs, dikes, levees, floodwalls, channel alterations, high flow diversions, spillways, land treatment measures, shoreline protection works, and stormwater management facilities—permit deliberate changes in the volume of runoff, peak stage of the flood, time of rise and duration of flood waters, location of flooding, extent of area flooded, and velocity and depth of flood waters. The effectiveness of these measures for protecting property and saving lives has been well demonstrated Flood control projects have saved billions of dollars in property damage and protected hundreds of thousands of people from anxiety, injury, and death

Throughout the second half of this century, the number and size of structural flood control projects have been decreasing. High construction costs coupled with increased cost-sharing requirements for nonfederal sponsors of projects have made some structures unaffordable. Structural measures also have been criticized for destroying riparian habitat, scenic values, and water quality; creating a false sense of security; resulting in eventual loss of flood storage capacity due to sedimentation, and inducing development in floodplains. These criticisms have been coupled with greater recognition that humans should attempt to adjust to floods and not just try to control them.

It appears likely that the rate of construction of new flood control projects may hold steady or decrease slightly and that relatively few large flood control structures will be built in the future Local and private construction of smaller flood control projects is certain to continue and may even increase.

One issue that the nation must face in the coming decades is how to deal with the aging inventory of existing flood control structures. Many dams and reservoirs are nearing or even past their design lives, and the flood control capacity of many reservoirs has been reduced by sedimentation. The financial